Electric Vehicle Rate Issues

prepared for
Kansas Corporation Commission

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ELECTRIC VEHICLE RATE ISSUES

1. INTRODUCTION

Electric vehicles (EVs) have considerably lower fuel costs per mile and emissions per mile than do conventionally gasoline-fired vehicles.[1] Virtually all of the major automobile manufacturers are now producing, or will soon produce, EVs.

The prospect of many millions of EVs reaching the road over the next two decades has the electric power industry considering the logistical issues that need to be addressed to accommodate the repetitive charging of EV batteries. Among these issues are questions concerning how utilities can best set rates that will recover the costs of producing and delivering electricity for EVs.

This paper provides a brief overview of the electricity ratemaking issues raised by EVs and methods by which U.S. utilities are presently setting EV rates.

2. KEY RATEMAKING ISSUES

This section describes many of the ratemaking issues that are raised by EV charging needs.

2.1. What are the goals of utility ratemaking?

As a general rule, retail electricity prices should be set as a compromise among several goals, including the following:

- full recovery of utilities' regulated costs;
- fair allocation of costs among customer classes;
- encouragement of efficient use of electricity;
- retail electricity price stability; and
- rate simplicity.

Conflicts among the foregoing goals are generally resolved by allocating regulated costs among customers according to measures of electricity consumption that are related to cost, providing larger customers with prices that vary by time of use according to some combination of time-varying marginal costs and time-varying market values, holding per-unit regulated cost recovery fairly steady over periods of a few years or longer, and charging similar customers similar prices in spite of differences in the costs of serving these customers.

[1] Depending upon fuel prices and electricity generation mixes, EVs promise to reduce fuel cost per mile by at least 75% and CO_2 emissions by at least 50%.

2.2. Do EVs warrant special rate treatment?

For any individual utility, the pricing of the electricity used by EVs should generally adhere to the same compromises as have been reached for other electricity uses. Nonetheless, special treatment of EV electricity usage may be warranted by differences in the costs of serving EVs relative to other electricity uses.

First, the time pattern of electricity consumption by EVs is likely to be different from that of most other electricity uses. Ideally, electricity prices for all types of electricity use would vary by hour in accordance with hourly variations in the marginal costs (or market prices) of electrical energy production and generation operating reserves. Because EVs' battery storage of electric power enables EVs to charge preponderantly at night when these marginal costs are relatively low, the ratemaking goals of fairness and encouragement of efficient off-peak consumption arguably support offering lower prices of service to EV customers than to most other electricity uses. This outcome can be achieved on a first-best basis through hourly pricing of EV electricity service, but it can also be achieved on a second-best basis through other forms of time-varying pricing.

Second, EV charging by many households or businesses in a particular neighborhood or other area may require upgrades in the distribution systems (and, less probably, in the transmission systems) that serve that area. For the purposes of fairness and discouragement of high local peak loads, prices of service to EV customers should arguably reflect these prospective or actual upgrade costs. Ideally, electricity prices for all types of electricity use would vary by area according to the expected impacts of load changes on local upgrade needs, thus discouraging increases in local peak loads and recovering upgrade costs from those customers most responsible for upgrade needs. In practice, however, the goal of rate simplicity has dominated the goals of fairness and efficiency when it comes to locational differentiation of distribution costs: we know of no utilities that vary distribution charges by areas according to distribution system limitations.

Third, EV offers externality benefits relative to other transportation fuels. In principle, it would be most efficient if the costs of air pollution, water pollution, and national defense, for example, were incorporated into fuel costs through mitigation requirements, taxes, and cap-and-trade schemes applicable to the relevant pollutants and fuels. Incorporation of these externalities into fuel costs would allow consumers to see, in relative fuel prices, the full benefits of EV relative to other transportation choices. In practice, however, the incorporation of these externalities into fuel costs – through SO_x and NO_x markets, for example – is only partial. For the purposes of environmental benefits and efficiency, it may therefore be reasonably argued that EV owners should be subsidized to the extent that the value of externalities is not incorporated into relative fuel prices. Such subsidies would accrue to EV owners in the forms of reduced electricity prices or payments for part of their charging equipment capital costs; and utilities would recover the costs of these subsidies through higher prices paid by all other electricity customers. Of course, placing values on externalities is difficult and often controversial; so legislatures and regulators almost always implement pro-environmental policies with arbitrary rules that are not supported by any explicit valuation of externalities.[2]

[2] Present Kansas Corporation Commission policy does not incorporate externalities into pricing.

2.3. What types of time-variant rates should be offered to EV owners?

There are two basic choices.

First, EV electricity rates could change hourly to reflect day-ahead marginal costs or market prices of electricity. This approach would give the most accurate price signal. Responding to this price signal would require some sort of "smart grid" computerized response mechanism. EV owners might not appreciate the price uncertainty inherent in this approach, however.

Second, EV electricity rates could change on a time-of-day and seasonal basis to reflect marginal costs or market prices of electricity as forecast before the beginning of each rate year. This time-of-use rate could be the same as applies to the customers' non-EV loads, or it could be specially tailored for EV loads. This approach gives EV owners some price certainty, but will preclude prices from accurately signaling when charging would be least costly for the power system.

2.4. Should EV rates vary by customer location?

This issue has two parts. The first part concerns how a utility should recover the costs of the distribution system upgrades that are attributable to electric vehicles: should upgrade costs be recovered separately from the users of each part of the distribution system, or should these costs be recovered from all of the utility's customers? The second part concerns how a utility can deal with the reliability problems that may be caused by EV-induced spikes in the local peak loads.

Cost recovery may be achieved through two different approaches: through charging customers the costs associated with their part of the distribution system; or through recovering costs from all of the utility's customers. Recovering costs from customers in each part of the distribution system has the advantages of: (a) allocating costs to the customers most directly responsible for those costs; and (b) inducing customers to change usage patterns in ways that minimize the need for upgrades. On the other hand, recovering upgrade costs from all of the utility's customers may be justified in three ways. First, the need for distribution upgrades is partly (and maybe largely) a matter of the happenstance of the design of the distribution system: a customer can hardly be faulted for being located in a part of the power system that just happens to be more in need of upgrades than another part of the power system. Furthermore, the stronger parts of distribution systems may tend to be those where poor customer load characteristics (e.g., high air conditioning loads) have required past upgrades; so locational EV rates could perversely reward present EV customers for their past costly behavior. Second, there is a widespread notion of "fairness" that holds that all customers of a particular class should be treated equally, regardless of their locations. Third, it is simpler – in terms of cost calculations and explanations to customers – to have all customers of a particular class pay the same price for upgrades.

Because upgrade costs are related to peak loads, it might make sense for EV rates to include demand charges as well as energy charges. Differences in the upgrade costs of different parts of the distribution system could then be reflected in differences in the demand charges that would be applicable to different parts of the distribution system.

Reliability problems associated with EV-induced spikes in local peak loads may be dealt with in two different but complementary ways. First, as just implied, demand charges can be used to induce individual customers to hold down their peak loads. Although customers will find it convenient to charge their EV batteries as quickly as possible, such as by taking EV charging service at 240 volts instead of the U.S. standard 120 volts, faster charging places greater stress on

distribution systems. Demand charges can induce slower charging. The second way of dealing with reliability problems would be to allow system operators some control of EV charging through a smart grid technology. Such control may be costless to customers, as it would occur at night while most customers are asleep; but could allow system operators to very precisely control total loads on each of the various parts of distribution systems.[3]

2.5. Should EV electricity rates be part of time-variant whole-house rates?

To answer this question, it is necessary to understand how time-of-use rates should depend upon the loads that are served under these rates. Specifically, for purposes of utility cost recovery and pricing efficiency, the price within each pricing period should equal a load-weighted average of the expected hourly marginal costs or market prices within each pricing period. The load weights depend upon the expected hourly pattern of the load being served: for a time-of-use rate applied to all loads, the weights would be based upon customers' total expected hourly loads; while for a time-of-use rate applied only to EV loads, the weights would be based upon customers' expected hourly EV loads. The different load weights would result, of course, in different time-of-use prices for an EV-only rate than for a whole-house rate.

If residential customers face hourly electricity rates, the question of whether EV electricity rates should be part of time-variant whole-house rates is moot: all loads subject to hourly pricing would be accurately priced, and it would not matter how the loads were aggregated. The question is relevant only when residential customers have electricity rates that change on a time-of-day or seasonal basis, or are flat (i.e., constant) for the whole year. For such non-hourly rates, the different hourly time-pattern of EV loads versus other household loads would result in different EV-only rates than whole-house rates.

Under a non-hourly rate structure, the advantage of separating EV electricity rates from rest-of-house rates is that utility cost recovery and price signals are more accurate than under the whole-house approach. In other words, the customers most responsible for causing power system costs would pay for those costs; and prices would better reflect the different costs of charging EVs and of serving other household needs. The advantage of whole-house electricity rates is simplicity: in each electricity pricing period, the customer would face a single price for all consumption; and there would be no need for separate metering of EV load.

2.6. How should EV rates evolve over time?

EV rates should evolve over time as the utility costs of serving EV customers change, as utility ratemaking methods change, and as EV ratemaking goals change. Utility costs of serving EV customers will change over time with changes in utilities' input costs (such as fuel costs) and with changes in power system technologies for generating and delivering power. Furthermore,

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[3] In a joint study, Better Place and PJM Interconnection found that, because time-of-use prices do not reflect real-time market conditions in general and locational marginal prices in particular, time-of-use pricing has little impact on the wholesale costs of serving EV load relative to conventional flat rates with no system operator control. The same study found that system operator control of EV loads through smart grid technologies can reduce the wholesale cost of serving EV load by substantial percentages relative to conventional flat rates with no system operator control. See Better Place, Inc. and PJM Interconnection, *An Assessment of the Price Impacts of Electric Vehicles on the PJM Market*, May 2011, particularly Tables I and III, p. 21.

the proliferation of EVs will itself affect power system marginal costs and market prices, with the resulting increase in relative off-peak usage likely reducing the efficient ratio of peak to off-peak EV rates.

Utility ratemaking methods will change over time as computer technologies (such as "smart grids") play a larger role in the communication and use of price, load, and other power system information. EV ratemaking goals will change over time as EV moves from its present novelty status and as public policy with respect to environmental issues (e.g., CO_2) evolves.

2.7. How should EV rates reflect the special needs of EV customers?

EVs need to charge batteries at times and locations that will make EVs a viable transportation option and will be convenient to consumers. The key difficulties are that present battery characteristics limit driving distances between charges and require at least a few hours to complete a charge. Charging will be relatively cheap and convenient when it occurs at night in consumers' homes. It will be relatively expensive and inconvenient when it occurs during the daytime when consumers have driven their EVs to work or to shopping areas, where power must be obtained from charging stations open to the public.

From a ratemaking perspective, the issues are whether special accommodations should be made for the long charging times of EVs and for differences between at-home charging and public station charging. As a matter of efficiency, electricity rates should reflect costs, and should not discriminate among electricity customers or electricity uses. As a matter of public policy, the development of EVs might be encouraged by EV rates that are discounted relative to costs and that consider the special charging needs of EVs.

There are at least two dangers with offering discounts for EV electricity uses. The first danger is that the discounts that are justified to develop the EV market might become permanent. Instead, any discounts justified by market development should fade away over time as the EV market matures or fails. The second danger is that the discounts may inadvertently discourage innovation in EV technologies. For example, rates that reflect utilities' true costs of offering EV service might encourage the development of faster-charging batteries, while rates that are discounted for many consecutive hours might make the development of faster-charging batteries less profitable for battery manufacturers.

2.8. How should EV rates reflect the value of using off-peak wind?

EV charging has been touted as a means of mitigating the two adverse characteristics of wind power, namely its relatively high off-peak availability and its intermittency.[4] EVs can mitigate these adverse characteristics in two distinct ways: by timing charging to use off-peak wind energy; and by integrating into "smart grids" in ways that allow EV charging to automatically ramp up and down as wind power output ramps up and down.

[4] "Intermittency" refers to the fact that wind power output suddenly and unexpectedly changes with sudden and unexpected changes in wind conditions.

The value of off-peak EV charging depends upon the value of off-peak electrical *energy service*. The value of EVs ramping up and down depends upon the value of electrical *regulation service*. Thus, EV electricity rates should thus reflect both energy service and regulation service values.

With respect to energy service, the availability of wind power generally has the effect of reducing the power system's off-peak marginal costs and market prices of electricity.[5] If EV electricity prices reflect these marginal costs and market prices, then the value of using off-peak wind will be fully captured in off-peak EV electricity prices, and these prices would be sufficient to induce efficient levels of off-peak EV charging. Consequently, if off-peak EV electricity prices reasonably reflect the off-peak marginal costs and market prices of electrical energy, no further consideration need be given to the value of using off-peak wind.

With respect to regulation service, wind power's intermittency has the effect of increasing the value of this service. In principle, any resources that provide this service, including EVs, should be compensated for doing so. The compensation should reflect the marginal costs and (where available) the market prices of this service. In principle, in exchange for accepting the computerized "smart" controls that would be required to have EV charging respond to wind power's intermittency, EV customers should receive a discount that reflects the value of the regulation service that they thus provide.

In summary, EV rates should reflect the value of off-peak wind just as they should reflect the value of all other generation. Specifically, EV rates should reflect the system marginal costs of each of the services that are used by or provided by EV, where system marginal costs reflect the power system's whole portfolio of generation and transmission assets.

2.9. What types of EV rates should apply to non-residential customers?

Non-residential customers include general service (commercial and industrial) customers and various customers who might offer public or private EV charging services.

The same pricing principles that apply to residential customers also apply to non-residential customers. For purposes of utility cost recovery and pricing efficiency, however, the higher per-customer loads of non-residential customers tilt the choice of approach in favor of hourly day-ahead pricing (and away from non-hourly pricing) of non-residential EV loads. In the event that hourly pricing of non-residential EV loads is not permissible, then these same purposes of cost recovery and efficiency favor separate pricing and metering of EV loads.

If the EV rates applicable to public EV charging services differ from those available to private residential and non-residential customers, some arbitrage will occur among charging resources. In other words, customers will tend to charge their EVs at whatever charging location offers the lowest price. This may or may not adversely affect customer behavior in terms of the time patterns and locations of charging, and may or may not adversely affect power system operations.

[5] Because of the abundance of coal-fired generation in Kansas, this is less generally true in Kansas at the present time than it may be in the future.

2.10. Should utilities build, own, and operate public charging infrastructure?

Utilities certainly need to build, own, and operate the distribution systems that support the public charging infrastructure. If the distribution system costs incurred to provide such support is significant, these costs should be borne by the beneficiaries of these systems. This implies that either: (a) EV rates should vary by location, as previously discussed in Section 2.4; or (b) there need to be special tariffs for public charging stations that would allow utilities to recover the costs of their distribution system support.

Whether utilities need to build, own, and operate the public charging stations themselves is a very different issue. Such a need could arise only if there are some "economies of scope" that would give utilities greater expertise or lower costs in running public charging stations than could be expected of unaffiliated enterprises running such stations. We are not aware of any reason that such economies of scope might exist. On the contrary, it seems that the expertise needed to run public charging stations is quite different than that needed to run a power system, and that allowing public charging stations to be run by non-utility enterprises would encourage competition that would provide customers with consumer-responsive charging services at least cost.

2.11. Who should pay for EV charging stations?

The beneficiary pays principle implies that charging station costs should be paid by the customers who benefit from the charging station, who are the customers who use the charging station. EV charging does not pose any free-rider problems: in all cases, there will be no doubt about the identities of the EV customers who use particular facilities, nor about the time of their use, nor about the kWh and kW amounts of their use.

In the simple case of EV charging in homes or private commercial enterprises, the costs of charging facilities should be fully borne by the owners of these homes or commercial enterprises. If multiple EV owners make use of these charging facilities, the owners of these homes or commercial enterprises can make their own determination of how to allocate fixed costs among the EV owners. Likewise, non-utility owners of public charging stations can make their own determinations of how to recover fixed costs from their customers.

Complications arise if a public charging station is built, owned, and operated by a utility. In such a case, fixed charging station costs should be allocated among the customers who use the station; but if the utility is guaranteed cost recovery, there is the issue of recovering or refunding any under- or over-collections. A simple cost allocation would recover fixed costs through a per-kWh charge set annually according to expected sales; and the next year's fixed cost revenue requirement would be adjusted to reflect any under- or over-collections of the current year.

3. OVERVIEW OF CURRENT UTILITY EV RATEMAKING PRACTICE[6]

We have identified eleven utilities in five states that have tariff schedules that are specifically designed for electric vehicle charging.[7] Table 1 lists these utilities and their tariffs. Most of these tariffs apply to residential customers only. The few tariffs that apply to non-residential general service (GS) customers usually limit their applicability to customers with peak demands of 500 kW or less. While most of the tariffs are permanent, nearly half are experimental. The Exp column indicates, with a "yes" or a number, which tariffs are experimental: where the tariff specifies a maximum number of customers who may participate in the experimental rate, the number in the Exp column indicates that maximum.

In addition to the utilities identified in the table, we have found two utilities – Portland General Electric in Oregon and Progress Energy in Florida, North Carolina, and South Carolina – who specifically say that their customers take EV charging service through their standard non-EV rates, and that EV customers have the option of requesting the time-of-use rate applicable to their customer class. In addition, some utilities, like Consumers Energy in Michigan, offer EV rates but nonetheless allow customers to take EV charging service through their standard non-EV rates.

3.1. Are EVs separately metered from other electricity uses?

Most of the EV tariffs shown in Table 1 require that electric vehicles be metered separately from all other loads. Among the non-experimental tariffs, single metering (i.e., a single meter on the whole residential load, including EV load) is required by the Sacramento Municipal Utility District's two tariffs, San Diego Gas & Electric's EV-TOU-2 tariff, Southern California Edison's TOU-D-TEV tariff, and Georgia Power's tariff. Two utilities seem to be using their experimental tariffs to examine how customer behavior varies according to whether there is separate metering or single metering. Pacific Gas and Electric's Schedule E-9A allows either separate metering or single metering, while its nearly identical Schedule E-9B requires separate metering. Similarly, Consumers Energy's Option REV-1 tariff requires single metering while its nearly identical Option REV-2 requires separate metering.

3.2. Do EV tariffs have minimum terms for participation?

Over half of the tariffs in Table 1 require that customers remain on the rate for a minimum term, usually for one year. San Diego Gas & Electric's EPEV tariffs have a two-year minimum, while Alabama Power is at the extreme edge with a five-year minimum.

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[6] The information in this section was gathered in October 2011.

[7] We do not claim that these are the only EV tariffs that are presently being offered in the U.S.

Table 1
Electric Vehicle Utility Tariffs

State	Utility	Schedule	Class	Exp
Alabama	Alabama Power	BEVT	GS	
California	Pacific Gas and Electric	E-9A E-9B	Res Res	yes yes
	Sacramento Municipal Utility District	GS-TOU2 RTEV	GS Res	
	San Diego Gas & Electric	EPEV-X EPEV-Y EPEV-Z EV-TOU EV-TOU-2	Res Res Res Res Res	1,000 1,000 1,000
	Southern California Edison	TOU-D-TEV TOU-EV-1 TOU-EV-3	Res Res GS	
Georgia	Georgia Power	TOU-PEV-1	Res	
Michigan	Consumers Energy	REV-1 REV-2 REV-3	Res Res Res	yes yes 250
	Detroit Edison	D1.7 D1.7 D1.9-1 D1.9-2	Res GS Res Res	 2,500 yes
	Indiana Michigan Power	RS-OPES/PEV	Res	yes
Nevada	Nevada Power	GSHEVRR–TOU RHEVRR–TOU	GS Res	
	Sierra Pacific Power	OD-RHEVRR–TOU OGS-HEVRR	Res GS	

3.3. Do EV tariffs have prices that vary by time of day?

Nearly all of the EV tariffs have prices that vary by time of day, and some have prices that vary by season as well. The two exceptions to time-of-day pricing are both in Michigan and are both experimental rates that the utilities can use to estimate customer response to different EV rate designs.

Consumers Energy's Option REV-3 charges $35 per month for the first 300 kWh of separately metered EV service, regardless of time of use; and charges a flat rate for all subsequent usage that varies by summer versus non-summer season but does not vary by time of day. The utility can compare the behavior of customers on Option REV-3 to that of customers on Option REV-2, which has time-of-day pricing but is otherwise similar to REV-3.

Detroit Edison's Schedule D1.9-2 has a $40 per month flat charge on separately metered EV service, regardless of the quantity or timing of use. The utility can compare the behavior of customers on this rate to that of customers on Schedule D1.9-1, which has time-of-day pricing that depends upon quantities consumed, but is otherwise similar to D1.9-2.

3.4. What are the time periods for EV tariffs?

Table 2 describes the seasonal and peak and off-peak periods of the EV tariffs. The "Summer Months" column shows that most of the EV tariffs have two seasons, with summer being distinct from the rest of the year. Just a few EV tariffs (marked by "NA" for "not applicable") have no seasonal variation in their rates.

To encourage EVs to use electricity when marginal costs of power supply are relative low, nearly all utilities' EV rates offer low electricity prices during "off-peak" periods. Table 2 shows that off-peak hours usually comprise nights and early mornings. About a quarter of the EV tariffs count all weekend hours as off-peak, and about a quarter of these tariffs count all holiday hours as off-peak.[8] Pacific Gas and Electric has the distinction of having the only EV rates that have different non-peak hours on weekends than on weekdays.

A few rates have unusual characteristics. San Diego Gas and Electric, Southern California Edison, and Georgia Power have both off-peak and "super off-peak" periods, the latter of which are intended to strongly encourage customers to charge their cars between the late night and early morning hours.[9] Consumers Energy Schedule REV-3 has prices that are differentiated by season but not by time of day. Detroit Edison's Schedule D1.9-2 is excluded from the table because it has a flat monthly charge with no time variation.

Most utilities do not differ between the Summer and Winter seasons in their definitions of the off-peak periods for EV charging. The only exceptions are Alabama Power's Rate BEVT, which has a shorter off-peak charging time for Winter as compared to Summer, and Sacramento Municipal Utility District's Schedule RETV, which defines the weekday off-peak period as 8 pm to 2 pm in Summer and as 10 am to 5 pm and 8 pm to 7 am during the non-Summer months.

[8] Different utilities have different definitions of holidays.

[9] For these utilities, Table 2 shows only the super off-peak periods, and Table 3 shows super off-peak prices.

Table 2
Time Periods of the Electric Vehicle Tariffs[10]

State	Utility	Schedule	Summer Months	Off-Peak Hours			
				Summer	Winter	Week-ends	Holi-days
Alabama	Alabama Power	BEVT	June-Sept	9p-10a	9p-7a	all	all
California	Pacific G&E	E-9A	May-Oct	12a-7a	12a-7a	9p-5p	
		E-9B	May-Oct	12a-7a	12a-7a	9p-5p	
	Sacramento M.U.D.	GS-TOU2	June-Sept	10p-noon	10p-noon	all	all
		RTEV	May-Oct	8p-2p	8p-7a[11]	all	all
	San Diego G&E	EPEV-X	May-Oct	12a-5a	12a-5a		
		EPEV-Y	May-Oct	12a-5a	12a-5a		
		EPEV-Z	May-Oct	12a-5a	12a-5a		
		EV-TOU	May-Oct	12a-5a	12a-5a		
		EV-TOU-2	May-Oct	12a-5a	12a-5a		
	Southern Cal. Edison	TOU-D-TEV	June-Sept	12a-6a	12a-6a		all
		TOU-EV-1	May-Oct	9p-noon	9p-noon		
		TOU-EV-3	June-Sept	9p-noon	9p-noon		
Georgia	Georgia Power	TOU-PEV-1	NA	11p-7a	11p-7a		all
Michigan	Consumers Energy	REV-1	June-Sept	11p-7a	11p-7a		
		REV-2	June-Sept	11p-7a	11p-7a		
		REV-3	June-Sept	NA	NA	NA	NA
	Detroit Edison	D1.7	June-Sept	7p-10a	7p-10a	all	
		D1.9-1	NA	11p-9a	11p-9a	all	
	Indiana Michigan	RS-OPES/PEV	NA	9p-7a	9p-7a	all	
Nevada	Nevada Power	GSHEVRR–TOU	June-Sept	10p-6a	10p-6a		
		RHEVRR–TOU (A)	June-Sept	10p-6a	10p-6a		
		RHEVRR–TOU (B)	July-Aug	10p-6a	10p-6a		
	Sierra Pacific Power	OD-RHEVRR–TOU	July-Sept	10p-6a	10p-6a		
		OGS-HEVRR	July-Sept	10p-6a	10p-6a		

3.5. What are the peak-to-off-peak price ratios for EV tariffs?

Table 3 shows peak and off-peak prices and peak to off-peak price ratios for various EV rates in each of the two seasons, Summer and Winter. For every utility, data are those for the highest peak price and the lowest off-peak price applicable to EVs, including all applicable energy rate components (i.e., generation, delivery, and other charges, as applicable). Consistent with the general U.S. pattern of marginal energy costs and energy prices being higher in Summer than Winter, the simple average peak to off-peak price ratio for the EV tariffs shown in the table is 3.58 in Summer and 2.69 in Winter.

[10] This table excludes Detroit Edison's Schedule D1.9-2, which does not vary over time.

[11] Off-peak hours also include 10 am – 5 pm.

Table 3
Peak and Off-Peak Rate of the Electric Vehicle Tariffs (cents/kWh)[12,13]

State	Utility	Schedule	Summer			Winter		
			Peak	Off-Pk	Ratio	Peak	Off-Pk	Ratio
Alabama	Alabama Power	BEVT	17.82	4.52	3.94	7.31	4.52	1.62
California	Pacific G&E	E-9A	49.38	16.20	3.05	30.04	16.20	1.85
	Pacific G&E	E-9B	48.95	24.91	1.97	29.65	25.73	1.15
	Sacramento M.U.D.	GS-TOU2	16.60	8.80	1.89	8.69	6.89	1.26
	Sacramento M.U.D.	RTEV	24.01	8.40	2.86	10.80	7.54	1.43
	San Diego G&E	EPEV-X	27.08	13.89	1.95	17.79	14.35	1.24
	San Diego G&E	EPEV-Y	29.34	7.66	3.83	25.06	8.27	3.03
	San Diego G&E	EPEV-Z	38.46	6.74	5.71	34.23	7.09	4.83
	Southern Cal. Edison	TOU-D-TEV	61.76	19.38	3.19	30.18	19.59	1.54
	Southern Cal. Edison	TOU-EV-1	32.95	15.99	2.06	25.52	15.92	1.60
	Southern Cal. Edison	TOU-EV-3	34.16	14.69	2.33	19.97	14.16	1.41
Georgia	Georgia Power	TOU-PEV-1	19.29	1.25	15.44	19.29	1.25	15.44
Michigan	Consumers Energy	REV-1	18.57	5.39	3.45	10.54	5.39	1.96
	Consumers Energy	REV-2	18.57	5.39	3.45	10.54	5.39	1.96
	Detroit Edison	D1.7 (res)	12.36	5.66	2.18	6.94	5.71	1.21
	Detroit Edison	D1.7 (comm)	6.66	5.60	1.19	5.60	5.60	1.00
	Detroit Edison	D1.9-1	18.20	7.70	2.36	18.20	7.70	2.36
	Indiana Michigan	RS-OPES/PEV	14.13	3.92	3.61	14.13	3.918	3.61

Reflecting their generally high costs, the California investor-owned utilities have the highest EV rates, particularly in the peak periods but also in the off-peak periods. Georgia Power's off-peak EV rate is an extraordinarily low 1.25 cents per kWh, with the consequence that Georgia Power's peak to off-peak price ratio is an outlier at 15.44. Excluding this outlier, the price ratios generally range between 1 and 5, with simple average values of 2.88 and 1.95 in the Summer and Winter seasons, respectively. In other words, excluding Georgia Power, off-peak EV prices tend to be about a third of on-peak prices in Summer and about half of on-peak prices in Winter.

Comparing across the two seasons for each schedule, we observe that Summer price ratios are higher than those in Winter, with Alabama Power's Summer price ratio being almost two-and-a-half times its Winter price ratio. With off-peak being nearly the same in both seasons, the difference in seasonal price ratios is entirely due to Summer on-peak prices being about 50% higher than Winter on-peak prices.

[12] The rate schedules for Pacific Gas & Electric (E-9A and E-9B) and Schedule TOU-D-TEV for Southern California Edison are Inclining Block Rates that rise as the customer's usage increases relative to "Baseline usage." For PG&E, the price data are applicable to electricity usage that is 131%-200% of the Baseline, while for SCE, the price data are applicable to electricity usage that is more than 130% of the Baseline.

[13] This table excludes San Diego Gas & Electric's Schedules EV-TOU and EV-TOU-2 because they are delivery-only rates. It excludes the Nevada rates because of ambiguities in certain peak prices.

3.6. Do EV tariffs have prices that vary by amount of electricity consumption?

Few EV tariffs have prices that vary according to the quantity of electricity consumed. The exceptions are Pacific Gas and Electric's Schedule E-9 options and Southern California Edison's Schedule TOU-D-TEV, all of which have "tiered rates" by which prices increase sharply as electricity consumption increases; and Consumers Energy's Option REV-3, which has a fixed charge on the first 300 kWh per month of service and then a flat per-kWh charge thereafter.

The foregoing exceptions are likely to disappear in the near future. The Pacific Gas and Electric and Consumers Energy exceptions are temporary experimental rates. Pacific Gas and Electric and Southern California Edison have tiered EV rates because they have tiered standard residential tariffs: the California Public Utilities Commission has indicated that it wants the tiers eliminated from the EV rates.[14]

3.7. Do EV tariffs have demand charges?

None of the EV tariffs we have examined include demand charges. All of the EV tariffs include energy charges, and some have monthly customer charges.

3.8. Can EV customers buy unbundled electricity services?

Some utilities allow EV customers to buy utility transmission and distribution service while buying the actual energy from third-party generation sources. These utilities are located in states that have unbundled delivery service from generation service for customers in general. Thus, unbundled delivery service is available from the regulated California utilities (Pacific Gas and Electric, San Diego Gas & Electric, Southern California Edison) and some Michigan utilities (Detroit Edison, Indiana Michigan Power). Unbundled delivery service is not available from the other utilities shown in Table 1.

3.9. Do utilities subsidize EV service?

The Michigan utilities – Consumers Energy, Detroit Edison, and Indiana Michigan Power – all offer up to $2,500 subsidies for the installation of the equipment needed to charge an electric vehicle in a home.

4. OBSERVATIONS ABOUT KANSAS

4.1. What initiatives has Kansas undertaken to prepare itself for EVs?

The Mid-America Regional Council and the Kansas City Regional Clean Cities Coalition have convened consumers, businesses, and local governments for the purpose of preparing the Greater Kansas City area for early adoption of EVs. The effort has resulted in the creatiofn of

[14] California Public Utilities Commission, Decision 11-07-029, July 14, 2011, pp. 20-22.

stakeholder groups that are addressing key aspects of plug-in EV preparedness and that have created the Greater Kansas City Plug-In Readiness Strategy.[15] Its objectives include:

- Creating an organized EV charging infrastructure in the metro area that includes charging stations at home, at the workplace, in public places, and at fleet facilities;
- Identifying best practices for governmental policies to encourage adoption of EVs and to simplify deployment of infrastructure;
- Developing pricing options;
- Developing incentives for consumer purchase of EVs; and
- Educating the public about EVs.

Through the Metropolitan Energy Information Center, Kansas City has received a grant of $441,178 from the U.S. Department of Energy's program for Clean Cities' Community Readiness and Planning for Plug-In Electric Vehicles and Charging Infrastructures Selection. The purpose of this grant is to "develop phased EV infrastructure installation plans for the Kansas City metropolitan area and for smaller communities, including the travel corridors between them. It will develop and implement replicable actions for adoption by individual municipalities in the areas of planning, zoning, construction, permitting, and fleet policies."[16]

Kansas had 6,179 retail hybrid registrations during the years 2007-2009. For the years 2012-2015, Kansas has 3,471 of forecast EV sales.[17] By contrast, in the year 2009, Kansas had 2,415,000 of total motor vehicle registrations, of which 875,000 were automobile registrations (including taxis).[18] The inference is that, for the next few years, at least, EV will constitute a very small piece of the Kansas motor vehicle market.

4.2. How might Kansas' EV rates depend upon the Southwest Power Pool?

Because all of Kansas' major utilities are members of the Southwest Power Pool (SPP), developments in SPP determine a substantial portion of the costs of serving EV loads in Kansas. In general, rates for EV loads should exceed the SPP market prices for energy; and as a matter of economic efficiency, the ratio of peak to off-peak retail prices should mimic the ratio of peak to off-peak SPP energy prices.

To provide a sense of the cost basis for setting EV rates that vary by time of day or year, we analyzed SPP energy market prices for a node near Topeka during a recent 36-month period. Based upon SPP's prices, we identified the seasonal and time-of-day groupings that minimized the variance of prices within periods. It turned out that the Kansas Summer season would be

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[15] Mid-America Regional Council and the Kansas City Regional Clean Cities Coalition, *Greater Kansas City Plug-In Readiness Strategy*, February 16, 2011, available at http://www.marc.org/pluginreadiness.htm.

[16] http://energy.gov/articles/awards-advanced-vehicle-development, posted September 8, 2011.

[17] Center For Automotive Research, *Deployment Rollout Estimate Of Electric Vehicles, 2011-2015*, Tables 6 and 7, January 2011, available at http://www.cargroup.org/?module=Publications.

[18] U.S. Census Bureau, *State Motor Vehicle Registrations, 1990 to 2009*, Table 1098, available at http://www.census.gov/compendia/statab/2012/tables/12s1098.pdf.

April through September, off-peak hours would be 11 pm to 6 am, and weekends and holidays would have the same off-peak hours as weekdays. These time periods are similar to those of the EV tariffs listed in Table 2, though the Summer season is a bit unusual in beginning somewhat early in the year.

Table 4 shows the simple average SPP energy prices for the optimal pricing periods that we identified. These prices are significantly lower than the EV prices shown in Table 3, which is not surprising because the latter include transmission, distribution, and other charges besides the generation energy production costs that are the focus of Table 4. Nonetheless, the peak to off-peak price ratios for SPP shown in Table 4 are within the range of those for the EV rates shown in Table 3. What is surprising is that there has been no systematic seasonal variation in SPP's average peak period prices during these last 36 months, and that off-peak prices have tended to be higher in Winter than in Summer.

Table 4
Average SPP Energy Prices Near Topeka, by Season and Period, September 2008-August 2011 (cents/kWh)

Season	Peak 6 am - 11 pm	Off-Peak 11 pm - 6 am	Ratio
Summer (April-Sept)	3.29	1.76	1.87
Winter (Oct-March)	3.33	2.29	1.45

Future SPP energy prices will certainly differ from past prices. Differences will occur because of economic recovery (relative to the depressed period covered by Table 4), because SPP is inaugurating a significantly new "Day Two" market design, and because the large volumes of wind power prospectively entering the SPP grid will put downward pressure on electrical energy prices, particularly in off-peak periods.

4.3. In what general directions might Kansas' EV rates effectively evolve?

Given the general patterns of the presently offered EV tariffs, it seems that these tariffs can effectively evolve in the following directions:

- Either electric vehicles will be separately metered or the whole facilities (e.g., households) of which EV charging is a part will be subject to time-of-use pricing that reflects the time-varying utility costs of offering electricity services.
- EV tariffs will vary by time of day because utility costs vary by time of day.
- Rate tiers will not become a standard characteristic of EV tariffs unless there is some good cost reason (e.g., necessity of upgrading distribution equipment) for doing so.
- Unbundled delivery charges for EV charging service will only be available in those jurisdictions that have unbundled delivery charges for other services.
- Subsidies will be uncommon, particularly as EVs lose their novelty.

As a general matter, we would recommend that Kansas offer EV tariff rates that are differentiated by time of day (and perhaps by time of year) in rough correspondence with forecast time variations in SPP energy prices.