Driving Transportation Electrification Forward in Pennsylvania

Considerations for Effective Transportation Electrification Ratemaking

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EXECUTIVE SUMMARY

Transportation electrification can provide considerable benefits to all classes of society. The potential benefits associated with electric vehicles (EVs) include substantial reductions in transportation fuel costs and, through better utilization of existing electricity system infrastructure, lower electricity rates for all electricity customers. These benefits will not happen automatically, however. The extent to which they are realized depends on the achievement of two key goals: (1) minimizing charging costs to customers to facilitate widespread adoption of EVs, and (2) charging EVs in a manner that minimizes costs to the grid.

With respect to charging costs, some electric rate structures currently used in Pennsylvania present financial barriers to potential EV customers and owners of public EV charging stations. These barriers likely depress uptake of EVs. With respect to grid costs, as EV adoption grows, managing peak demand—when electricity costs are at their highest—will become a key challenge for electric utilities. At high EV penetration levels,[1] widespread charging during times of peak demand could exacerbate grid constraints and increase costs for customers by driving the unnecessary construction of transmission and distribution infrastructure and additional generation capacity purchases.[2]

Thoughtful ratemaking by Pennsylvania's electric distribution companies (EDCs), along with programmatic efforts by EDCs to boost customers' adoption of EVs, can help maximize the societal benefits of EVs by supporting the financial viability of public EV charging stations, steering EV charging practices to benefit the grid and society, and supporting integration of renewable energy.

This report summarizes key issues and best practices in EV rate design. It then assesses the potential of rate designs currently available in Pennsylvania to encourage EV adoption and improve capacity utilization of the grid, and it discusses how other ratemaking mechanisms (such as performance incentive mechanisms) might be used to achieve state and Public Utility Commission (PUC) goals. Finally, the report provides recommendations for improving Pennsylvania's rate design structures and alternative ratemaking mechanisms to capture the greatest benefits of EVs for Pennsylvania ratepayers.

In other jurisdictions, time-varying rates—in some cases specifically tailored to EV customers—have proven extremely effective in motivating EV customers to charge off-peak. The rates allow customers to save money and do so conveniently since off-peak hours generally align with the hours that customers have parked their cars at home.

Unlike many other states, however, Pennsylvania EDCs do not offer EV-specific rate structures, and several EDCs offer no time-varying rates whatsoever. To determine how well the EDCs' rates support transportation electrification, we examined the rates of the six largest EDCs, as of July 2018:

[1] Current penetrations of EVs are unlikely to have a material impact on the grid, but as adoption increases, more attention to load management is warranted.

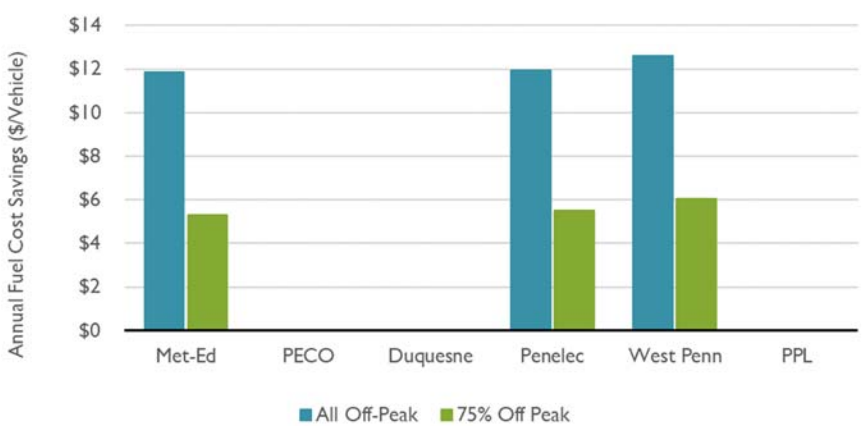
[2] Generation capacity is purchased through the wholesale capacity market, with capacity needs based on utilities' peak demands.

Pennsylvania Electric Company (Penelec), Metropolitan Edison (Met-Ed), West Penn Power Company (West Penn), PECO Energy Company (PECO), Duquesne Light Company (Duquesne), and PPL Electric Utilities (PPL).

Our analysis found that the EDCs' current rate structures are ill-suited to advance transportation electrification in a manner that supports electricity system efficiency. None of the EDCs in Pennsylvania offer time-varying rates (such as time-of-use, or TOU, rates) for the delivery portion of the bill, and only three of the EDCs offer energy supply TOU rates for residential customers: Penelec, Met-Ed, and West Penn.[3] However, these TOU supply rates do little to encourage EV customers to enroll in a time-varying rate, since EV customers' fuel cost savings on the TOU supply rates are miniscule relative to the standard rate.

Figure ES-1 shows annual fuel cost savings for two charging patterns for customers on TOU rates, one in which all charging is done off-peak and a second in which three-quarters of the charging is done off-peak. The remainder of the EDCs (PECO, Duquesne, and PPL) do not offer either TOU delivery or TOU supply rates as part of their default service. Therefore, their rates provide no savings irrespective of when charging occurs. Without such savings, customers have little incentive to shift their charging to off-peak periods.

Figure ES-1. TOU rate annual fuel cost savings relative to standard rate



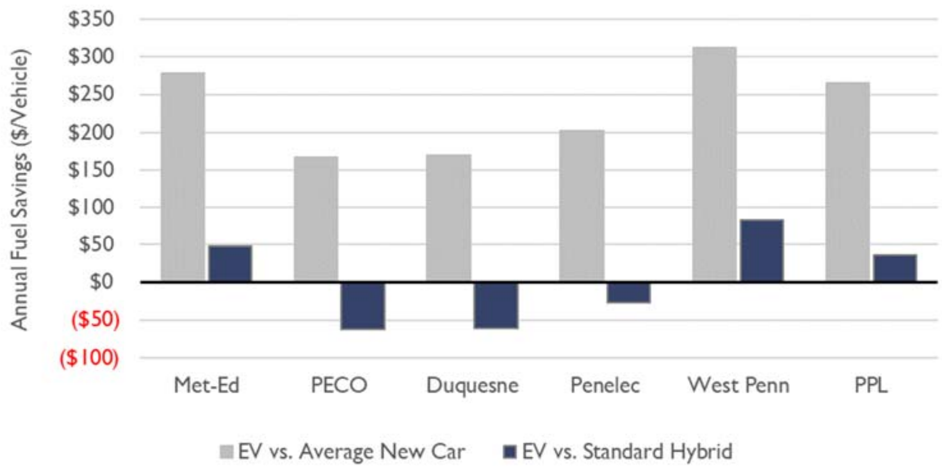
Note: Based on typical charging patterns of California EV customers on TOU Rates which showed that 75 percent of the charging occurs during the hours of 10 pm and 7 am.

Unsurprisingly, the EDCs' current rate structures (including those with TOU supply rates) also do not provide meaningful fuel cost savings relative to internal-combustion vehicles, thereby providing little incentive for customers to adopt EVs. We modeled the annual fuel cost savings for a 100-mile battery electric vehicle (BEV) relative to an average new car (with an efficiency of 38 mpg) and a standard hybrid

[3] For energy supply, customers can choose to take service through a competitive supplier or through the EDCs' default service. Our analysis focused on the default service rates of the EDCs.

car (with an efficiency of 55 mpg). As shown in Figure ES-2 below, for three of the EDCs, EV fuel cost savings under current rates are negative relative to the standard hybrid car with an efficiency of 55 mpg.[4]

Figure ES-2. Annual fuel cost savings of 100-mile BEV on TOU rate relative to internal combustion engine vehicles



Based on our analysis of the Pennsylvania EDCs' current rates, we recommend that the EDCs:

- Follow Pennsylvania law by making TOU rates an option in their default supply service. Effort should be made to ensure that the price differentials between on-peak and off-peak rates are high enough to motivate off-peak charging and enable greater fuel savings for EV customers and system cost savings for all consumers.[5]
- Offer simple time-varying *delivery* rates to encourage EV customers to charge during hours in which the distribution system is not stressed.
- Analyze commercial and industrial rates to determine whether modifications (such as temporarily reducing demand charges) are warranted to support greater private investment in public charging stations, including DC fast charging (DCFC) stations.[6]
- Explore EV-only TOU rates in addition to whole-house TOU rates.

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[4] U.S. Energy Information Administration. Annual Energy Outlook 2018, Table 41. https://www.eia.gov/outlooks/aeo/supplement/excel/suptab_41.xlsx . Standard hybrids do not draw electricity from an external source, and therefore must rely at least in part on gasoline during their standard operation. A Toyota Prius is one of the more common examples of a standard hybrid vehicle.

[5] 66 Pa.C.S.A. § 2807(f)(5). See also Dauphin County Indus. Development Authority v. Pennsylvania Public Utility Com'n, 123 A.3d 1124 (Pa. Cmwlth. 2015) and the PUC's April 6, 2017 Secretarial Letter in Dockets No. P-2013-2389572 and No. M-2016-257805.

[6] TOU rates or rates with a lowered demand charge can increase the business case for privately owned public charging stations.

- Explore reducing or eliminating the customer charge for second meters and submetering as a means for lowering the cost of EV-only rate implementation.
- Work to maximize customer enrollment in TOU rates through education, outreach, and incentives.
- Report EV-related data to the Pennsylvania PUC and stakeholders, including data on EV customers, sales, demand, load profiles, costs for EV integration, EV education and outreach activities, and lessons learned.

In addition, we recommend that the Pennsylvania PUC consider implementing performance metrics and incentives with a focus on encouraging enrollment in TOU rates and improving system capacity utilization.

1. INTRODUCTION

Electric vehicles (EVs) have great potential to reduce greenhouse gas emissions while lowering costs for all electricity customers through more efficient utilization of existing electricity infrastructure. However, these benefits are by no means assured. The extent to which they are realized depends on: (1) charging EVs in a manner that minimizes costs to the grid, and (2) minimizing charging costs to customers to encourage broader EV adoption.

EVs draw considerable power from the grid when charging—enough to easily double a household's power demand, when an EV is charged with a Level 2 charger. As a result, as the penetration of EVs increases,[7] charging EVs during times of peak demand could exacerbate grid constraints and increase costs for customers due to the unnecessary construction of transmission and distribution infrastructure and additional generation capacity purchases.[8] Consequently, managing the timing of EV charging is critical to avoiding costly grid build-outs.

EVs can be used to reduce emissions while reducing grid and customer costs. By absorbing excess energy from renewables when energy is plentiful but demand is low (e.g., during the overnight hours with wind generation), EVs can help to integrate renewable resources. If EV charging occurs when the grid is underutilized and increases utility revenues without commensurate increases in cost, it can reduce electricity rates for all customers—regardless of whether the customer drives an EV.

Utility rate design is a key motivator for influencing whether customers charge EVs in a manner compatible with grid conditions, as well as the extent to which customers are motivated to adopt EVs by potential fuel savings.[9,10] Existing rate design structures—such as time-invariant rates and the use of inflexible demand charges for commercial and industrial customers—do not promote efficient integration of EVs and other distributed energy resources on the grid. Further, these rate designs do not effectively allocate system costs among customers or provide sufficient fuel cost savings to encourage

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[7] Current penetrations of EVs are unlikely to have a material impact on the grid, but as adoption increases, more attention to load management is warranted.

[8] Generation capacity is purchased through the wholesale capacity market, with capacity needs based on utilities' peak demands.

[9] EV load at utilities without time-varying rates shows that customers tend to plug in their vehicles when they return home from work in the evenings. See: Idaho National Laboratory, 2014. "EV Project Electric Vehicle Charging Infrastructure Summary Report: January 2013 through December 2013." Available at: https://avt.inl.gov/sites/default/files/pdf/EVProj/EVProject%20Infrastructure%20ReportJan13Dec13.pdf.

[10] Numerous studies show that fuel cost savings are critical for motivating customers to purchase an EV. For example, a survey of nearly 20,000 EV owners in California found that fuel cost savings are the number one motivator for an EV purchase. In addition, NREL's annual surveys for the years 2015–2017 show that fuel cost savings consistently ranks as either the first or second most important reason for considering EVs. See: Center for Sustainable Energy (2016). California Air Resources Board Clean Vehicle Rebate Project, EV Consumer Survey Dataset: http://cleanvehiclerebate.org/eng/surveydashboard/ev and Mark Singer, "The Barriers to Acceptance of Plug-in Electric Vehicles: 2017 Update" (NREL, November 2017), https://www.nrel.gov/docs/fy18osti/70371.pdf.

the adoption of EVs. In contrast, cost-based time-varying rates that reflect the low marginal costs of serving additional load during off-peak hours can help to support additional EV adoption.

Both the Pennsylvania General Assembly and the Pennsylvania PUC have explicitly recognized the important role that rate design and alternative ratemaking mechanisms can play in supporting the evolving energy landscape:

- In the spring of 2018, the legislature passed and Governor Wolf signed into law House Bill 1782 (Act 58 of 2018), clarifying the EDCs' ability to propose decoupling and other alternative ratemaking structures for Commission consideration.[11] By severing the link between revenues and sales, decoupling reduces the EDCs' motivation to increase sales in order to increase its revenues. It thereby also lessens the utility's aversion to sales reductions (through energy efficiency or other distributed energy resources). The bill also explicitly allows for "performance-based rates" that can be set or adjusted based on the utility's performance. Such mechanisms can operate as part of, or in addition to, existing rate base/rate of return ratemaking.
- On May 3, 2018, the Commission issued a Proposed Policy Statement Order in Docket M-2015-2518883, an exploration of alternative ratemaking that the Commission opened in December 2015. The Order lists several new alternative ratemaking approaches that could be considered in Pennsylvania, including:
    - Performance incentive mechanisms (PIMs),
    - Revenue decoupling, and
    - Variations of demand-based and time-of-use pricing options, such as critical peak pricing.

  In terms of rate design, the Order specified the following over-arching principles:
    - Policies must support the continued efficient use of all energy resources.
    - The evolution of a distributed energy environment requires substantial and well-targeted investment in distribution infrastructure.
    - Policies must encourage least-cost solutions, with cost recovery based on long-term cost causation.
    - Rate design should embrace, where feasible, the additional capabilities enabled by smart meter deployment.
    - As noted by the Office of Consumer Advocate, "costs are variable in the long run." Therefore, it may be appropriate for energy utilities to design rates in a manner that minimizes the long-term costs of serving existing and new loads.

[11] House Bill 1782. Available at: http://www.legis.state.pa.us/CFDOCS/Legis/home/Amendments/list_amendments.cfm?chamberchamber=H&Session=2017&sIndex=0&bBody=H&bType=B&bNumber=1782&PrintersNumber=2418

The Order also clearly recognized the need for improvements to EDC rate design to both foster distributed energy adoption and increase capacity utilization. Implementing effective EV rate designs and alternative ratemaking mechanisms will be an important component for achieving the Commission's objectives.

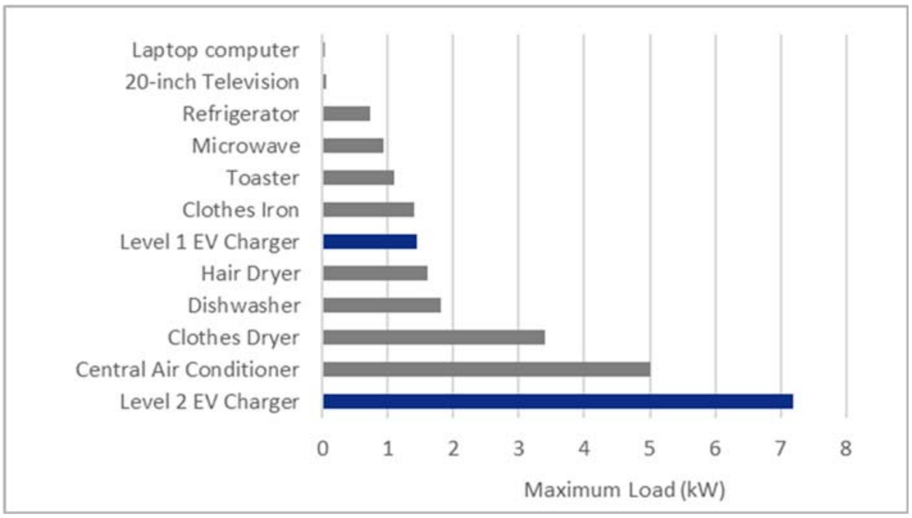
In this report, we assess how Pennsylvania EDC rate structures should be improved to encourage EV adoption and optimize the benefits of EVs. Section 2 provides a general discussion of the advantages and disadvantages of various utility rate structures for EV charging. Section 3 summarizes best practices in EV rate design. Section 4 discusses technologies, practices, and programs to maximize customer enrollment in EV rate designs. Section 5 assesses the capability of existing Pennsylvania EDC rate designs to grow EV adoption and access the benefits of EVs for customers and the grid. Section 6 provides recommendations for improving Pennsylvania's rate design structures.

2. BENEFITS AND DRAWBACKS OF VARIOUS EDC RATE STRUCTURES FOR ELECTRIC VEHICLES

Utility rate design is a key determinant of whether customers choose to charge EVs in a manner compatible with grid conditions, as well as the extent to which customers are motivated by potential fuel savings to buy EVs instead of gasoline- or diesel-powered vehicles.[12]

EVs draw considerable power from the grid when charging and can easily double a household's power demand when charged with a Level 2 charger. Further, their instantaneous power draw can be significantly higher than any other typical household appliance, as shown in the figure below.[13]

Figure 1. EV charging load relative to household appliances



If nothing is done to manage the timing of EV charging, EV adoption could strain Pennsylvania's electric system, potentially leading to costly grid build-outs. Fortunately, this need not be the case. Because many EVs—like their gasoline counterparts—sit idle most of the day, there is often considerable flexibility regarding the timing of EV charging. Most drivers do not care when their EVs get charged, as long as the vehicles are ready to drive when needed. This inherent flexibility sets EVs apart from most major residential electricity end-uses (e.g., air conditioning) and opens the possibility of encouraging efficient charging without inconveniencing consumers. Further, "smart" EV charging—i.e., charging that

[12] Studies reveal that saving money relative to driving an internal combustion engine vehicle is one of the most important motivators of EV purchase decisions. For example, a survey of nearly 20,000 EV owners in California found that fuel cost savings are the number one motivator for an EV purchase. In addition, NREL's annual surveys for the years 2015–2017 show that fuel cost savings consistently ranks as either the first or second most important reason for considering EVs. *See:* Center for Sustainable Energy (2016). California Air Resources Board Clean Vehicle Rebate Project, EV Consumer Survey Dataset: http://cleanvehiclerebate.org/eng/survey-dashboard/ev. *and* Mark Singer, "The Barriers to Acceptance of Plug-in Electric Vehicles: 2017 Update" (NREL, November 2017), https://www.nrel.gov/docs/fy18osti/70371.pdf.

[13] A Level 1 charger uses a standard 120-volt outlet and provides approximately 4.5 miles per hour of charging. A Level 2 charger uses a 240-volt outlet and provides approximately 20 miles per hour of charging. DC fast chargers are another, much more expensive option, and they deliver power at 200–600 V_{DC} to provide approximately 240 miles per hour of charging.

can be scheduled in advance to occur at times that balance both grid and customer needs—can help with both EV and renewable integration.

Depending on how it is managed, EV load could result in large positive or negative impacts on the grid. Thus, it is critical that Pennsylvania establish a framework that will enable it to integrate EVs into the grid in the lowest-cost manner. EDCs can play a prominent role in this regard, as they can provide price signals to customers to encourage EV owners to charge in a manner that is consistent with grid conditions.

Effective EV price signals can:

1) **Lower electricity rates for all utility customers through more efficient utilization of existing grid assets.** If EV charging occurs when the grid is underutilized and increases utility revenues without commensurate increases in cost, it can reduce electricity rates for all customers—regardless of whether the customer drives an EV. This allows utilities and their customers to get more value from the existing electricity system that has been built to meet peak demand.

2) **Avoid unnecessary grid upgrades by encouraging customers to shift charging to off-peak hours.** If electric vehicles charge during peak hours, the need for new investments will increase. For example, higher peak demands can exacerbate grid constraints resulting in the need for additional distribution and transmission system capacity. Also, higher peak demands can require additional capacity purchases through the wholesale market.

3) **Reduce emissions by better aligning charging with renewable energy production.** EVs can help to absorb excess energy from renewables when energy is plentiful, but demand is low, such as during the overnight hours when wind generation tends to be high.

4) **Encourage customer adoption of EVs by maximizing fuel cost savings.** EDCs can offer time-varying rates designed to provide meaningful fuel cost savings relative to new internal-combustion vehicles, thereby providing an incentive for customers to adopt EVs.

5) **Create a viable business case for public charging infrastructure.** Fast charging infrastructure, referred to as DC fast chargers (DCFC), can promote adoption of EVs. Changes to rate designs are needed to grow the DCFC market as most DCFC stations are billed on a rate with a demand charge, but high demand charges can make development of DCFC stations uneconomical in the near term.

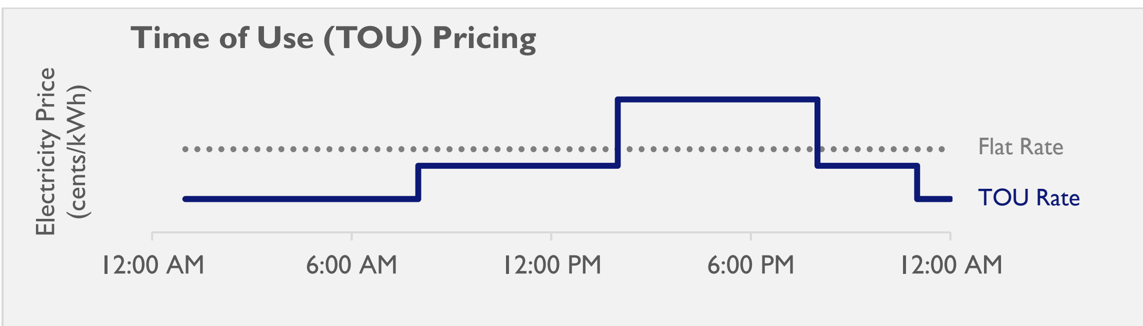
However, many EDC rate structures do not accomplish these goals. The following sections discuss the advantages and disadvantages for EVs of the most common electric rate structures in the United States today, including: flat rates, time-of-use pricing (TOU), critical-peak pricing, peak-time rebates, real-time and hourly pricing, and demand charges. We also discuss considerations for designing public charging rates.

2.1. Flat Rates

Standard, time-invariant electricity rates do little to encourage EV adoption or optimal charging times. Real-world experience suggests that flat rates lead to inefficient charging practices.[14] Because flat rates charge the same price regardless of when usage occurs, customers are apt to charge their EVs solely based on personal convenience, without regard for whether the times they choose are beneficial to the grid. In contrast, time-varying rates convey price signals that better reflect the cost of producing and delivering energy during different hours.

2.2. Time-of-Use Pricing

TOU rates consist of two or more pricing tiers, based on pre-defined time periods. Electricity is priced higher during hours when the peak is more likely to occur, and lower during hours that are generally off-peak. Relative to a dynamic rate structure where the hourly price is not known in advance, TOU rates pose relatively low financial risks to customers because the pricing is known ahead of time and customers can choose to curtail their electricity use during on-peak times.



2.3. Critical-Peak Pricing

This rate structure is often used in conjunction with TOU rates but can be used with an otherwise flat rate structure as well. Critical-peak pricing imposes a very high price tier that is only triggered for very specific events, such as for system reliability at times when generating units need to be shut down on short notice or demand is unusually high.[15] The timing of the events is generally not known until a day in advance, and the events typically last for only 2–6 hours.

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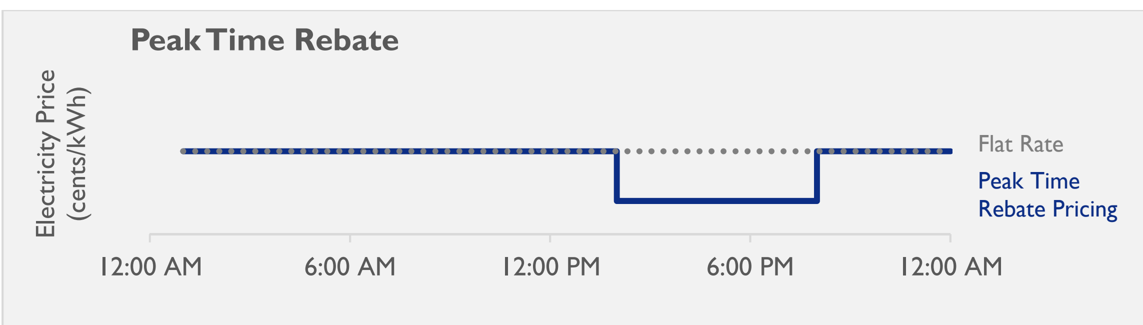
14 Idaho National Laboratory, 2014. "EV Project Electric Vehicle Charging Infrastructure Summary Report: January 2013 through December 2013." Available at: https://avt.inl.gov/sites/default/files/pdf/EVProj/EVProject%20Infrastructure%20ReportJan13Dec13.pdf

15 Hledik, R. et al., 2016.

2.4. Peak-Time Rebates

A peak-time rebate program is similar to critical-peak pricing, except that customers earn a financial reward for reducing energy relative to a baseline instead of being subject to a higher price. As with critical-peak pricing, the number of event days is usually capped for a calendar year and is linked to conditions such as system reliability concerns or very high supply prices.[16] While peak-time rebate programs tend to be widely accepted by customers, they have two drawbacks relative to critical-peak pricing:

- Baseline usage can be difficult to determine with accuracy. For example, a customer may earn a reward simply because the customer was out of town on the day of the event rather than because the customer actively reduced their electricity consumption in response to the event.
- Peak-time rebates tend to result in lower reductions than critical-peak pricing. Customers generally respond more strongly when they are faced with paying more for consumption during peak hours than when they are offered a reward for lowering consumption.[17]

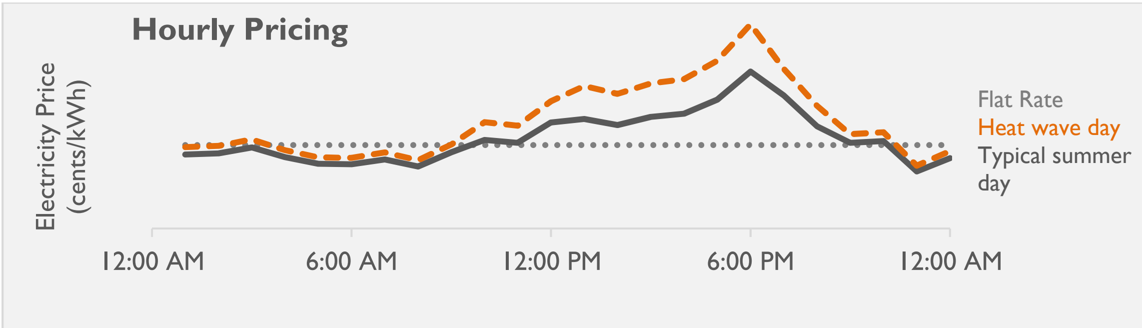


[16] United States of America. Federal Energy Regulatory Commission. *Assessment of Demand Response and Advanced Metering.* Washington D.C.: United States, 2010.

[17] Faruqui, A. et al., 2012. “Time-Varying and Dynamic Rate Design.” Available at https://www.raponline.org/wp-content/uploads/2016/05/rap-faruquihledikpalmer-timevaryingdynamicratedesign-2012-jul-23.pdf.

2.5. Real-Time and Hourly Pricing

These rates charge customers for electricity based on the wholesale market price[18] rather than a pre-set rate schedule. Prices fluctuate hourly or in 15-minute increments, reflecting changes in the wholesale price of electricity. Customers are typically notified of prices on a day-ahead or hour-ahead basis.



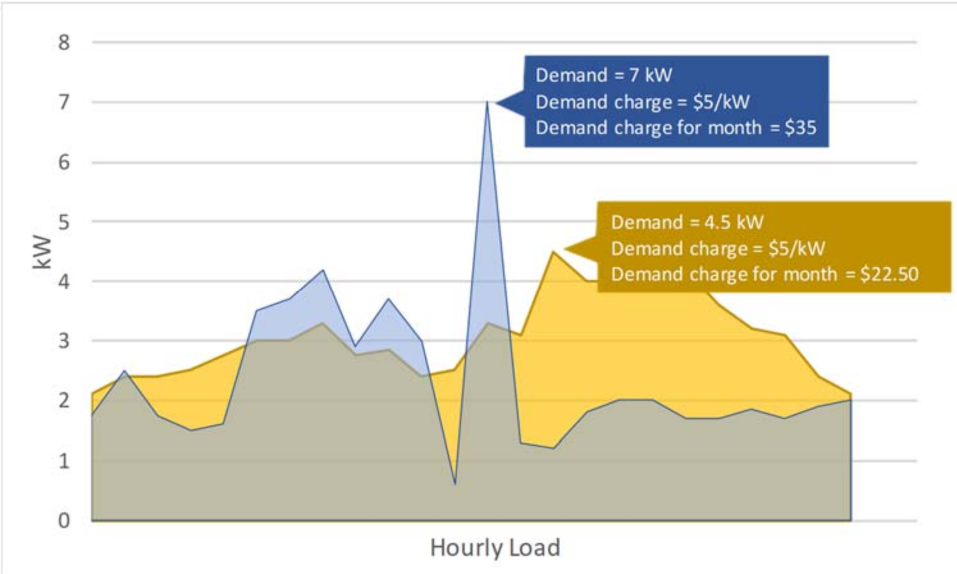
2.6. Demand Charges

In addition to time-varying energy rates, some utility rates include a demand charge, particularly for large commercial and industrial customers. Demand charges are designed to recover the utilities' costs associated with serving peak demand. Instead of assessing a charge based on when and how much energy is consumed (measured in kWh), demand charges are applied to a customer's maximum consumption (measured in kW) during a month.[19] Demand charges can be designed to be time-limited (that is, they only apply during certain peak hours of the day), or they can apply during any hour. Figure 2 illustrates how a demand charge functions.

[18] There may be adjustments to the wholesale market price for energy to account for transmission congestion and other factors. Thus, the price the customer faces is generally the locational marginal price of energy, plus distribution and other costs.

[19] In some cases, demand charges are applied to some measure of a customer's maximum consumption over the course of a year.

Figure 2. Hypothetical demand charge example



Demand Charge Considerations for Public Charging Rates

Access to public charging, including DCFC stations, is critical for the development of the EV market. DCFC stations generally provide between 50 kW and 350 kW of power, which facilitates long-distance electric travel and helps to provide prospective EV drivers with range confidence. Public charging stations are also important for providing charging options for customers in multifamily dwellings or single-family households with only on-street parking.[20] In addition, DCFC stations support the electrification of medium- and heavy-duty fleet vehicles that have intensive duty cycles.

Currently, the deployment of DCFC in Pennsylvania is limited in terms of both the number of stations and their geographic distribution. The map in the figure below from the Department of Energy's Alternative Fuels Data Center reveals that there are only 46 DCFC locations with 77 DCFC plugs in the entire state, most of which are concentrated in Philadelphia and Pittsburgh metro areas.[21] In comparison, despite its significantly smaller size and population, Maryland has 66 DCFC locations with 150 plugs and the Maryland Public Service Commission is considering a Statewide EV Portfolio proposal that would substantially expand DCFC deployment.[22] Ohio has 48 locations with 92 plugs, but the Public Utilities Commission of Ohio recently approved a proposal for utility-facilitated deployment of an

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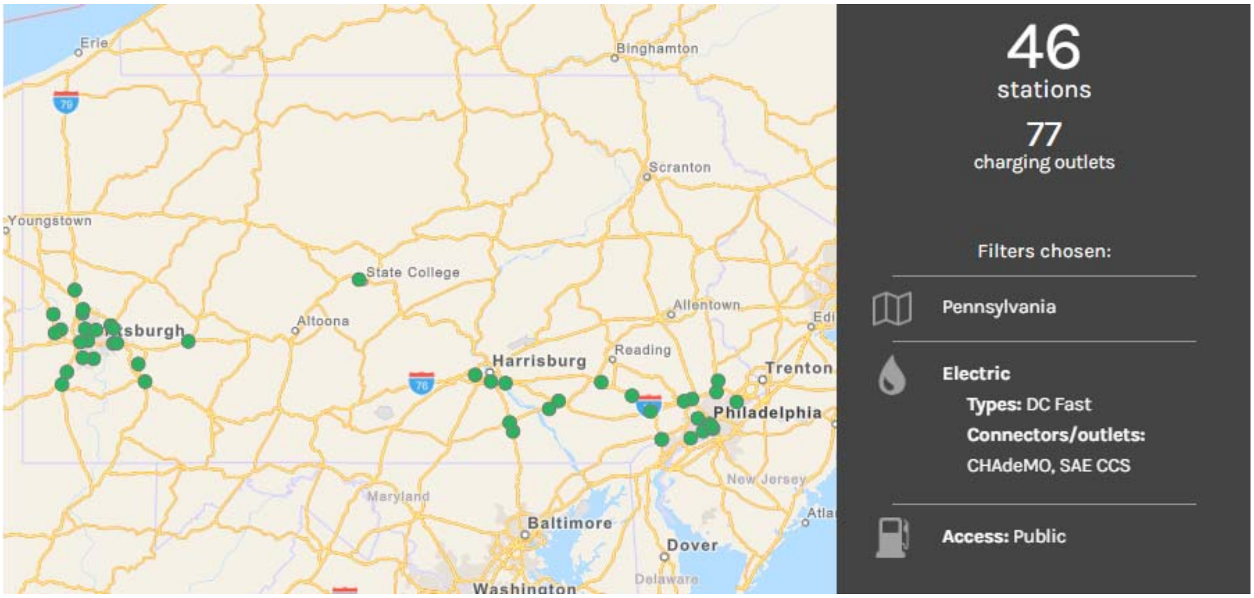
[20] Approximately 25 percent of U.S. households live in multifamily dwellings, and approximately 39 percent of single-family households have no access to charging at home. National Research Council of the National Academies, *Overcoming Barriers to Deployment of Plug-In Electric Vehicles* (Washington, DC: National Academies Press, 2015), 85, https://download.nap.edu/cart/download.cgi?record_id=21725.

[21] Alternative Fuels Data Center. We do not include Tesla Supercharger locations because they employ proprietary technology that is accessible only for drivers of Tesla vehicles.

[22] Alternative Fuels Data Center. Regarding Petition for Implementation of Statewide Electric Vehicle Portfolio available at: https://webapp.psc.state.md.us/newIntranet/Casenum/NewIndex3_VOpenFile.cfm?FilePath=C:\Casenum\9400-9499\9478\\1.pdf

additional 75 DCFC stations. Even as battery range improves and battery costs continue to fall, a comprehensive network of DCFC stations is needed to support a growing number of EVs.

Figure 3. Map of Pennsylvania's DCFC stations



Rate design is inextricably linked to the development of a sustainable, growing DCFC market. Most DCFC stations are billed on a commercial rate, which typically includes a demand charge. High demand charges make development of DCFC stations uneconomical unless station utilization is high. Empirical analysis by Rocky Mountain Institute demonstrated that demand charges can account for over 90 percent of the costs of operating these stations, due to the fact that these stations tend to have low overall energy consumption, despite their brief periods of high electricity demand. When EV penetration and station utilization are low, this dynamic makes it extremely challenging for a DCFC owner to recoup its costs.[23]

To illustrate, consider a DCFC station with two 50-kW ports that occasionally has two vehicles charging at once, for a total of 100 kW of demand. Under a high demand charge of $20/kW, the DCFC owner would pay a monthly demand charge of $2,000. Under a more moderate demand charge of $6/kW, the monthly demand charge would be $600.[24] While such demand charges may be tenable for future levels of EV penetration, currently many charging stations experience low utilization rates, with some only being used once every few days.

Under the high demand charge case, a charging station with a low utilization rate of one charge every two days (15 charges per month) would have an operating cost of $142 per charging session, equivalent

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[23] Garrett Fitzgerald and Chris Nelder, "EVgo Fleet and Tariff Analysis" (Rocky Mountain Institute, April 2017), https://www.rmi.org/wp-content/uploads/2017/04/eLab_EVgo_Fleet_and_Tariff_Analysis_2017.pdf.

[24] Demand charges generally range from $3/kW to $25/kW. In the Northeast, distribution demand charges average approximately $11/kW.

to a cost of $2.84/kWh. At four times the utilization rate (60 charges per month), the cost would fall to $39 per session (equivalent to a cost of $0.77/kWh).

A more moderate demand charge of $6/kW would still result in a cost per session of $49, assuming only 15 charges per month, or $15 per session assuming 60 charges per month. These results are shown the table below. Such costs would be difficult, if not impossible to recoup from customers under such low utilization. Yet, in many areas low utilization is likely to be the norm until the EV market grows. Of course, EV market growth is in part driven by the existence of a network of DCFC infrastructure, thereby creating a chicken-or-egg problem.

Table 1. Impact of a demand charge on a charging station with 100 kw demand

		High Case	Mid Case
Demand Charge ($/kW)		$20	$6
Customer Charge ($/Month)		$70	$70
Energy Charge ($/kWh)		$0.08	$0.08
Energy per Session (kWh)		50	50
15 charging sessions/month	Annual DCFC Bill	$25,560	$8,760
	Cost/session	$142	$49
	Cost/kWh	$2.84	$0.97
60 charging sessions/month	Annual DCFC Bill	$27,720	$10,920
	Cost/session	$39	$15
	Cost/kWh	$0.77	$0.30

The challenging economics of operating DCFC stations merits further evaluation of demand charges vis-à-vis transportation electrification. In the long term, when EV adoption and station utilization are higher, standard demand charges may be more appropriate for DCFC stations. In the short term, modifications to demand charges can be made to improve station economics and competition for the deployment of DCFC services while allowing for reasonable utility cost recovery. Indeed, several utilities across the country have begun to modify their existing commercial and industrial tariffs to encourage greater private investment in public charging infrastructure, as discussed in Section 3.2.

Some have raised concerns that reducing demand charges for EV charging stations could result in costs being shifted onto other customers. Since demand charges assign costs to customers in proportion to responsibility for total system capacity—and are often the main approach to recovering utility capital costs—the fear is that exempting EV station load from full demand charges could unjustly impose a burden on other ratepayers by forcing them to shoulder costs that they have not caused. However, cost-shifting will not occur as long as electricity is priced at or above the utility's marginal cost of service.[25]

Although utilities might collect less revenue under a reduced demand charge for DCFC, cost-shifting will be avoided as long as EV charging rates are set at or above the utility's marginal cost of service (MCOS). The MCOS value reflects the incremental cost of serving new capacity, and so using it to set charging rates will ensure that any new costs that these stations impose on the overall system are recovered.[26,27]

Taken on the whole, discounted demand charges for DCFC during the early years of EV adoption are likely to benefit all customers, because they help to promote additional EV adoption. As more customers adopt EVs, the additional electricity consumption will put downward pressure on rates for all customers, provided that EV customers primarily charge off-peak. In this way, discounted demand charges are similar to economic development rates that have long been provided to certain large customers whose load would otherwise not remain on the system.

[25] This is true for both vertically integrated and restructured utilities. However, any required distribution upgrades directly related to the charging station should also be recovered from the charging station owner to avoid shifting these costs onto other customers.

[26] Favorable EV charging rates may also be compared with Economic Development Rates (EDR), which use reductions in electricity costs to induce local business development. The cardinal standard in these cases, often called the "No Worse Off" rule, is that no customer should be disadvantaged by the preferential rate. In the short term, this "No Worse Off" rule will hold as long as incremental associated costs are covered. *See:* John Wolfram, "Economic Development Rates: Public Service or Piracy?," *IAEE Energy Forum* First Quarter 2016 (2016).

[27] Over the long haul, expenditures on capacity expansion spurred by new EV charging load may best be considered embedded costs, which are typically recovered through demand charges.

3. BEST PRACTICES FOR DESIGNING EV RATES

The following section summarizes several key elements of best practice designs for EV rates. These elements include: implementation of TOU rates, modification of demand charges, and consideration of EV-only rates.

3.1. Implementation of Time-of-Use Rates

TOU rates are the most popular form of time-varying rate, both for EV customers and non-EV customers. In some cases, TOU rates are specifically tailored to EV customers. These rates have been offered by utilities for decades and are gaining popularity now that advanced meters are reducing the costs associated with implementation. Results from a survey conducted by the Smart Energy Power Alliance (SEPA) indicate that at least 45 utilities across the country have TOU rates targeted to EVs.[28]

TOU rates are popular for several reasons:

- **Effectiveness:** TOU rates have been shown to be highly effective in shifting EV load.
- **Simplicity:** TOU rates provide an easy-to-understand price signal that reflects general trends in utility costs, without requiring customers to monitor hourly energy prices. TOU rates are particularly well suited to "set it and forget it" technologies, such as the timers on many EV chargers.
- **Efficiency:** TOU rates can be designed by layering different types of utility costs (generation, transmission, and distribution) to reflect the temporal variability of all three.

In contrast, critical-peak pricing and peak-time rebates only target a few peak hours per year. While such an approach may work well for avoiding additional generation capacity costs, it does not avoid daily higher-cost energy hours. In addition, such rates typically do not reflect the wider range of local distribution peak hours. Another consideration is that the specific hours for critical event days are generally called only a day in advance, making critical peak pricing and peak time rebates less compatible with "set it and forget it" technologies.

Hourly dynamic pricing is an efficient alternative to TOU pricing but is more complex and shifts more risk to customers. Where dynamic pricing is offered, enrollment tends to be low.[29] Further, dynamic pricing

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[28] Erika Myers, Medha Surampudy, and Anshul Saxena, "Utilities and Electric Vehicles: Evolving to Unlock Grid Value" (Smart Electric Power Alliance, March 2018), 24. Erika Myers, Medha Surampudy, and Anshul Saxena, "Utilities and Electric Vehicles: Evolving to Unlock Grid Value" (Smart Electric Power Alliance, March 2018), 24.

[29] For example, only about 17,500 customers out of 3 million have enrolled in Commonwealth Edison's dynamic pricing program. Dick Munson, "Data Reveals Real-Time Electricity Pricing Would Help Nearly All ComEd Customers Save Money," *EDF Energy Exchange* (blog), November 14, 2017, http://blogs.edf.org/energyexchange/2017/11/14/data-reveals-real-time-electricity-pricing-would-help-nearly-all-comed-customers-save-money/. For example, only about 17,500 customers out of 3 million have enrolled in Commonwealth Edison's dynamic pricing program. Dick Munson, "Data Reveals Real-Time Electricity Pricing Would Help Nearly All ComEd Customers Save Money," *EDF Energy Exchange* (blog), November 14, 2017,

may be too variable for public charging stations. In California, the Public Utilities Commission rejected San Diego Gas & Electric's proposed dynamic rate for public charging infrastructure. The Commission wrote, "Dynamic rates are complicated, highly variable, and do not provide enough predictability for drivers that may not be participating in a specific utility program."[30] Instead, the Commission directed the utility to design a TOU rate that provides more predictability for drivers.

TOU rates have proven extremely effective in motivating customers to charge off-peak, since customers can save money doing so and off-peak hours generally align with the hours that customers have parked their cars at home. Most TOU rates are applied to all of a customer's load, rather than just the EV load itself. For residential customers, this is referred to as a "whole-house" TOU rate. Key considerations for implementing TOU rates include the ratio between peak and off-peak prices, the proportion of hours in peak and off-peak windows, and the differentiation of costs by time.

Peak and Off-Peak Price Ratios

The ratio between peak and off-peak prices must be sufficient to motivate customers to shift their load. A study of early-adoption EV customers in SDG&E's service territory found that a peak to off-peak price ratio of 6:1 results in about 10 percent more off-peak charging than a ratio of 2:1.[31]

Peak and Off-Peak Windows

Narrow peak periods and wide off-peak periods provide customers with the most flexibility to shift energy consumption to off-peak hours, but care must be taken to avoid creating a new peak by shifting load to immediately before or after the peak period window.[32]

Time-Differentiated Costs

To be efficient, time-varying rates must reflect grid costs. When designing TOU rates, it can be instructive to examine distribution costs on a class level. In some cases, commercial areas peak during

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http://blogs.edf.org/energyexchange/2017/11/14/data-reveals-real-time-electricity-pricing-would-help-nearly-all-comed-customers-save-money/.

[30] California Public Utilities Commission, Decision on the Transportation Electrification Priority Review Projects, Decision 18-01-024, Application 17-01-020 et al, January 11, 2018, page 42.

[31] Nexant. 2014. "Final Evaluation of SDG&E Plug-in Electric Vehicle TOU Pricing and Technology Study." Available at www.sdge.com/sites/default/files/documents/1681437983/SDGE%20EV%20%20Pricing%20&%20Tech%20Study.pdf.

[32] To mitigate the sharp rise in demand at the beginning of the off-peak period, some utilities are exploring managed charging. Managed charging would allow a utility (or third party) to remotely reduce the rate of vehicle charging in a manner similar to traditional demand response programs. However, the cost of the communications infrastructure necessary to relay such signals may be cost prohibitive. *See:* Erika Myers, "Utilities and Electric Vehicles: The Case for Managed Charging" (Smart Electric Power Alliance, April 2017), 5, https://sepapower.org/resource/ev-managed-charging/. In some cases, utilities assign customers a specific time to start charging to avoid a sudden surge in demand. Conversation with Pasi Miettinen, President and CEO of Sagewell, Inc.

the middle of the day, while circuits serving residential customers peak in the evening. Such findings may suggest establishing different on-peak and off-peak periods for different customer classes.

It is also useful to distinguish grid costs by time. One way in which this is done is by assigning marginal generation, transmission, and distribution costs to each hour of the year. For capacity, this can be done using loss of load probabilities for each hour of the year,[33] while for energy, the costs are based on the variable operating costs of different power plants (for vertically integrated utilities) or wholesale market hourly energy prices.

While TOU rates are more commonly—and less controversially—used to recover marginal generation costs, distribution costs are similarly temporal, driven by customer peak demands that tend to occur during certain hours. For example, in setting rates, Southern California Edison evaluates the extent to which each component of its distribution system serves "peak" (load-variant) vs. "grid" (non-load-variant) functions. In the aggregate, the utility estimates that 47 percent of its distribution system costs vary directly with the peak system need, while the remaining balance is tied to "grid" functions whose costs are driven by a variety of factors.[34]

The distribution system costs associated with peak demand are most appropriately recovered through a time-varying rate structure. SCE uses the Peak Load Risk Factor (PLRF) approach to assign each hour of the year a portion of total peak distribution system costs in proportion to the probability that load on each of will exceed established planning thresholds and spur system upgrades. Although utilities often propose to recover distribution costs through fixed fees or non-coincident demand charges, these are neither equitable nor effective strategies for recovering costs that are driven by coincident peak demand.[35]

3.2. Modification of Demand Charges

As described in detail above, some utilities have temporarily reduced or eliminated demand charges for public charging infrastructure, opting instead to price electricity using TOU rates. Cost-shifting onto

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[33] The loss of load probability is the probability demand will exceed the available generating capacity. The loss of load probability accounts for the fact that an increase in load during a peak hour has a much greater impact on reliability than an increase in load during an off-peak hour. Loss of load probabilities can be estimated based on a probabilistic outage model that accounts for historical forced outage rates, scheduled unit maintenance, and other factors. Total capacity costs can then be allocated across hours in a year based on the loss of load probability.

[34] Southern California Edison. 2018. *Phase 2 of 2018 General Rate Case: Marginal Cost and Sales Forecast Proposal.* 43.

[35] For example, Southern California Edison's testimony describes how customer load during off-peak periods has no impact on distribution capacity costs and should therefore pay proportionally less toward such costs. "If peak demands on Subtransmission and distribution facilities were consistently experienced only on hot summer days throughout the utility's service area, it would improve pricing accuracy to recover peak capacity-related marginal costs based on how customers' demands affect system constraints during these high-cost days. This allows a customer who uses electricity predominantly in the lower cost periods to pay proportionately less, because of that customer's peak load were to increase or decrease, there would be no impact on distribution system capacity requirement." See Southern California Edison. 2018. *Phase 2 of 2018 General Rate Case: Marginal Cost and Sales Forecast Proposal.* 12.

other customers due to such rates can be avoided if electricity is priced at or above the utility's marginal cost of service, since EV stations are supporting incremental load growth, rather than representing existing load on the system.

TOU rates, particularly when combined with a critical-peak price, can be used to recover costs to meet system and local peak demand. These rates are cost-based, and therefore the recovery of local and system peak demand costs through a TOU rate will not result in any cost-shifting.[36] A small demand charge can recover the remainder of the costs associated with an individual customer's demand (and that customer's specific distribution infrastructure costs). However, temporary reduction of this remaining demand charge may be warranted due to the additional load growth that the charging infrastructure is helping to support.

Examples of utility modifications of demand charges to support transportation electrification include:

- In Oregon, Pacific Power implemented a tariff that would shift a portion of demand charges to on-peak energy rates for customers with DCFC, initially reducing DCFC bills by up to 59 percent. The demand charge would gradually be phased back in, so that by Year 9 all customers are transitioned back onto standard rates.[37]
- In New York, Con Edison's Business Incentive Rate is available to DCFC customers for seven years, until April 30, 2025. This incentive reduces customer demand charges by between 34 percent and 39 percent.[38]
- In California, Southern California Edison will offer a rate to general service customers serving EV loads that does not include a demand charge for five years. During Years 6 through 11, the demand charge will be gradually phased back in.[39]
- In Rhode Island, National Grid will pilot a 100 percent distribution demand charge discount for dedicated DCFC station accounts. The discount would be in effect for three years with the opportunity to extend the demand charge credit for an additional three years.[40]
- On Long Island, the Public Service Enterprise Group proposes to refund operators of public EV charging facilities for per-unit energy expenditures that exceed a predetermined "set point," to be determined by the regulatory body. Since enrolled

[36] The exception to this is if you build a DCFC in a location where the grid is constrained. However, this can be avoided by getting the utility involved in the siting. Also, the utility could potentially limit the demand charge discount to areas on the distribution system where there is sufficient capacity.

[37] Max St. Brown, "Staff Report Re: Schedule 45- Public DC Fast Charger Delivery Service Optional Transitional Rate," Docket No. ADV 485/Advice No. 16-020, May 8, 2017.

[38] Consolidated Edison Company of New York, Inc., Tariff Book, Revision 5, Leaf 201, Rider J, issued February 1, 2017.

[39] California Public Utilities Commission, Decision on Transportation Electrification Standard Review Projects, Decision 18-05-040, May 31, 2018, p. 111.

[40] The Narragansett Electric Company, Settlement Agreement, Docket Nos. 4770 and 4780, June 16, 2018.

facility owners will be commercial rate customers, this refund will be to the effect of reducing the overall demand charge burden.[41]

- In Maryland, Baltimore Gas and Electric has proposed to provide a fixed demand charge credit to non-residential customers with EV chargers based upon the nameplate capacity of the installed charging infrastructure.[42]
- In Connecticut, demand charge discounts offered by Connecticut Light and Power at two pilot public charging stations have reduced monthly bills by between 65 percent and 88 percent.[43]
- In Hawaii, the Hawaiian Electric Companies' EV-F rate spares qualifying commercial charging facilities—with peak demand under 100 KW—any demand charge, applying only a time-of-use rate. The utilities' EV-U rate applies to a select group of DCFC charging stations, again imposing only a (higher) time-of-use rate.[44]
- In Washington D.C., the Potomac Electric Power Company has proposed to provide a fixed demand charge credit to non-residential customers with EV chargers based upon the nameplate capacity of the installed charging infrastructure. This proposal parallels that of BGE.[45]

3.3. Consideration of EV-Only Rates

Customers may prefer an EV-only TOU rate to a whole-house rate because it limits the risk of having a larger bill due to TOU rates' not aligning with their non-EV base load. It is also much easier for customers to monitor and control the timing of EV charging compared to other household energy usage, since EVs typically feature automated charging controls.

However, a key challenge to successful implementation of EV-only rates lies in the metering required. EV-only rates require a second revenue-grade meter or the use of submetering technology to record electricity use that is specifically attributable to EV charging.

Although a second meter makes it easy to apply TOU rates only to EV charging, the additional meter and installation charges involved can be formidable. The installation can cost thousands of dollars up front for customers, eliminating virtually all the fuel cost savings associated with the EV-only rate. Some utilities also assess an additional customer charge for the second meter. These high costs have contributed to very low customer enrollment in EV-only TOU rates that require a second meter.

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[41] Public Service Enterprise Group, "Utility 2.0 Long Range Plan, 2018 Annual Update," Docket No. 14-01299, June 29, 2018.

[42] Baltimore Gas and Electric, et al., "Proposal to Implement Statewide Electric Vehicle Portfolio," Docket No. PC44, January 19, 2018.

[43] Jeffrey R. Gaudiosi, Esq., "EV Pilot Filing Letter, Attachment 1," Docket No. 13-12-11, June 24, 2016.

[44] Hawaiian Electric Companies, "Electric Vehicle Pilot Rates Report," Docket No. 2016-0168, March 29, 2018.

[45] Potomac Electric Power Company, et al., "Proposal to Implement Statewide Electric Vehicle Portfolio," Docket No. PC44, January 19, 2018.

Submetering offers a lower-cost alternative to requiring a second meter for EV-only rates. Several different submetering technologies are available. These include:

- Stand-alone submeters such as the WattBox TM from eMotorWerks, with a cost of approximately $250. In some pilot programs, connectivity and data transfer issues have been a problem. In addition, installation typically requires an electrician and will incur an additional cost.
- Submeters integrated with the EV supply equipment (EVSE). At-home EVSE is generally Level 2 charging with costs typically between $500 to $900. The installation of these EVSE requires an electrician at additional cost. EVSE-integrated submeters have been used by some municipal utilities, are being piloted at a large scale in California, and will soon be piloted in Minnesota.
- Mobile (in-car) submeters such as the FleetCarma C2 device. This device is "plug-and-play," allowing the EV owner to simply plug it into a port under the dash of the vehicle. The device then collects vehicle charging and driving data and sends the data securely to FleetCarma servers over the cellular network. However, the annual costs to the utility associated with the use of this device at present appear quite high.
- On-board metering (integrated into the vehicle itself) may be an option for off-peak charging rebate programs and could potentially be extended to other rate structures in the future. A key barrier to extending on-board metering to other rate structures is the requirement for revenue grade metering and the implications for billing responsibility.

Each metering option has certain advantages and drawbacks. While a second utility meter is a straightforward option, the costs of installation can be prohibitively high, and customer charges associated with a second meter can deter customers. Submetering is promising, particularly if installation costs can be reduced further and data transfer issues can be fully resolved.

4. MAXIMIZING CUSTOMER ENROLLMENT

To achieve the benefits promised by time-varying rates, customer enrollment levels must be maximized. Simply designing a rate well is not sufficient for ensuring its success. Due to customer inertia, low levels of customer enrollment are common when customers are required to actively opt in to new rates.

Electric utilities can achieve high levels of customer enrollment through defaulting customers onto a rate (through an opt-out design).[46] Where defaulting customers onto a time-varying rate is not feasible or advisable, utilities must actively encourage enrollment through a combination of education, outreach, and incentives. In addition, it is important to ensure that utility incentives, auto dealership incentives, and customer incentives are all aligned.

4.1. Utility Activities to Maximize Customer Enrollment

Activities to maximize EV customer enrollment in EV rates may include:

- **Website Tools:** Rate comparison calculators, such as Southern California Edison's Electric Vehicle Rate Assistant Tool, provide an easy way for customers to compare their potential cost savings over several different rate options.
- **Dealership Education and Incentives:** Auto sales representatives often have little to no understanding of the rates available to EV drivers, or the potential savings these could provide to customers. In California, a collaboration of organizations developed and conducts a dealership training curriculum, and a $250 dealership incentive is provided for each EV purchase in which the customer also signs up for an EV rate.
- **Direct Outreach to EV Customers:** It can be difficult for a utility to identify which of its customers have purchased an EV. To identify customers, utilities may be able to work with state agencies to access Department of Motor Vehicle registration records and directly contact EV drivers. Some utilities also offer gift cards or other rewards to customers. For example, Salt River Project in Arizona provides EV customers with a $50 gift card simply for signing up for the utility's EV mailing list. Establishing these points of contact can be an important first step to educating and enrolling customers in an EV rate.
- **Price Guarantees:** Price guarantees may be offered for the first six months or year after a customer signs up for a new rate. These guarantees ensure that the customer will not pay more on the time-varying rate than they would on a standard rate, thereby reducing the customer's risk of signing up for a rate structure that is new to them.

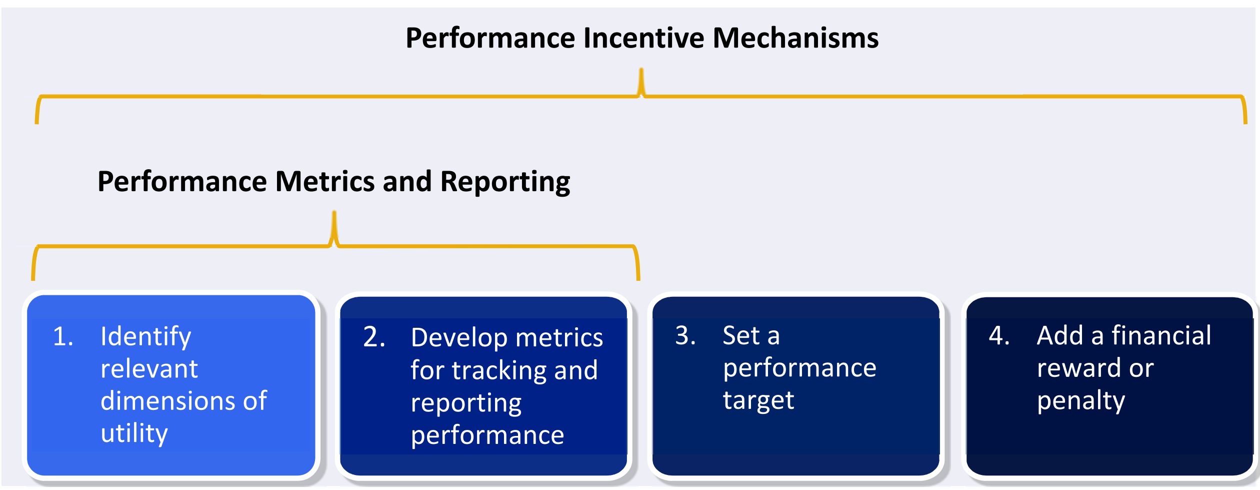
[46] California Public Utilities Commission, Order Instituting Rulemaking on the Commission's Own Motion to Conduct a Comprehensive Examination of Investor Owned Electric Utilities' Residential Rate Structures, the Transition to Time Varying and Dynamic Rates, and Other Statutory Obligations, Docket No. R1206013

4.2. Performance Incentive Mechanisms for Electric Utilities

Under traditional cost of service regulation, utilities have an incentive to make capital investments to the extent that a utility's rate of return exceeds its cost of acquiring capital.[47] If EVs charge during peak hours, the need for new investments will be increased. For example, with higher peak demands, distribution and transmission system capacity may need to be expanded. These investments could be avoided by using time-varying rates to shift customer charging, but utilities may have little incentive to do so, since they earn a return on capital investments.

Performance incentive mechanisms (PIMs) can be used to offset the incentives embedded in traditional cost of service regulation that are not well-aligned with the public interest. Further, performance incentives provide a clear signal to utilities regarding both regulator and customer priorities. PIMs use metrics and targets to set expectations and provide financial rewards or penalties to a utility for achieving (or failing to achieve) a specific outcome related to a policy goal. This is shown in the figure below. We note that Pennsylvania's Act 58 of 2018 explicitly allows for performance-based rates that are set or adjusted based on a utility's performance.[48]

Figure 4. Performance incentive mechanisms vs. performance metrics



Source: Whited, M., Woolf, T., Utility Performance Incentive Mechanisms: A Handbook for Regulators (2015).

PIMs could be used in several ways in Pennsylvania. For example, PIMs could be developed that target EV customer enrollment in time-varying rates that encourage charging in a manner consistent with grid conditions. Such a PIM would incentivize the utility to take an active role in reaching out to customers and educating them about available rate designs.

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[47] This is known as the "Averch-Johnson effect."

[48] HB 1782, available at: https://openstates.org/pa/bills/2017-2018/HB1782/./

An alternative PIM could target improvements in capacity utilization by reducing peak demand while increasing off-peak electricity use for EV charging. This would indirectly incentivize utilities to encourage enrollment in time-varying rates for both EV customers and non-EV customers.

Regulators that seek to facilitate transportation electrification have also used PIMs to motivate utilities to implement programs that support EVs, including medium- and heavy-duty vehicles. Such incentives become even more important for decoupled utilities, since decoupling reduces the utility's incentive to increase electricity sales. Two states recently proposed EV-specific PIMs: Rhode Island and New York. The sections below provide detail on the design and level of these incentive mechanisms.

National Grid, Rhode Island EV PIMs

The settlement agreement in Rhode Island's recent rate case dockets proposed an innovative performance incentive structure for EVs. Several of National Grid's electric PIMs are designed to incentivize the utility to facilitate increases in penetration of consumer-, government- and commercially-owned EVs in the state. These electric transportation PIMs advance the state's important policy goals of developing electric transportation infrastructure, minimizing program costs, ensuring that the incentives provided under the electric transportation initiative will benefit a wide-range of customers (including low-income customers), and supporting the development of the EV industry. One PIM is focused on consumers and the other on the government and commercial sectors. The performance metric for both PIMs is incremental EV registrations as compared to a baseline for the utility's service territory.

<u>Consumer PIM</u>

The consumer EV PIM is designed to reward reductions in CO_2 emissions due to increases in EV adoption above a baseline.[49] For the consumer EV PIM, minimum, midpoint and maximum targets reflect a 30 percent, 55 percent, and 80 percent increase over the baseline, represented in CO_2-equivalent reductions. [50]

The incentives per incremental vehicle range from $402 in 2019 to $377 in 2021. The slight decline over the three years reflects anticipated market transformation over time. The table below summarizes the proposed incremental vehicle targets, potential incentives, and CO_2 reductions.[51, 52]

[49] The baseline is developed by applying an EV sales growth rate derived from the Energy Information Administration's Annual Energy Outlook 2018 projection of EV sales in New England to historical data on Rhode Island EV registrations. Minimum, midpoint, and maximum targets reflect a 30%, 55%, and 80% increase over the baseline. These targets are then converted to CO_2 equivalents.

[50] CO_2 targets are developed by multiplying the number of incremental vehicles by a weighted average battery electric vehicles (BEV)/plug-in hybrid electric vehicles (PHEV) annual CO_2 metric tons per vehicle factor. When the utility reports its results, it will need to apply annual CO_2 metric tons per vehicle factors of 2.32 for BEVs and 2.08 for PHEVs, based on the actual distribution of incremental vehicle purchases.

[51] Docket 4770 – Application of The Narragansett Electric Company d/b/a National Grid for Approval of a Change in Electric and Gas Base Distribution Rates and Docket 4780 – The Narragansett Electric Company d/b/a National Grid Proposed Power Sector Transformation Vision and Implementation Plan. Settlement Testimony. June 6, 2018.

[52] Docket 4770, Settlement Attachments. June 6, 2018. Attachment 29.

Table 2. Rhode Island's consumer EV performance incentive mechanism

	Incentive ($)			Target (Incremental Vehicles)		
	2019	2020	2021	2019	2020	2021
Minimum	$103,500	$137,250	$186,000	257	354	493
Midpoint	$189,750	$252,000	$341,250	471	649	904
Maximum	$276,000	$366,750	$496,500	686	944	1,315

Government and Commercial PIM

The utility's baseline for government and commercial electric vehicle sales in Rhode Island is based on an estimated growth rate for light-duty fleet registrations from 2014–2016. The utility's target is based on projected improvements of 20 percent, 40 percent, and 60 percent for the minimum, midpoint, and maximum, respectively, over the baseline.

The incentives per incremental vehicle range from $2,585 to $3,833, depending on both the target level and year. As with the structure for the consumer PIMs, the decline over the three years reflects anticipated market transformation over time. The proposed incremental vehicle targets, potential incentives, and CO_2 reductions are summarized in the table below.[53,54]

Table 3. Rhode Island's government and commercial EV performance incentive mechanism

	Incentive ($)			Target (Incremental Vehicles)		
	2019	2020	2021	2019	2020	2021
Minimum	$34,500	$45,750	$62,000	9	14	22
Midpoint	$63,250	$84,000	$113,750	19	29	44
Maximum	$92,000	$122,250	$165,500	28	43	65

Apartment Building and Disadvantaged Community EVSE Sites PIM

This PIM rewards the Company for activating electric vehicle supply equipment (EVSE) sites for apartment buildings and disadvantaged communities ahead of schedule.[55] The incentive is $23,500 for each site activated over the expected number of sites activated. The Company may earn a maximum of approximately $94,000 per year in 2019 and 2020.

[53] Docket 4770, Settlement Testimony. June 6, 2018.

[54] Docket 4770, Settlement Attachments. June 6, 2018. Attachment 29.

[55] Docket 4770, Settlement Testimony. June 6, 2018. Pages 74-75.

Table 4. Rhode Island's apartment building and disadvantaged community site EV performance incentive mechanism

	2019	2020	2021
Apartment Buildings	-	1	5
Disadvantaged Community Sites	-	1	5
Total	-	2	0
Earnings at Maximum	$94,019	$94,291	$0

These PIMs are part of a larger utility transportation electrification initiative that includes the following:

- An off-peak charging rebate of 6 cents from June through September and 4 cents in all other months for every kWh charged between 9 p.m. and 1 p.m.;
- Installation of additional Level 2 charging ports, to be used by government light-duty fleets, Income-Eligible communities, Multi-Family apartment buildings, and public transit;
- Installation of a limited number of DCFC charging ports that are available for public charging in underserved areas and one of which will be co-located with an energy storage unit;
- Implementation of a demand charge discount of 100 percent for DCFC charging for three years, to be phased out over Years 4, 5, and 6;
- Utility-provided advisory services to support electrification of customer fleets, including conducting long-term fleet electrification studies for approximately 12 fleet operators in Rhode Island; and
- Evaluation of each element of the electric transportation initiative on an annual basis and to share its learnings with stakeholders and industry participants.

While the PUC did not approve the CO_2 Electric Vehicle and Fleet Electrification PIMs for immediate implementation, the commission is collecting data to determine whether incentives should be implemented at a later date.[56]

National Grid Niagara Mohawk's EV PIMs

One of Niagara Mohawk's approved electric PIMs, referred to as an earnings adjustment mechanism (EAM), is for Environmentally Beneficial Electrification. The EAM is designed to incentivize the utility to facilitate increases in penetration of EVs and heat pumps. For EVs, the performance metric is incremental avoided lifetime metric tons of CO_2 due to increased EV registrations in the Company's service territory. Incremental registrations are determined by comparing to a peer group of other utilities' service territories and include battery EVs and plug-in hybrid EVs.

The minimum, midpoint, and maximum CO_2 reduction targets and associated incentives for 2018, 2019, and 2020 are shown in the table below.[57]

[56] Docket Nos. 4770/4780 – Rate Case Decision. Motions from Open Meeting on August 3, 2018.

[57] Case 17-E-0238 & 17-G-0239, Appendix 7, Pages 4 and 5.

Table 5. New York's EV earnings adjustment mechanism

EV EAMs		Incentive ($M)			Target (Incremental Avoided Lifetime Metric Tons CO2)		
		2018	2019	2020	2018	2019	2020
Beneficial Electrification	Minimum	$0.3	$0.5	$0.6	13,533	15,355	17,756
	Midpoint	$0.9	$1.1	$1.2	23,592	26,143	29,505
	Maximum	$1.7	$2.5	$2.7	41,546	45,861	52,044

Discussion of Utility Incentives

EV PIMs in Rhode Island and New York are focused on increasing EV adoption through metrics and incentives that drive incremental EV vehicle registrations. However, PIMs can be developed to achieve a wider array of objectives consistent with Pennsylvania policymakers' goals. Customer enrollment on TOU rates, if properly designed, can reduce costs to the grid by encouraging customers to charge off-peak and incentivizing customer adoption of EVs. We recommend that performance incentives be considered to encourage utilities to enroll customers on these rates. An alternative or additional PIM could be established that focuses on improving capacity utilization, such as reducing weather-normalized peak demand relative to a forecast baseline.

Prior to establishing PIMs, performance metrics (without financial incentives) can be established to monitor performance and determine whether there are areas that need improvement. For example, reporting on TOU enrollment and capacity utilization can provide performance transparency and a baseline from which to measure future performance improvements, with or without financial incentives. If areas where improvement is needed are identified, then it may be appropriate to address them through financial incentives.

5. Analysis of Current Pennsylvania EDC Rates

5.1. Overview of Current Pennsylvania EDC Rate Structures

Unlike many other states, Pennsylvania EDCs do not offer EV-specific rate structures. Further, none of the utilities in Pennsylvania currently offer delivery TOU rates. For energy supply, customers can choose to take service through a competitive supplier or through the EDCs' default service. As part of their default service rates, Penelec, Met-Ed, and West Penn offer energy supply TOU rates as an option for residential customers. The remaining EDCs, including PPL, Duquesne, and PECO, currently do not offer TOU rates as part of their default service, notwithstanding the Pennsylvania Commonwealth Court's 2015 decision that requires them to do so.[58] Instead, the only option for customers of these EDCs is to obtain TOU energy supply rates through other energy generation suppliers.

Although PPL, Duquesne, and PECO do not currently offer default service TOU rates, some of these EDCs previously offered or proposed energy supply TOU programs that are now discontinued.[59] For example, PPL offered a Commission-approved default service TOU program for supply rates in 2011 that was discontinued in 2014, following which PPL obtained approval from the Commission to offer a TOU option to customers that would be provided through retail market suppliers.[60] In October 2013, PECO offered a program called the Smart Time Pricing pilot program through a competitive supplier to gauge customer interest and barriers to TOU enrollment, although the pilot program is no longer offered to customers.[61] Despite this, none of the EDCs have historically offered TOU delivery rates to customers.

In Pennsylvania, the three EDCs that offer TOU rates as part of their default service are shown in Table 6. TOU rates for energy supply offered by West Penn, Met-Ed, and Penelec provide very similar peak to off-peak ratios and are not offered during the winter months. They therefore fail to provide any customer incentive for charging during off-peak hours within the winter months. This also reduces customers' annual fuel cost savings when compared to standard rates. Also, unlike the TOU rates offered in New York, there is no variation in the monthly service fee that is charged to customers who choose TOU rates over the standard rates.

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58 Dauphin County Industrial Development Authority v. Pa. PUC, 123 A.3d 1124 (Pa. Cmwlth. 2015).)

59 The rates cases of PECO and Duquesne were ongoing as of the date of this report's publication. However, it appears unlikely that either utility will include a delivery TOU rate in its final tariff.

60 Pennsylvania Public Utility Commission, Petition of PPL Electric Utilities Corporation for Approval of a New Pilot Time-of-Use Program, Sept 2014.

61 Nexant, PECO Smart Time Pricing Pilot Enrollment Report, June 2014, https://www.puc.state.pa.us/pcdocs/1294627.pdf.

Table 6. Utility on-peak vs off-peak supply rates by season

	On-Peak Rates ($/kWh)		Off-Peak Rates ($/kWh)		Peak:Off-Peak Ratio	
Utility	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**
Met-Ed	$0.08	$0.06	$0.05	$0.06	1.5	1.0
Penelec	$0.08	$0.06	$0.05	$0.06	1.6	1.0
West Penn	$0.09	$0.07	$0.05	$0.07	1.6	1.0

Note: PECO, PPL and Duquesne rates do not offer TOU options as part of default service to customers.

5.2. Methodology

For each of the major EDCs in Pennsylvania, we assessed the impact that the EDCs' rate designs can have on fuel cost savings for EV customers. We analyzed the EDCs' existing energy default supply TOU tariffs for those that offer TOU pricing, or the default supply flat rate tariffs for the EDCs that do not offer TOU rates.

Cost savings for EV customers are important for two reasons:

1) TOU rates incentivize EV customers to charge off-peak, which reduces costs for the grid. However, EV owners are only likely to switch to and remain on TOU rates if those rates provide noticeable potential for savings relative to their standard rates. Without such an opportunity for savings, there is little incentive for customers to transition to a new rate, or to remain on that rate.

2) Fuel cost savings are also one of the primary motivators of EV purchase decisions.[62] Providing greater fuel cost savings from charging an EV on a TOU rate relative to filling up a gasoline-powered vehicle incentivizes customers to purchase an EV. More importantly, it contributes to the achievement of electricity system benefits associated with greater EV adoption. It is important to re-emphasize that TOU rates, if designed properly, are rooted in cost-causation principles. Thus low off-peak rates provide both cost-savings to EV customers while also better reflecting actual system costs than flat rates.

To determine whether the EDCs' TOU rates would provide meaningful fuel cost savings, we estimated per-vehicle annual fuel cost savings of charging an EV under the EDCs' respective TOU rates relative to two internal combustion engine vehicles: a typical new gasoline-powered vehicle and operating a standard hybrid vehicle. For EDCs that do not have TOU rates (PECO, Penelec, and Duquesne) fuel cost savings on the standard flat rates accurately represent the savings these customers would experience compared with a gasoline-powered vehicle.

Our analysis sought to account for all the various rate design components faced by EV owners, including incremental customer charges, delivery charges, standard offer service supply charges, and various

[62] Singer, "The Barriers to Acceptance of Plug-in Electric Vehicles: 2017 Update."

miscellaneous volumetric charges.[63] For internal combustion engine gasoline costs, we used average monthly regional gasoline prices from 2017.[64] Monthly assumptions for average vehicle miles traveled were derived from research conducted by the AAA Foundation for Traffic Safety.[65]

Our analysis focused on average savings for an owner of a typical full BEV with a range of 100 miles, such as a Nissan Leaf or a BMW i3. Based on the U.S. Energy Information Administration's (EIA) Annual Energy Outlook 2018, we assumed that 100-mile BEVs achieve an average fuel efficiency of 93 miles per gallon of gasoline equivalent, or 2.8 miles per kWh.[66]

We evaluated savings under two charging profiles for customers on EV TOU rates: one in which all charging takes place during off-peak hours, and one consistent with the typical charging patterns of California EV customers facing TOU rates,[67] in which most—but not all—charging occurs during off-peak hours. The latter profile is more likely to be representative of actual customer charging behavior. Consideration of this more realistic charging behavior is important for ensuring that customers will have a reasonable opportunity to achieve fuel savings, even when they must occasionally charge during on-peak hours.[68] We discuss the results of our analysis in the following sections.

5.3. Results for Whole-House TOU EV Fuel Cost Savings Relative to Charging on a Standard Rate

The results of our analysis show that all customers with access to TOU rates would experience some fuel cost savings, but these savings are very low.[69] Customers of Met-Ed, Penelec, and West Penn experience savings of a little more than $10 per year if all charging occurred off-peak. Under the scenario in which most, but not all, charging occurs during the off-peak period, the fuel cost savings are even lower. An

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[63] These include Universal Service Charges, Energy Efficiency and Conservation charges, Smart Meter Charges, and other EDC specific riders/charges as applicable.

[64] U.S. Energy Information Administration (EIA). Monthly Regular Conventional Retail Gasoline Prices, Region PADD-1B. https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_nus_m.htm.

[65] AAA Foundation for Traffic Safety, American Driving Survey 2015-2016. https://aaafoundation.org/wp-content/uploads/2018/02/18-0019_AAAFTS-ADS-Research-Brief.pdf; AAA Foundation for Traffic Safety, American Driving Survey 2013-2014. https://newsroom.aaa.com/wp-content/uploads/2015/04/REPORT_American_Driving_Survey_Methodology_and_year_1_results_May_2013_to_May_2014.pdf. Based on this data, the average vehicle travels 11,381 miles per year.

[66] U.S. EIA. AEO 2018 Table 41. https://www.eia.gov/outlooks/aeo/supplement/excel/suptab_41.xlsx .We note that this assumption is likely conservative, as many new EVs have fuel economies of 3.3 miles per kWh.

[67] Based on typical charging patterns, approximately 75 percent of EV charging occurs between the hours of 10 pm–7 am.

[68] California Public Utilities Commission, D.11-07-029 Establishing Policies to Overcome Barriers to Electric Vehicle Deployment and Complying with Public Utilities Code Section 740.2, July 14, 2011, 15. This aspect of EV rate design was recognized by the California Public Utilities Commission, who wrote: "Although our goal is to maximize off-peak charging, we appreciate that, at times, Electric Vehicle owners will need to charge their vehicles during peak periods or may simply find it convenient to do so. To ensure broad consumer acceptance of Electric Vehicles, it is crucial to accommodate the Electric Vehicle owners' charging needs and preferences…"

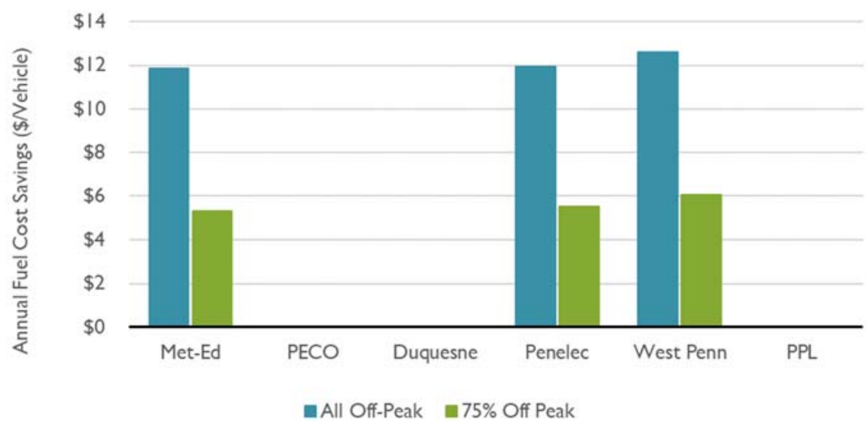
[69] Since the three utilities that offer TOU rates as part of default service offer very similar rates (with similar differentials between peak and off-peak rates), the magnitude of these savings is very similar across these utilities.

average EV customer of Met-Ed, Penelec, or West Penn would experience fuel cost savings of less than $10 per year from switching to TOU rates.

The benefits of such low savings from TOU rates are unlikely to outweigh the inconvenience associated with customers switching to TOU rates, and thus these rates are likely to see very little customer uptake. This result is problematic, as customers who do not switch to a TOU rate would have very little incentive to charge their vehicles during off-peak periods and could potentially lead to higher electricity costs for Pennsylvania ratepayers.

Figure 5 presents fuel cost savings by EDC and charging pattern. By definition, the EDCs that do not offer TOU rates provide no fuel cost savings relative to the standard rate. Therefore, the savings for PECO, PPL, and Duquesne are shown to be zero.

Figure 5. Whole-house TOU rate annual fuel cost savings relative to standard rate



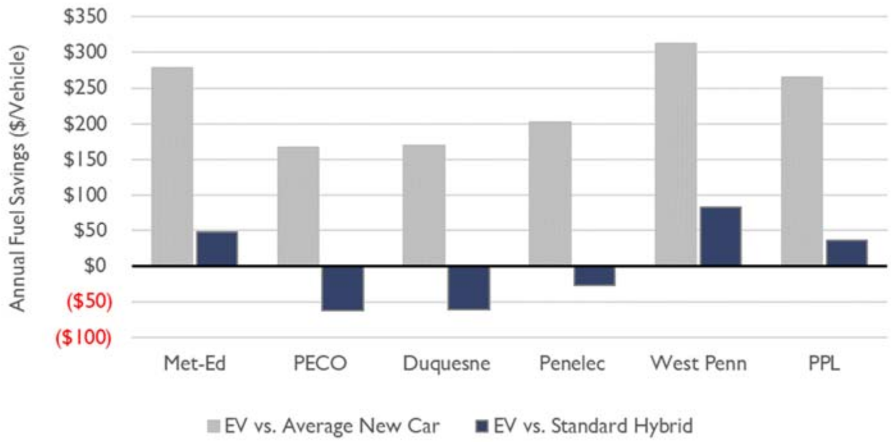
Note: The analysis was based on TOU Rates for Met-Ed, Penelec, and West Penn and Standard Flat Rates for PPL, Duquesne, and PECO.

5.4. Results for Whole-House TOU EV Fuel Cost Savings Relative to Two Types of Internal Combustion Engine Vehicles

We find that the fuel cost savings provided by EVs on the TOU rates relative to internal combustion vehicles vary greatly depending on the utility and the vehicle in question. Figure 6 presents our calculated fuel cost savings for each utility for a typical 100-mile BEV on a whole-house TOU rate relative to two alternative types of internal combustion vehicles: a typical new gasoline-powered car with an efficiency of 38 mpg, and a standard hybrid with an efficiency of 55 mpg.[70]

[70] U.S. EIA. AEO 2018 Table 41. https://www.eia.gov/outlooks/aeo/supplement/excel/suptab_41.xlsx. Standard hybrids do not draw electricity from an external source, and therefore must rely at least in part on gasoline during their standard operation. A Toyota Prius is one of the more common examples of a standard hybrid vehicle.

Figure 6. Annual fuel cost savings of 100-mile BEV relative to internal combustion vehicles



Note: The analysis was based on TOU Rates for Met-Ed, Penelec and West Penn and Standard Flat Rates for PPL, Duquesne and PECO.

In nearly all utility service territories, an EV operating under the TOU rate would generate positive fuel cost savings relative to a typical new gasoline-powered vehicle. The savings provided by a new EV relative to a typical new internal combustion vehicle range up to more than $300 per year for a West Penn customer. Most of the remaining EDCs have savings that range from $160–$250 per year.

However, when compared to a standard hybrid vehicle, such as a Toyota Prius, EV fuel savings largely disappear. At three of the six EDCs (PECO, Duquesne, and Penelec), an EV customer would likely have *higher* fuel costs relative to a hybrid vehicle. This comparison is important, because customers considering purchasing an EV are likely to compare these vehicles to highly efficient gasoline-fueled options, such as standard hybrids.

We observe small savings in annual fuel costs for customers of Met-Ed and PPL (both less than $50 a year) and savings of approximately $65 a year for customers of West Penn. We note that for cost-conscious vehicle purchasers, an EV's fuel cost savings would need to be sufficiently large to outweigh the current higher up-front costs of an EV. The fuel savings in Pennsylvania are not likely to cross that threshold under current rates.

6. Conclusions and Recommendations

Pennsylvania's EDCs have a unique opportunity to influence EV adoption and steer EV charging practices to benefit the grid and all Pennsylvanians. To attain these benefits, rates must be designed carefully and thoughtfully. Our evaluation of Pennsylvania EDC's existing rate structures reveals that there are many opportunities for improvement. We recommend that the EDCs update their residential rate designs and rates for DCFCs to unlock the full potential of EVs. Specifically, we offer the following nine recommendations:

1) Not all EDCs offer TOU rates as an option for default supply service. Customers who do not wish to shop for energy should still have the option to take service on a TOU rate. **Therefore, we recommend that all EDCs offer a TOU supply service option.**

2) None of the Pennsylvania EDCs offer time-varying delivery rates, even though peak demand on the transmission and distribution systems can drive the need for expensive infrastructure upgrades. By utilizing the smart meters that Pennsylvania has deployed, the EDCs could implement time-varying rates that improve EDCs' capacity utilization (the ratio of peak demand to average demand), encourage adoption of EVs and other distributed energy resources, and reduce costs for customers over the long run. **We recommend that the EDCs encourage EV customers to charge during hours in which the transmission and distribution system is not stressed by implementing simple TOU rates for delivery service.**

3) The TOU rates that are currently available to customers offer very little in the way of fuel cost savings to customers. In fact, in some cases these savings are negative relative to an efficient internal combustion engine vehicle. This lack of fuel cost savings provides no meaningful incentive for customers to enroll in a TOU rate or purchase an EV. **While the ultimate design of TOU rates is dependent on a utility's costs and peak periods, we recommend that EDCs with low price differentials between on-peak and off-peak rates increase the price ratio to motivate off-peak charging and enable greater fuel savings.**

4) The substantial variability in rate structures and pricing across Pennsylvania's six EDCs is a barrier to EV adoption. The lack of a more consistent utility approach to EVs across service territories promotes inconsistencies in manufacturer and dealer marketing efforts, which drives customer confusion. Some Pennsylvania EDCs have taken an important step in the right direction by offering a whole-house TOU rate that would enable EV drivers to save money on fuel costs, while encouraging beneficial charging behavior. **We recommend all Pennsylvania EDCs offer whole-house TOU rates.**

5) Public charging infrastructure is critical to EV adoption, but currently faces substantial business case barriers due to demand charges. **We recommend that an analysis of commercial and industrial rates be undertaken to determine whether modifications are warranted to support greater private investment in the development of the public charging services market—particularly for DCFC stations.**

6) No Pennsylvania EDCs currently offer an EV-only rate. We recommend that the EDCs explore adding an EV-only rate. **To encourage customers to enroll in EV-only rates, EDCs should also consider reducing or eliminating the customer charge for second meters and exploring submetering to lower the cost for EV-only rates**.

7) Simply establishing time-varying rates does not ensure their success. Rate design efforts must be complemented by utility efforts to education and incentivize customers to enroll in the rates. **We recommend that the EDCs develop plans to maximize customer enrollment in time-varying rates through education, outreach, and incentives.**

8) Performance incentive mechanisms may be warranted to motivate EDCs to actively promote efficient EV use of the grid. **We recommend that EDCs propose and the PUC approve performance metrics and PIMs to help ensure that the EDCs actively take**

steps to encourage adoption of EVs and charging patterns that improve system capacity utilization.

9) Ultimately, rate structures that are approved and implemented should pass a data-driven assessment of effectiveness. This should include confirmation that an EV customer who charges mostly off-peak achieves fuel savings relative to an EV customer who remains on a standard rate, as well as verification that a proposed rate provides sufficient fuel savings to encourage customers to adopt EVs over high-efficiency internal combustion engine vehicles. **We recommend that the EDCs start by reporting additional data to the Commission and stakeholders. We recommend that the EDCs file publicly available quarterly reports containing the following metrics and data (in spreadsheet format). Ideally, such reporting would occur frequently enough to make mid-course corrections, if necessary.**

a. Number of EV customers
b. Number of total customers on whole-home TOU rates and proportion of EV customers
c. Number of customers who opted to leave the TOU rate and proportion of EV customers
d. Aggregated customer load profiles, including the percentage of EV charging that occurred on-peak versus off-peak
e. Monthly average energy (kWh) and peak demand (kW) associated with EVs
f. Costs to integrate EVs into the grid, including the location of any distribution upgrades and the type of upgrade required
g. TOU rate education and outreach activities undertaken by EDCs, including relevant budgets
h. Lessons learned and modifications made; for example, if low enrollments prompted a utility to seek an alternate marketing approach, this should be discussed.