Smart Electric Power Alliance

Utilities and Electric Vehicles

THE CASE FOR MANAGED CHARGING

APRIL 2017

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ABOUT SEPA

SEPA facilitates collaboration across the electric power industry to enable the smart deployment and integration of clean energy resources. Our focus centers on solar, storage, demand response, electric vehicles, grid management, and other enabling technologies. provide additional information.

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ACKNOWLEDGEMENTS

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Executive Summary

EVs are quickly becoming one of the largest flexible loads on the grid in certain parts of the United States. In an era of flat to declining load growth, many utilities see EVs as a strategic opportunity, but don't know how best to effectively insert themselves into the emerging electrification of America's transportation fleet.

While most industry analysts see EVs as a boon for utilities, risks do exist. This downside is mostly associated with poor load management, such as peak load increases, transformer and substation impacts, or "timer peaks," an inadvertent result of time-of-use rates. Even though time-of-use rates have helped shift charging hours to utilities' preferred times of the day—late evening and early morning hours—customers often schedule their vehicles to begin charging the moment off-peak rates begin, resulting in sharp load ramps.

Poor load management and suboptimal rate schedules could, in turn, require costly solutions. In a study commissioned by the Sacramento Municipal Utility District, an estimated 17 percent (12,000) of the utility's transformers may need to be replaced due to EV-related overloads, at an average estimated cost of $7,400 per transformer.[1]

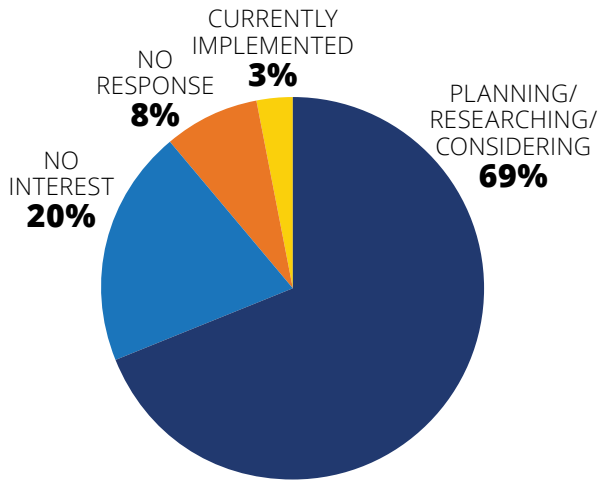
MANAGED CHARGING AS A SOLUTION

The challenge for utilities is to find a way to distribute these charging events across the full span of off-peak hours, or even better, to time vehicle charging for periods of high renewable energy production—mid-day for solar or night-time for wind.

Managed charging—also called V1G, intelligent, adaptive, or smart charging—allows a utility or third-party to remotely control vehicle charging by turning it up, down, or even off to better correspond to the needs of the grid, much like traditional demand response (DR) programs. Managed charging is different than vehicle-to-grid (V2G) dispatch, that is, the use of a plugged-in EV with available charged battery capacity to backfeed power to the grid. While V2G has been tested in a small number of pilots, a number of technical and regulatory issues need to be resolved before it can be widely and effectively used. While managed charging also faces some barriers, solutions are in process and could help prepare a solid foundation for V2G.

Using managed charging as an effective grid resource—with benefits for customers and utilities—could represent a compelling opportunity for

E-S 1: UTILITY INTEREST IN ELECTRIC VEHICLE MANAGED CHARGING DEMAND RESPONSE PROGRAMS



Source: Smart Electric Power Alliance, 2017

1 SEPA, SMUD, and Black & Veatch, *Planning the Distributed Energy Future, Volume II: A case study of utility integrated DER planning from Sacramento Municipal Utility District.* Expected release date May 2017. This was for the high-penetration scenario case of 240,000 EVs.

utilities. As of February 2017, more than 580,000 EVs were sold in the United States,[2] representing approximately one terawatt-hour (TWh) of annual consumption.[3] According to Bloomberg New Energy Finance (BNEF), EV electricity consumption is projected to increase to approximately 33 TWh annually by 2025, and 551 TWh by 2040.[4]

Given the projected growth in EVs, and the increasing need for flexible grid resources, more utilities are evaluating the opportunity for managed charging. In the Smart Electric Power Alliance's (SEPA) 2017 Utility Demand Response Survey, 69 percent of respondents indicated that they are planning, researching, or considering DR programs that integrate EV managed charging, compared to 20 percent that, at present, have no interest.

PILOTS AND INTEROPERABILITY BOTTLENECKS

Utilities have been among the most innovative field testers of managed charging technologies to date, experimenting with different vendors and technology types, and achieving a certain degree of success.

- **San Diego Gas & Electric**'s day-ahead, price-varying EV rate reflects circuit and system conditions and the changing price of energy throughout the day.[5] Through a user-friendly phone app, EV drivers can save money by setting vehicle charging times to low-priced hours of the day.
- **Southern California Edison** used a workplace charging pilot—leveraging afternoon peaks and load reduction strategies—to learn more about driver behavior and responsiveness to pricing signals.[6] The program included a high price option allowing users to have no charging disruption; a medium price allowing for peak demand curtailment from a faster Level 2 to a slower Level 1 charging rate; and a low price allowing drivers to be entirely curtailed during a demand event. One of the findings of the study was that drivers need maximum optionality, meaning if they need to charge at certain times, they want the ability to opt out.
- **Pepco**'s pilot program reduced chargers from a Level 2 to a Level 1 rate of charge for an hour during a DR event and provided opt-out capabilities for customers.[7] When assessing the economics of the pilot, Pepco found that that the ongoing costs of the communications link were too expensive. Identifying a cheaper solution would increase the viability of future projects.

The Pepco pilot points to some of the technical bottlenecks for utilities looking at managed charging, including network communication and equipment interoperability. As with other grid modernization technologies, such as advanced metering infrastructure and smart thermostats, the key to wide deployment of managed charging is finding an inexpensive, reliable way to send communication signals.

The signals a utility would send to EVs and vehicle chargers combine messaging, or application, protocols (e.g., OpenADR 2.0, OCPP) and transport layer protocols, also known as network communication interfaces (e.g., Wi-Fi, cellular).

2 Electric Drive Transportation Association, 2017, http://electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952.

3 BNEF, EV sales forecast in the US 2010–2040, May 2016.

4 BNEF, EV sales forecast in the US 2010–2040, May 2016.

5 http://www.sdge.com/newsroom/press-releases/2016-01-28/sdge-install-thousands-electric-vehicle-charging-stations.

6 http://www3.sce.com/sscc/law/dis/dbattach5e.nsf/0/B2DF49B34871148088257FBE0073125F/$FILE/R1309011-A1410014-SCE%20PEV%20Smart%20Charging%20Pilot%20Final%20Report%20.pdf.

7 http://www3.sce.com/sscc/law/dis/dbattach5e.nsf/0/B2DF49B34871148088257FBE0073125F/$FILE/R1309011-A1410014-SCE%20PEV%20Smart%20Charging%20Pilot%20Final%20Report%20.pdf.

The messaging protocol contains the instructions—don't charge until after midnight—while the network protocol ensures a message gets from point A to point B, but does not provide any instructions or guidance as to behaviors of the receiving devices.

One of the main issues to date is deciding on a uniform messaging protocol amongst a large field of open and proprietary protocols deployed by different vehicle and charging equipment manufacturers. The development and use of appropriate and uniform communication standards is the most effective way to move the needle on managed charging.

A ROBUST AND GROWING ECOSYSTEM

Despite relatively limited EV deployment to date, and the small number of pilot projects to develop and test managed charging, the EV and EV charging industry is already fairly robust. At the date of publication, approximately one-third of all manufacturers of electric vehicle supply equipment (EVSE) had a managed charger offering, and half of all EV manufacturers had been involved in managed charging pilots either directly or indirectly, or have managed charging capabilities.[8] This report provides a wide-lens overview of the managed charging ecosystem including:

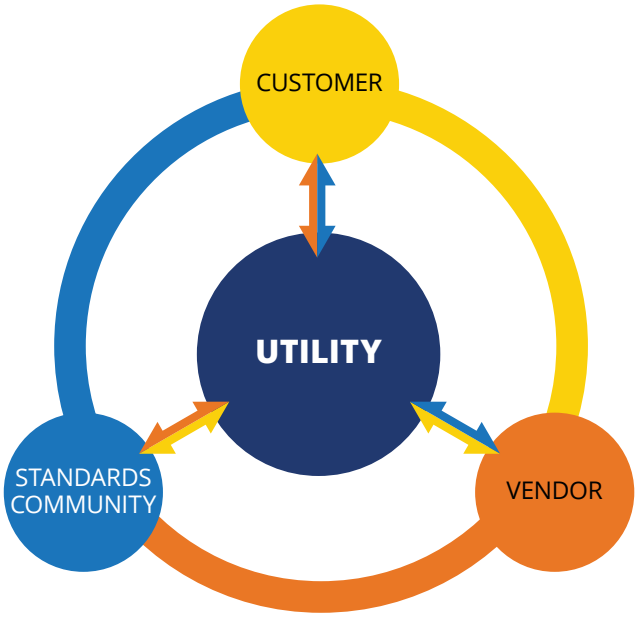
- Examples of utility programs
- A list of vehicle-grid integration (VGI) and connected-car platform providers[9]
- A list of compatible EVSE
- Examples of automotive industry activities

UTILITIES ARE THE NEXUS

Though the U.S. EV market is still nascent, utilities need to be involved and should begin planning now to help shape the relevant policies, regulations, and standards for the future. Utilities have a central role to play as a nexus for stakeholders in the EV space. With their deep knowledge of customer interests and expectations, utilities can proactively communicate the needs of the customer and the grid to vendors—including EV and charging equipment manufacturers—and recommend the most efficient and cost-effective strategies for common communication and other interoperability standards.

Despite the potential benefits of managed charging, getting consumer buy-in for these programs may require utilities to develop a range of outreach and engagement strategies. After all, most consumers buy an EV not to improve grid health, but to meet their transportation requirements and, in some cases, environmental values.

E-S 2: UTILITY ROLE IN MANAGED CHARGING



Source: Smart Electric Power Alliance, 2017

8 This includes EVSE and EV manufacturers with product offerings available in the U.S.

9 VGI and connected car platforms essentially connect multiple vehicle and/or charging equipment types to a single communications platform.

Utilities will need to keep customer considerations front and center by developing programs with user-friendly features, flexibility, and incentives. A customer-centric approach might include opt-out and override features, messaging and alerts based on customer preferences, smart phone functionality for control and management, and rewards, rebates, and other perks to keep customers happy and engaged.

EVs are only one of many distributed energy resource (DER) technologies that can be leveraged to develop a smarter, more reliable grid. As consumers evolve to become prosumers, utilities must keep pace with their demands and expectations through experimentation and continual self-assessment of the traditional utility business model.

Despite some initial growing pains, managed charging could prove to be a gateway for consumer adoption of other utility-managed DERs. It could also provide an innovative, highly replicable solution as our nation's fleet transitions from conventional fuels to electricity.

Introduction

Electric vehicles (EVs) are quickly becoming one of the largest flexible loads on the grid in certain parts of the United States. Depending on the vehicle type (including plug-in hybrid electric and battery electric vehicles) a single EV represents between 1.4 kilowatt (kW) and 20 kW of load,[10] or 500 to 4,350 kilowatt-hours per year (kWh/year) of energy consumption (as shown in Table 1 below)—analogous to the proliferation of air conditioning systems years ago. As of February 2017, over 580,000 EVs were sold in

TABLE 1: ANNUAL EV CONSUMPTION BY VEHICLE TYPE

VEHICLE TYPE*	ASSUMED % ALL-ELECTRIC MILES**	AVERAGE ANNUAL CONSUMPTION (KWH)	MAXIMUM POWER DRAW WHEN CHARGING VIA LEVEL 2 EVSE (KW)***
PHEV10	10-15%	500	3.3-3.6
PHEV20	33%	1,400	3-3.3
PHEV40	75%	3,500	3.3-6.6
BEV100	100%	3,500	3.3-10
BEV300	100%	4,350	10-20

Sources: ICF, The EV Project, Ford Motor Company, Smart Electric Power Alliance, 2017

*PHEV = plug-in hybrid electric vehicle, BEV = battery electric vehicle; e.g., a PHEV10 has a battery capacity for approximately 10 all-electric miles

** It is assumed that all vehicle types would be driven 12,000-13,000 miles annually, except a BEV100 at 10,000 miles due to the range restrictions of the battery

*** Level 2 EVSE = electric vehicle supply equipment that operates using a 240-volt outlet

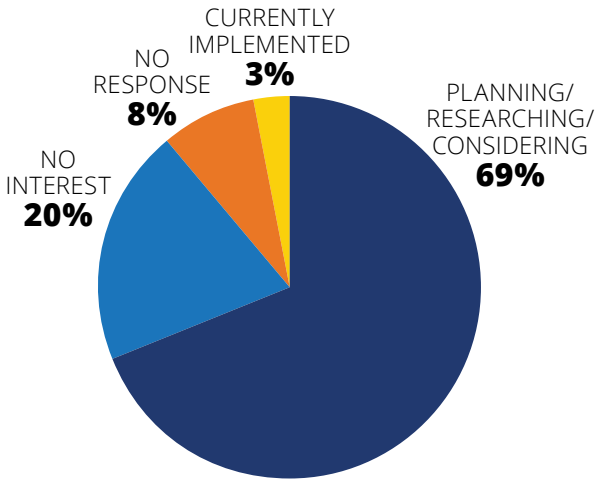
10 Using Level 1 to Level 2 chargers; DC fast charging load would be higher.

the United States,[11] consuming approximately one terawatt-hour (TWh) of electricity annually.[12]

EV loads are projected to grow as battery prices decline and EV manufacturers offer new models at progressively lower price premiums over conventional vehicles. Bloomberg New Energy Finance (BNEF) forecasts EVs will consume 33 TWh of electricity annually by 2025 and 551 TWh by 2040.[13]

In addition to growth in EV purchases, a rapid increase in electric vehicle supply equipment (EVSE) deployment is also expected. Navigant Research projects that U.S.-based EVSE sales will grow from approximately 120,000 units in 2016 to nearly 900,000 units in 2025—a 23 percent compound annual growth rate.[14]

FIGURE 1: UTILITY INTEREST IN ELECTRIC VEHICLE MANAGED CHARGING DEMAND RESPONSE PROGRAMS



Source: Smart Electric Power Alliance, 2017

Getting involved early could give utilities an opportunity to participate in EV-charging infrastructure deployment and standards development to better modulate charging events and source grid services through managed charging (also known as V1G,[15] intelligent charging, adaptive charging, or smart charging).

Given this projected growth in EVs and infrastructure, it is not surprising that utilities are evaluating managed charging. As Figure 1 illustrates, 69 percent of respondents to the Smart Electric Power Alliance's (SEPA) 2017 Utility Demand Response Survey indicated that they are planning, researching, or considering EV managed charging demand response programs, while only 20 percent expressed no interest.

The scale of the managed charging opportunity is strongly influenced by the regional and state factors that, to date, impact the rate of EV deployment. These factors include, but are not limited to:

1. In-state incentives and policies, including rebates, tax credits, and access to high-occupancy vehicle lanes
2. Demographics of the service territory
3. State requirements for zero emission vehicles
4. Transportation fuel costs
5. Availability of charging infrastructure
6. EV readiness planning for local jurisdictions

Though near-term opportunities may be limited, utilities could play a larger and more influential role in shaping EV deployments. Through active participation in infrastructure deployment, programs, incentives, and educational support, utilities can provide value to the grid within their service territories. Examples of these activities are

11 Electric Drive Transportation Association, Feb. 2017, http://electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952.

12 BNEF, EV sales forecast in the US 2010–2040, May 2016.

13 Ibid.

14 Navigant Research, 2Q 2016, Electric Vehicle Charging Services: Level 1, Level 2, DC Fast Charging, and Wireless Charging for Residential and Commercial Applications: Global market analysis and forecasts.

15 V1G is a term used to describe a vehicle with some capabilities of V2G, but without the able to discharge stored energy to the grid among other things.

WHAT ABOUT RANGE ANXIETY?

Managed charging may not work for everyone. Unlike other distributed energy resources (DERs), EVs are primarily used for transportation and some customers may have concerns about being able to make it to their final destination if their car does not have adequate vehicle charge—a concern that is also described as range anxiety. Providing options for customers to opt-out or override a managed charging event is an important program consideration.

outlined in SEPA's May 2015 member brief, *Can Electric Vehicles Offset Solar Losses for Utilities?*[16]

Given that their aggregate charging load can be large, flexible, and intelligent, EVs are part of a larger discussion around grid evolution. Most industry analysts think about EVs as a way to increase load and utility revenue, in a scenario of flat or declining load growth. However, managed EV charging loads can also be a useful means of aligning high production of renewable energy generation with EV demand. At the same time, managed charging can also reduce emissions in the transportation and utility sectors and improve grid economics.

These opportunities have real value. Consulting firms ICF and Energy+Environmental Economics (E3) calculated that managed charging in a high renewable energy penetration scenario (40 percent) would yield a net present value benefit of $850 per vehicle in California.[17] Managed charging could also translate to monetary value for consumers via aggregators in the wholesale power markets. Aggregating the charging rates of a large number of EVs could provide meaningful DR capabilities and benefits to the grid. For example, eMotorWerks, a California-based EV charging company, estimates customers may be compensated up to $400 annually for participating in an EV rewards program.[18]

What is Managed Charging?

Managed charging is essentially a combination of infrastructure and communication signals sent directly to a vehicle or via a charger to control a charging event. Indirect efforts to manage charging patterns rely on customer response behavior. For example, EV time-of-use (TOU) rates provide predetermined price signals to influence when a customer charges a vehicle. The communications signals used in managed charging enable a utility or third party to reduce the rate of charge or curtail it entirely, such as during a high-load event on the grid. Further, these controls can be leveraged by utilities, load balancing authorities via aggregators, or other interested parties to provide grid services, such as capacity, emergency load reduction, reserves, or regulation, or to absorb excess generation from renewable energy resources, like solar and wind.[19]

It is also important to note that different EV charging levels offer different potential for managed charging. Long-dwell charging with Level 1 or Level

16 https://sepapower.org/resource/may-member-brief-can-electric-vehicles-offset-solar-losses-for-utilities/.

17 California Transportation Electrification Assessment, October 2014, http://www.caletc.com/wp-content/uploads/2016/08/CalETC_TEA_Phase_2_Final_10-23-14.pdf.

18 https://emotorwerks.com/rewards; Factors include such things as: the geography/utility a customer lives, local incentives (such as those from utilities), size of vehicle battery, miles driven, typical times of charging, etc.

19 https://www.dropbox.com/sh/zmkca2v9cdiu9os/AAA4YtWgmeu0dJPmz1xnPHCZa/ISO%20Markets%20and%20Grid-Scale%20Services?dl=0&preview=parent_ucs_final_updated.pdf.

THE FUTURE OF VEHICLE-TO-GRID (V2G)

Managed charging is different than vehicle-to-grid (V2G) dispatch, that is, the use of a plugged-in EV with available charged battery capacity to backfeed power to the grid. V2G can potentially provide services to the grid in exchange for financial compensation to the vehicle owner.

There are several demonstration projects around the country, but V2G is still more conceptual than commercial. While V2G technology is likely to develop over time, it will require additional elements for widespread adoption, such as approval/consent of vehicle manufacturers so as to not invalidate warranties and usage guidelines,[20] additional hardware expense for AC/DC[21] conversion and control, and interconnection permits and engineering/technical requirements of local grid operators/utilities.

V2G is not discussed in the context of this paper; however, the Appendix includes reference materials from the Electric Power Research Institute and others which address this topic in more detail.

2 provide more time for managed charging events and flexibility for deferring customer charging. Alternatively, the high power demand of DC Fast Charging (DCFC) may be attractive for managing from a capacity perspective, though possibly less useful, depending on EV driver needs and priorities.

BENEFITS AND OPPORTUNITIES FOR MANAGED CHARGING

Managed charging can:

- Improve grid economics by achieving higher utilization rates, and therefore capacity factor, of generation assets
- Reduce emissions by aligning charging with surplus renewable generation
- Reduce grid stress and maintain grid stability by minimizing charging ramp rates and reducing the strain on distribution transformers
- Reduce the need for new peak generation and distribution capacity resulting from EVs charging during peak hours, particularly as more drivers choose EVs in the coming years

Many utilities have initially turned to TOU rates to influence drivers to shift their EV loads to off-peak times of day. This approach serves the dual purposes of allowing all customers to reduce their overall costs by adjusting their energy use and encouraging EV charging when it is least-disruptive to the grid as a whole, such as night-time hours. Some service territories may also further refine these TOU rate schedules to reflect local conditions. For example, Hawaii, is considering a super off-peak time-of-day rate to absorb excess solar rooftop generation.

Though EV TOU rates can be helpful, the static nature of a rate schedule can also introduce new challenges. For example, San Diego Gas & Electric's (SDG&E) lowest-priced super off-peak EV rate begins at midnight.[22] Some concerns have been raised about the potential for households to program their EVs to begin charging exactly at midnight. With all of these chargers set to start at the same time, that could induce a steep ramp rate and a new load spike (also known as a timer peak) at the local distribution level.[23] Ideally, this

20 At the date of publication, no vehicle manufacturers provide a warranty for V2G activities due to concerns about battery life and safety.

21 AC=alternating current, DC=direct current.

22 SDG&E, http://www.sdge.com/clean-energy/ev-rates.

23 Stratton Report, November 15, 2016, http://strattonreport.com/news/emotorwerks-partners-mce-provide-smart-grid-enabled-ev-charging-stations/.

UTILITY INCENTIVES FOR MANAGED CHARGERS

Marin Clean Energy (MCE), a Community Choice Aggregator, found that it had an estimated 4,000 EV customers in late 2016 and forecasted a total of 25,000 EV customers by 2020. In response, MCE announced a private-public partnership to provide a $150 discount on new smart-grid-enabled EV charging stations.[24] Customers with existing EVSE were eligible for a free adapter that would upgrade their EVSE to be controlled via a smartphone app. Given the long-term projected demand, MCE expects to use the eMotorWerks JuiceNet platform to manage the deployment of these chargers to better respond to grid load and pricing conditions to and thus "avoid grid bottlenecks and lower electricity procurement costs." Further, the program participants will earn rewards for altering their charging habits during peak demand periods.

The Los Angeles Department of Water and Power (LADWP) is similarly focused on the future with its "Charge Up L.A.!" program, which offers up to $500 for Level 2 residential chargers or $4,000 for commercial chargers.[25] As a condition of the rebate program, recipients must agree to participate in LADWP's demand response program for the life of the installation in the event the utility needs to curtail that load. Further, LADWP can disconnect the load from the EV charger for the duration of the event without notice.

concern would be allayed by staggering charge times, using an intelligent assessment of charge status, incorporating customers' desired "charge by" times, the charge rate, and other factors thus distributing the charging across a wider time window.

The Chevrolet Volt offers a special delayed charging mode that can be used to mitigate a timer peak. The driver programs the desired departure time, and the vehicle calculates when charging should begin in order to be fully charged by that departure time. This particular program randomizes the start of charging, so if a number of similar vehicles employed the technology, their charging loads would be distributed as desired. Similarly, EV charging software providers, such as Greenlots, offer intelligent algorithms that can be deployed in EVSE, and other EV manufacturers are beginning to incorporate similar functionality.

As shown in Figure 2, managed charging has the potential to absorb excess renewable capacity, such as photovoltaic (PV) production during peak solar hours and wind spikes during off-peak hours. At the same time, managed charging can smooth unintended TOU timer peaks.

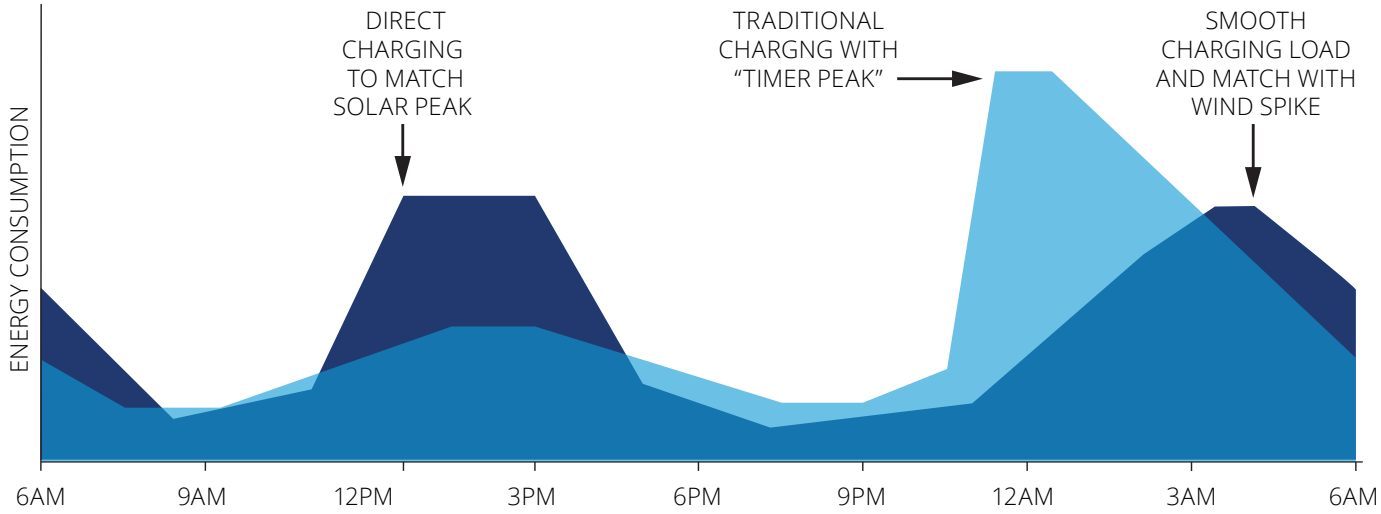
Avoiding grid upgrades is potentially an even more significant value for utilities than additional revenue from new load. Even during the early days of EV deployment, researchers in The EV Project identified the "clustering" trend, in which multiple EVs connected to a single distribution transformer caused strain on the equipment.[26] In some areas, this impact is even more pronounced today, leading to a risk of triggering costly upgrades to distribution equipment. Seeking to mitigate these costs, a Sacramento Municipal Utility District (SMUD) report found that managed charging reduced almost all of the cost impacts of higher

24 LADWP, 2017, https://tinyurl.com/zchs8sw.

25 Interview with Molly Amendt, SDG&E, March 10, 2017. Note: The time peak issue has not yet been a major issue for SDG&E.

26 The EV Project, 2013, What Clustering Effects have been seen by The EV Project?, https://avt.inl.gov/sites/default/files/pdf/EVProj/126876-663065.clustering.pdf..

FIGURE 2: OPPORTUNITIES FOR EV MANAGED CHARGING TO MEET GRID NEEDS (ILLUSTRATIVE)



Source: BMW of North America, 2016[27] with edits by Smart Electric Power Alliance, 2017

Note: The light blue area illustrates the impacts of a hypothetical TOU residential charging rate with the lowest rate period beginning at 11 pm. The dark blue area shows how managed charging could distribute charging loads with peaks in renewable energy generation.

IMPACTS OF EV CLUSTERING

When a concentration of EV chargers are powered by the same electrical distribution transformer, also known as clustering, they may cause damage and outages from overloading the transformer ratings or shortening the cool-down time, such as the usual low-load period. A single overloaded transformer can also affect other residential feeders by degrading power quality. The EV Project recommended utility-controlled managed charging as a solution for this issue.

Source: The EV Project, 2013

residential charging levels, potentially saving significant dollars in transformer upgrades.[28]

It is possible that major changes to distribution operations are already on the horizon for many utilities due to the growth of DERs, such as solar. Based on a 2017 study published by SEPA, Black & Veatch, and SMUD, *Planning the Distributed Energy Future, Volume II*, due to the forecasted DER changes for SMUD through 2030, it is likely that SMUD's peak will naturally move to evening hours because of current incentives to charge at night.[29] Like other utilities in similar circumstances, SMUD may decide to implement a managed charging program as a way to better respond to these trends over time.

27 Adam Langton of BMW of North America LLC, "BMW Electric Vehicles and the Grid," April 2016, https://www.dropbox.com/sh/zmkca2v9cdiu9os/AAB4BMGmFKBzhrOHDqEWKOyGa/The%20OEM%20Perspective?dl=0&preview=Langton_June2016_v2.pdf

28 Britta Gross, 2016, General Motors Presentation, https://www.dropbox.com/sh/zmkca2v9cdiu9os/AAB4BMGmFKBzhrOHDqEWKOyGa/The%20OEM%20Perspective?dl=0&preview=Gross+UCS+Day+2+-+The+OEM+Perspective+-+Boston+-+June+2016.pptx.

29 SEPA, SMUD, and Black & Veatch, *Planning the Distributed Energy Future, Volume II: A case study of utility integrated DER planning from Sacramento Municipal Utility District.* Expected release date May 2017.

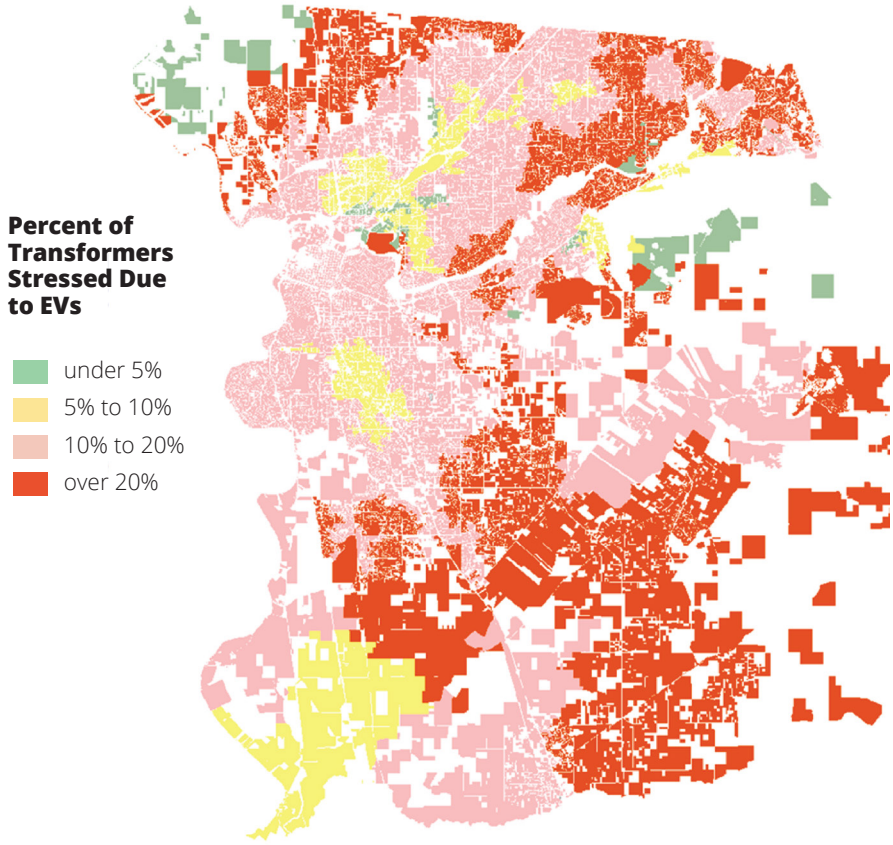
A POTENTIAL APPLICATION FOR MANAGED CHARGING: SACRAMENTO MUNICIPAL UTILITY DISTRICT (SMUD)

SMUD has experienced significant DER growth in its service territory over the past decade. To anticipate future necessary investments, the utility commissioned Black & Veatch to provide an integrated forecast of customer-side DER growth and estimate costs for any necessary distribution infrastructure upgrades. In an upcoming report by SEPA and Black & Veatch, Planning the Distributed Energy Future, Volume II, under a high-penetration DER scenario that included 240,000 EVs by 2030, it was found that up to 17 percent (12,000) of SMUD's service transformers may need to be replaced due to overloads, at an average estimated cost of $7,400 per transformer. This was mostly due to EV growth, and the transformer replacement costs translated to about $100 per EV, but SMUD is weighing this cost against the potential for significant new revenue from EVs.

It was assumed that nearly all EV owners would take advantage of SMUD's current EV rate, which encourages customers to charge between midnight and 6am, and this led to significant load increases during these night-time hours that caused the transformer overloads. If EV charging is concentrated during a limited number of hours, managed EV charging is one potential solution to reduce the transformer stress and defer upgrades (and possibly provide other grid services), as long as the cost of the communications infrastructure is low enough that managed charging can provide a net benefit. Another solution is rate-based incentives for EV owners to charge during the middle of the day to absorb excess PV generation.

Note: These results represent an EV adoption scenario that is 30-60% higher than SMUD expects in reality, and total upgrade costs could be lower if cheaper mitigation solutions are available. Today, only about 30% of EV owners in SMUD's territory take advantage of the EV rate, so charging may not be as concentrated during night-time hours as this analysis assumed. Each utility will need to conduct its own analysis to determine where EV adoption is likely to occur and how charging behavior affects utility infrastructure costs.

FIGURE 3: EV IMPACT ON TRANSFORMERS IN THE SACRAMENTO MUNICIPAL UTILITY DISTRICT SERVICE TERRITORY THROUGH 2030



Source: Smart Electric Power Alliance, Black & Veatch, and SMUD, 2017

MANAGED CHARGING COMMUNICATION PATHWAY OPTIONS

Network communication and equipment interoperability are a challenging barrier for managed charging, not unlike other grid modernization technologies, such as advanced metering infrastructure (AMI) and smart thermostats. The difficulty arises in finding a cost-effective way to send these communication signals. A critical factor in the broad deployment of managed charging is that it must be *inexpensive and reliable.* The development and use of appropriate communication standards is the most effective way to get there.

Communications to EVs and EVSE from a utility consist of a combination of messaging (or application) protocols (e.g., OpenADR 2.0/OCPP) and transport layer protocols (also known as network communication interfaces) (e.g., Wi-Fi, cellular). Though intertwined, the protocols for messaging and transport are distinct. The messaging protocol contains the instructions—e.g., wait to charge until after midnight—while the network protocol ensures a message gets from point A to point B, but does not provide instructions as to specific behaviors of the receiving devices.

TRANSPORT LAYER PROTOCOLS

Figure 4 provides a graphical view of the five most-used transport layer (communication networking) options for sending signals to a vehicle. These options correspond to preferences implemented by various vehicle or charging equipment manufacturers and distinctions between charging location requirements (e.g., residential vs. public EVSE). To summarize, the options include a:[30]

1. Wi-Fi signal sent directly to the EVSE using Control Pilot (CP) Smart Adapter or sent directly to the car through a telematics link or on-board diagnostic interface (OBD2)
2. Utility AMI backhaul link to a smart meter, using wireless networking protocols (e.g., Wi-Fi, ZigBee) or Power Line Carrier (PLC) protocols (e.g., Green PHY), which send signals directly through power lines
3. Cellular broadband signal to the EVSE through Global System for Mobile communications (GSM), which sends data through general packet radio service (GPRS) or through code division multiple access (CDMA) low bandwidth wireless connections (data speed requirements for EVSE can also vary, e.g., 2G, 3G, 4G, LTE). Cellular signals can also be directed to the vehicle through onboard integrated communications (e.g. OnStar, CarWings)
4. FM radio broadcast using a communication protocol standard, known as a radio data system (RDS), to embed digital information directly to the vehicle or the EVSE
5. Ethernet (also known as Local Area Network (LAN)) connection to the EVSE only; some EVSE have certain Ethernet cable requirements for data speed (e.g., CAT5, CAT6)

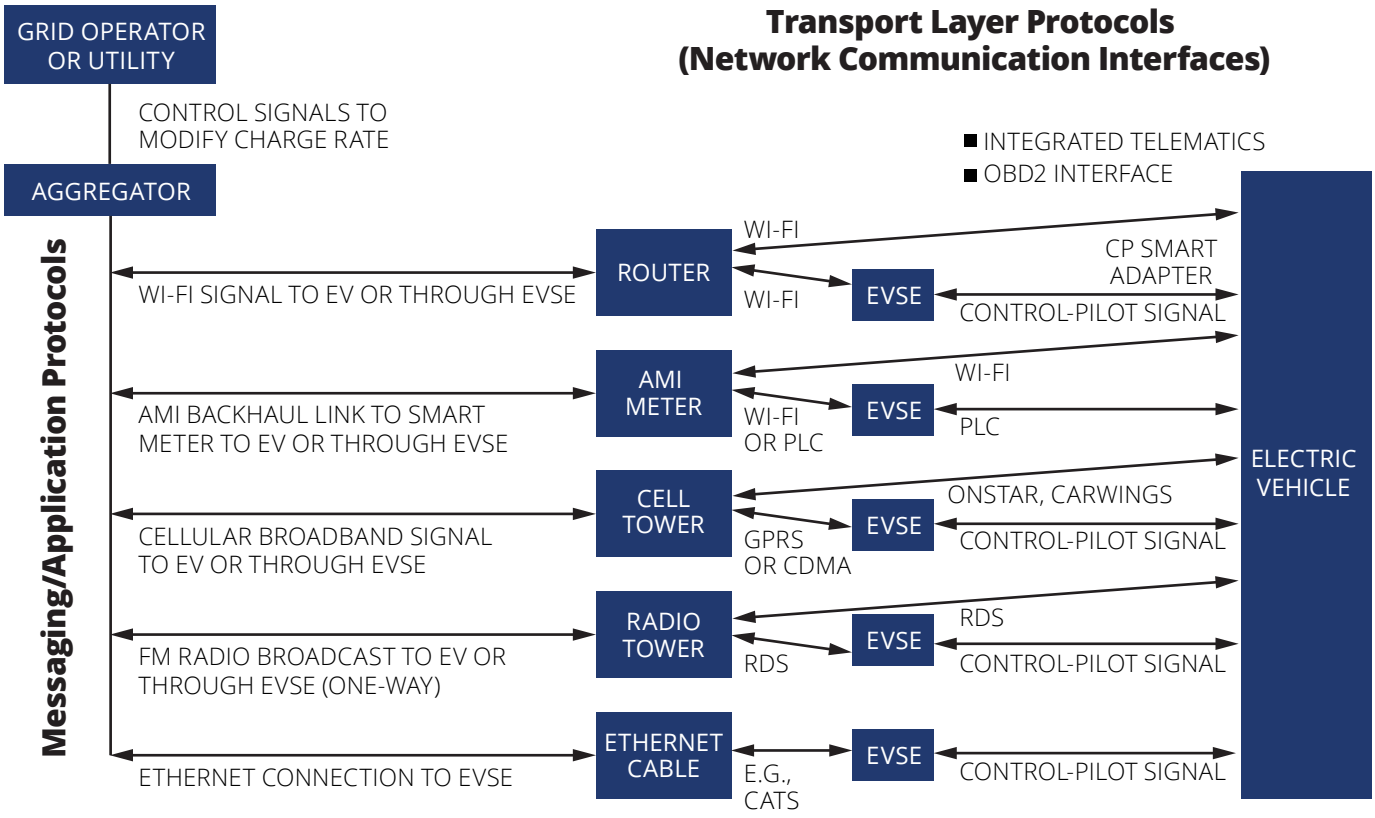
MESSAGING PROTOCOLS

Proprietary EVSE and EV Protocols

Leading EVSE and vehicle manufacturers have either incorporated common industry-developed messaging protocols in their products or developed their own proprietary protocols that require use of a proprietary platform software. Examples of proprietary platforms include the eMotorWerks JuiceNet, Itron/ClipperCreek's OpenWay network, and Siemen's VersiCharge platform.
Vehicles can also be managed via a direct telematics link or an on-board diagnostic interface (OBD2). Most vehicles sold today are considered "connected" vehicles and have built-in capabilities, such as GPS location software, which can be

30 Dr. David Tuttle, 2016, PEV-Grid Interactions Communications Types & Costs, University of Texas at Austin, https://www.dropbox.com/sh/zmkca2v9cdiu9os/AADy4CkK7fxIUYMIW05kTQZya/Technical%20Aspects?dl=0&preview=Tuttle+-+UT+-+Communication+Options.pdf.

FIGURE 4: MANAGED CHARGING NETWORK COMMUNICATION INTERFACE OPTIONS



Source: Dr. David P. Tuttle, 2016[31] with edits by Smart Electric Power Alliance, 2017

managed according to the local grid circuit. Many EVs also already have the ability to program their charging window that would enable the user to align charging with TOU or other EV rates. A more sophisticated way to leverage these vehicles would for the utility or aggregator to send price, emissions, or grid stress signals directly to the vehicle, so that the EV's charging program could use the information to modify its schedule. An example of this type of vehicle telematics capability is Microsoft's Azure Connected Vehicle proprietary cloud platform to be used in Renault and Nissan vehicles.[32]

EVSE and EV Open Protocols

Many industry stakeholders are advocating for uniform and non-proprietary communications messaging protocols between the EVSE and EV, such as ISO/IEC 15118 (also known as OpenV2G), that enables the managed charging functionality in a EV and can also provide an improved EV customer experience,[33] such as eRoaming and optimized load management. With eRoaming, the consumer can access all charging stations with one contract through automatic payment authorization and optimized load management, providing grid services based on charging costs, owner preferences, and

31 Dr. David Tuttle, 2016, PEV-Grid Interactions Communications Types & Costs, University of Texas at Austin, https://www.dropbox.com/sh/zmkca2v9cdiu9os/AADy4CkK7fxIUYMIW05kTQZya/Technical%20Aspects?dl=0&preview=Tuttle+-+UT+-+Communication+Options.pdf.

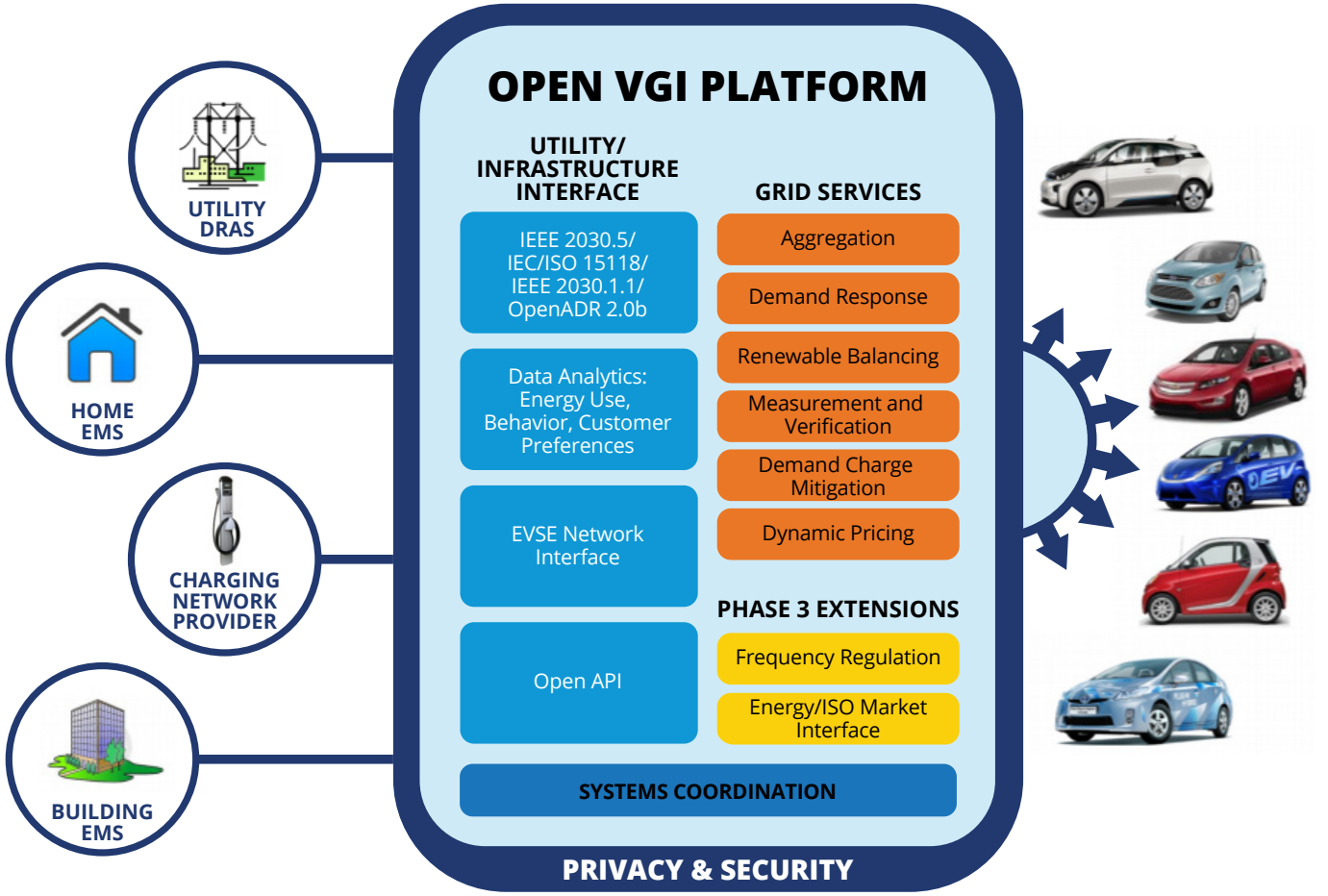
32 Microsoft, 2016, https://blogs.microsoft.com/blog/2017/01/05/microsoft-connected-vehicle-platform-helps-automakers-transform-cars/#sm.00000duv5owoiqfixwk1rmwelgrao (see white paper).

33 http://openv2g.sourceforge.net or https://www.iso.org/standard/55365.html.

vehicle-specific parameters such as battery wear. Some companies, Oxygen Initiative for example, are beginning to offer this protocol in their charging equipment.[34]

The Electric Power Research Institute (EPRI) is coordinating work on an Open Vehicle-Grid Integration Platform (OVGIP)[35] —a software application that connects EVSE and EVs to various nodes to allow utilities to more proactively manage charging activity that could help with a variety of grid services as shown in Figure 5. The goal of the OVGIP is to allow Original Equipment Manufacturers (OEMs) the flexibility to use existing on-vehicle communications technologies (i.e., IEEE 2030.5,[36] ISO/IEC 15118, and telematics) with utility standard interface protocols (i.e., OpenADR 2.0b, IEEE 2030.5) and EV charger application program interfaces (i.e., ISO/IEC 15118, OCPP, and industry applied standard and proprietary APIs) through a common platform. These will ultimately allow utilities to provide: "time-

FIGURE 5: OPEN VEHICLE-GRID INTEGRATION PLATFORM SCOPE



Source: Electric Power Research Institute, 2016

34 http://www.crossroadstoday.com/story/34623191/california-startup-poised-to-introduce-blockchain-payment-technology-to-united-states.

35 Open Vehicle-Grid Integration Platform: General Overview, July 2016, https://www.epri.com/#/pages/product/000000003002008705/.

36 IEEE 2030.5 is the same as SEP 2.0.

of-use (TOU) pricing, peak load reduction, demand charge mitigation, load balancing for intermittent solar/wind generation, Real Time Pricing (RTP), aggregated Demand Response (DR), and scheduling dispatch for ancillary services,"[37] to EVSE or EVs.

Other open protocols include a combination of the Open Automated Demand Response (OpenADR 2.0b) demand-response standard with Open Charge Point Protocol (OCPP), which can be used for communication between a charger and a central control system (i.e., utility).[38] OCPP was developed by the Open Charge Alliance and is an open protocol for communications between charging points and the network administrator. It provides site owners the option of changing network administrators without stranding equipment assets. OpenADR, currently managed by the OpenADR Alliance, provides an open and standardized way for electricity providers and system operators to communicate with each other and with their customers (in this case the network administrator) using a common language over any existing IP-based communications network. Originally developed as a peak-load management tool, it has since expanded to include other DERs.

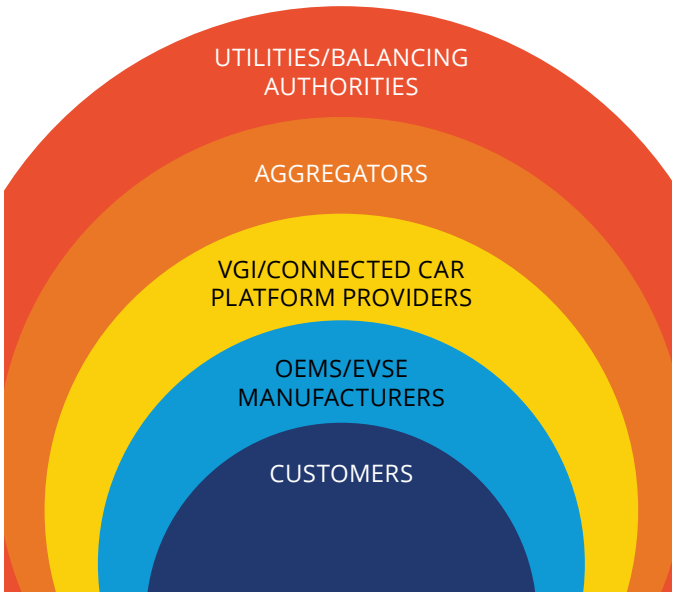
The Managed Charging Landscape

Given relatively limited EV deployment and few managed charging pilot projects to date, the managed charging industry has been growing quietly but steadily. At the date of publication, approximately one-third of all EVSE manufacturers had a managed charger offering and half of all vehicle manufacturers have been involved in development or have demonstrated managed charging capabilities.[39]

The ecosystem of companies in the industry is also complex. Figure 6 shows how these players inter-relate in the managed charging space. We do not cover third-party aggregators at length in this report as market rules are still in flux; however, aggregators could include utilities or providers of vehicle-grid integration (VGI) or connected car platforms, as discussed below.

We also don't address customers in this report, as they rely largely on the equipment and services provided by other players in this ecosystem.

FIGURE 6: THE MANAGED CHARGING ECOSYSTEM



Source: Smart Electric Power Alliance, 2017

37 Open Vehicle-Grid Integration Platform: General Overview, July 2016, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002008705.

38 OpenADR, 2016, Using OpenADR with OCPP: Combining these two open protocols can turn electric vehicles from threats to the electricity grid into demand-response assets, https://openadr.memberclicks.net/assets/using%20openadr%20with%20ocpp.pdf.

39 This includes EVSE and vehicle OEMs with product offerings available in the U.S.

However, customer considerations remain pivotal to any decision-making process. As referenced throughout this section, programs and equipment vendors have so far responded to customer feedback by allowing opt-out or override options to enhance charging flexibility and by offering participation incentives—either direct compensation or value exchanges such as free or reduced-price equipment.

As indicated above, the growth of the managed charging industry depends heavily on the actual value of the grid services that EVs can provide, much like many other DER technology discussions today. The value in certain states, such as California, is relatively clear due to in-state low carbon fuel requirements. Other benefits are unclear until TOU rates or related programs such as demand charges and demand response, are implemented widely enough to establish their values. With well-established economic signals in active markets, value determination will become more transparent. SEPA intends to update this report as the industry develops.

UTILITIES

Utilities (primarily those on the West Coast) have been among the most innovative field testers of managed charging technologies and have experimented with many different vendors and technology types with varying degrees of success. Many of the pilots and full-scale deployment efforts to date emerged from policy and regulatory initiatives, or the availability of research funding, as opposed to an urgent need for managed charging solutions. Three examples of utility pilots and programs provide an overview of the insights gained on pricing, flexibility, and connectivity.

San Diego Gas & Electric (SDG&E) introduced an innovative day-ahead price-varying rate that reflects circuit and system conditions, as well as the changing price of energy throughout the day. EV drivers who enroll in this pilot program can control their charging events through a phone app and potentially save money by charging during the lowest-priced off-peak hours. By installing and managing 3,500 utility-owned chargers at 350 different businesses and multi-unit family dwellings, SDG&E aims for these special rates to motivate EV drivers to efficiently integrate EV charging load with the grid.[40]

Southern California Edison (SCE) created a workplace charging pilot project to learn more about driver behavior and responsiveness to pricing signals. The pilot included afternoon peak events and load reduction strategies. SCE used OpenADR 2.0b and OCPP for the communication signals. Under the high price option, users had no charging disruption, with the medium price users' peak demand could be curtailed—as in reduced from Level 2 to Level 1 charging rate, and users choosing the lowest price agreed to halt charging during the entire demand event. SCE issued a final report in May 2016.[41] A key takeaway indicated that because drivers sometimes need to charge at certain times, they need an opportunity to opt out. Building on the pilot program findings, SCE implemented a Charge Ready program that requires that all Level 2 infrastructure site hosts commit to a future DR program.[42]

Pepco, in the Maryland/Washington D.C. area, tried a residential managed charging pilot, placing 35 ClipperCreek chargers using an Itron smart

40 SDG&E, SDG&E to Install Thousands of Electric Vehicle Charging Stations, Jan. 2016, http://www.sdge.com/newsroom/press-releases/2016-01-28/sdge-install-thousands-electric-vehicle-charging-stations. Interview with Molly Amendt, SDG&E, March 10, 2017.

41 SCE, Plug-In Electric Vehicle Smart Charging Pilot, May 2016, http://www3.sce.com/sscc/law/dis/dbattach5e.nsf/0/B2DF49B34871148088257FBE0073125F/$FILE/R1309011-A1410014-SCE%20PEV%20Smart%20Charging%20Pilot%20Final%20Report%20.pdf.

42 https://tinyurl.com/hvkest4 (see Participation Package document).

charging architecture that could respond to DR events.[43] When Pepco called a DR event, they reduced the chargers from Level 2 to Level 1 rate of charge for an hour, while also providing opt-out capabilities for customers. Between 2014 and 2015, the utility called seven DR events; however, it happened that no cars were charging during six of them. The small scale of the residential pilot limited results with respect to customer choices and cost savings. However, the study identified the ongoing cost of the utility's communications link to the intelligent EVSE was problematic. A Wi-Fi-connected EVSE communicating to the utility through the homeowner's internet connection could significantly improve the economics of the project, despite some tradeoffs with reliability.

VEHICLE-GRID INTEGRATION AND CONNECTED CAR PLATFORM PROVIDERS

Vehicle-grid integration (VGI) platform providers are emerging in the space to solve the complexity associated with connecting different vehicles across disparate charging networks, utilities, and energy management systems. Historically, EVSE manufacturers have developed cloud-based software systems to provide basic services, such as charge station authentication, payment processing, and data reporting. However, typical cloud-based platforms only function with the given manufacturer's station, creating challenges for utilities. VGI platforms solve the complexity associated with managing charging across different station manufacturers, station types (e.g., Level 2 and DCFC), vehicle makes and models, utility territories, and utility energy management systems. Listed in Table 2 below are all of the VGI and connected vehicle platforms identified at the date of publication.

EV Connect's EV Cloud is currently used by New York Power Authority (NYPA) to manage charging stations from multiple station manufacturers who apply both OCPP and proprietary cloud protocols. EV Connect's Platform provides NYPA with access to its OpenADR Virtual End Node (VEN) to manage charging loads throughout its territory regardless of station manufacturer, type, or protocol. The platform architecture can also manage dynamic pricing signals, load aggregation, carbon credit monetization, data analytics, and other features and functionality required by other industry stakeholders.

Greenlots' SKY open standards-based charge management platform includes similar features as well as a fleet management interface and provides utilities with the ability to remotely control grid loads through smart charging, DR, and energy storage initiatives. The City of Los Angeles has integrated a range of Level 2 and DCFC equipment options and has avoided electrical upgrade costs through the platforms charge prioritization capabilities.[44] Greenlots and Washington's Avista Utility announced a formal partnership in July 2016 to install 120 residential charging stations, 80 workplace and public charging stations, and 7 DCFC public stations as part of a pilot project.[45] The goal of the pilot project is to inform and test various "demand flexibility strategies."[46]

eMotorWerks, which developed a VGI platform called JuiceNet, has its own smart grid enabled JuiceBox EV charger, and provides JuiceNet platform capabilities to five other EVSE manufacturers. Additionally, eMotorWerks has started deploying its platform to control vehicle charging directly

43 http://webapp.psc.state.md.us/intranet/Casenum/NewIndex3_VOpenFile.cfm?ServerFilePath=C:%5CCasenum%5C9200-9299%5C9261%5C%5C120.pdf, pg. 7-1 to 7-2.

44 Interview with Thomas Ashley, Greenlots.

45 Avista Utility, https://www.avistautilities.com/services/transportation/Pages/evcharging.aspx.

46 PR Newswire, http://www.prnewswire.com/news-releases/greenlots-selected-by-avista-utilities-for-electric-vehicle-charging-pilot-300304441.html.

TABLE 2: VGI AND CONNECTED CAR PLATFORM PROVIDERS

VGI/CONNECTED CAR PLATFORM PROVIDER	PLATFORM(S) (DEVICES)	APPLICATION/ MESSAGING PROTOCOLS	NETWORK COMMUNICATION INTERFACES
DRIIVZ	Driivz Platform	Not available	Not available
EMOTORWERKS	JuiceNet platform (JuicePlug EVSE adapter)	OCPP, OpenADR, other API-based systems	Wi-Fi, Ethernet, Cellular
EV CONNECT	EV Cloud platform (EVSE partners include Efacec, GE, and OpConnect)	OCPP, OpenADR 2.0, other API-based systems	Wi-Fi, Ethernet, Cellular GSM (GPRS and CDMA)
FLEETCARMA	SmartCharge Rewards Platform, and Paired SmartCharging Platform (C2 telematics device)	OCPP, OpenADR, Proprietary	Cellular
GREENLOTS	SKY Smart Charging platform	OCPP, OpenADR 2.0b, SEP 2.0	Wi-Fi, Ethernet, Cellular, Green PHY
LIBERTY PLUGINS	HYDRA-R Multi-Charger Control System	OpenADR 2.0	Cellular, Ethernet
MICROSOFT	Azure cloud platform for vehicle telematics (Renault-Nissan) and EVSE (ABB)	Proprietary	Not available

Source: Smart Electric Power Alliance, 2017

over the telematics link with select OEMs. By controlling how and when large quantities of EVs charge throughout the day, eMotorWerks can bid that capacity into wholesale power markets such as the California Independent System Operator (CAISO), use it to balance renewable generation, or provide traditional DR services to the utilities, while observing driver behaviors and allowing driver override to avoid customer dissatisfaction. Once a JuiceNet-enabled resource (EVSE or vehicle) is registered with one of the eMotorWerks energy programs, the company estimates participating drivers may be compensated up to $400 annually, depending on the vehicle, driving habits, location, and mileage.[47]

FleetCarma offers a connected car platform and cloud-based software system.[48] The connected car platform not only offers real-time insights into driving and charging behavior for fleets, but can be provided to residential EV owners as part of a utility EV load management program.[49] The platform can also be used by utilities to understand the potential impacts of EVs on the grid and help with load forecasting as EVs scale across their service territory.[50]

47 https://emotorwerks.com/rewards.

48 http://www.fleetcarma.com/platform/smart-charging/.

49 http://www.fleetcarma.com/what-is-smart-charging/.

50 http://c.ymcdn.com/sites/www.peakload.org/resource/resmgr/17th_fall_conf/MalliaFleetCarma.pdf

ELECTRICAL VEHICLE SUPPLY EQUIPMENT (EVSE) MANUFACTURERS

EV charging companies have been the most active in this space as they work to enhance their business models. Listed in Table 3 below are all of the EVSE manufacturers offering compatible equipment identified at the date of publication. Of the over 60 EVSE manufacturers listed on the GoElectricDrive website,[51] 22 are represented [52] —approximately one-third of the EVSE market.

TABLE 3: EVSE MANUFACTURERS WITH UTILITY CONTROL CAPABILITIES

EVSE MANUFACTURER NAME	CHARGER NAME(S) (LEVEL AND TYPE)	PROPRIETARY/ EXTERNAL PLATFORM(S)	APPLICATION/ MESSAGING PROTOCOLS	NETWORK COMMUNICATION INTERFACES
ABB	Terra 53 CJ DCFC (SAE Combo and CHAdeMO 1.0)	External (e.g., Microsoft Azure)	OCPP w/ Demand/ Response API add-on	Cellular (GSM), Ethernet
ADDENERGIE	SmartTWO and, CoRE+ (Level 2 Commercial), SmartDC (SAE Combo and CHAdeMO)	Charging Station Network Management System (CSNMS)	OpenADR 2.0	Cellular, ZigBee, Wi-Fi
ADVANCED CHARGING TECHNOLOGIES (ACT)	Level 2 Commercial, DCFC (SAE Combo and CHAdeMO)	Not available	SEP 1.x, SEP 2.0	Ethernet, Wi-Fi (IEEE 802.11 b/g/n, ICPT IP/ Internet, Cellular GSM (GPRS), ZigBee
AEROVIRONMENT	EVSE-RS Version 1.0 (Level 2)	External (e.g., eMotorWerks JuiceNet platform or Liberty PlugIns HYDRA-R platform)	SEP 2.0	Wi-Fi, Ethernet, Cellular
ANDROMEDA POWER, LLC	ORCA Mobile and ORCA Air DCFC (CHAdeMO and SAE Combo)	ORCA InCISIVE Power Cloud platform	OpenADR 2.0b, OCPP 1.6, Open Smart Charging Protocol (OSCP)	Wi-Fi (IEEE 802.11g), Cellular (3G/4G), Ethernet
BLINK (CARCHARGING GROUP)	Level 2 and DCFC (CHAdeMO)	Not available	Not available	Wi-Fi (IEEE 802.11g and 802.15), Cellular (3G), Ethernet
BOSCH	Power Max 2 Level 2 and Power DC Plus (SAE Combo)	Not available	OCPP 1.5	Wi-Fi (IEEE 802.11 b/g/n)
BTCPOWER	Level 2 Commercial EV Charging Station	Fleet Plan cloud service and ChargePoint Home	SEP1.x, SEP2.0, OCPP	Ethernet, Cellular, Wi-Fi, ZigBee
CHARGEPOINT	CT4000 and CPF25 (Level 2) and Express 250 and Express Plus DCFC (CHAdeMO and SAE Combo)	ChargePoint platform, including ChargePoint Home	OpenADR 2.0b, OCPP 1.6, IEEE P2690, and other API-based systems	Wi-Fi (IEEE 802.11 b/g/n), Cellular (GSM (3G) and CDMA (3G))

Note: Table continues on next page.

51 https://www.goelectricdrive.org/.

52 Includes manufacturers that were not included on the GoElectricDrive website.

TABLE 3: EVSE MANUFACTURERS WITH UTILITY CONTROL CAPABILITIES

EVSE MANUFACTURER NAME	CHARGER NAME(S) (LEVEL AND TYPE)	PROPRIETARY/ EXTERNAL PLATFORM(S)	APPLICATION/ MESSAGING PROTOCOLS	NETWORK COMMUNICATION INTERFACES
CLIPPERCREEK	HCS-40 or CS-100 (Level 2)	External (e.g., eMotorWerks JuiceNet platform or Liberty PlugIns HYDRA-R platform)	Not available	W-iFi, Ethernet, Cellular
DELTA	EV AC Charger (Level 2)	Not available	Not available	Ethernet, Wi-Fi, Cellular GSM/GPRS (3G)
EMOTORWERKS	JuiceBox Pro (Level 2)	JuiceNet platform	OCPP, OpenADR, other API-based systems	Wi-Fi, Ethernet, Cellular
EVSE LLC	ChargeWorks 3703 (Level 1 and Level 2)	External (e.g., Greenlots SKY Smart Charging platform)	OCPP	Ethernet, Cellular, radio, Wi-Fi
GENERAL ELECTRIC (GE)	WattStation and DuraStation (Level 2)	EV Connect cloud platform	OpenADR 2.0 VEN	Ethernet (CAT5), Wi-Fi, Cellular (CDMA)
ITRON & CLIPPERCREEK	Smart Charging Station	OpenWay network	Proprietary	Wi-Fi, RF Mesh, Cellular, ZigBee
KEBAAG	KeContact P30 x-series (Level 2 and DCFC)	Not available	OCPP 1.5 and 2.0	Ethernet, Cellular (GSM)
LEVITON	Evr-Green 4000 (Level 2 Commercial)	External (e.g., ChargePoint platform or Liberty PlugIns HYDRA-R platform)	Not available	Wi-Fi (IEEE 802.11 a/b/g/n), Cellular (GSM (3G) and CDMA (3G))
MOEV	Smart EV Charger (Level 1 and 2)	Cloud-based control center	Not available	Ethernet, Wi-Fi, Cellular, ZigBee
OXYGEN INITIATIVE & INNOGY SE	Oxygen eStation and eBox (Level 2)	Oxygen eOperate	OpenV2G	Cellular (3G)
SCHNEIDER ELECTRIC	EVlink (Level 2 Public and DCFC (CHAdeMO and SAE Combo))	EV Cloud connected platform	OCPP 1.5	Wi-Fi (IEEE 802.15.4), Cellular
SEMACONNECT	ChargePro (Level 2 Commercial and Residential)	SemaConnect Network platform	Proprietary	Cellular (CDMA and GSM/GPRS)
SIEMENS	VersiCharge SG (Level 2)	Siemens proprietary cloud via CEA2045 compliant module	OpenADR 2.0b, OCPP	Wi-Fi (IEEE 802.11 b/g/n)
TRITIUM	Veefil UT, WP, 22 kW (DCFC: CHAdeMO and SAE Combo)	Not available	OCPP 1.5 and 1.6J	Cellular (3G), Ethernet

Source: Smart Electric Power Alliance, 2017

Note: SEP 2.0 is the same as IEEE 2030.5

Itron's smart charging station (Zigbee compatible) connects to its OpenWay network, which allows utilities to offer dynamic pricing, customer engagement, and participation in utility DR programs.[53]

Siemens also offers a proprietary cloud-based smart charger, known as the VersiCharge SmartGrid (SG).[54] By accessing the Siemens cloud, utilities or energy aggregators can offer dynamic pricing and other DR programs to customers. The VersiCharge has also recently been updated to communicate via OCPP to Greenlots' SKY platform and is also OpenADR 2.0b compliant.[55]

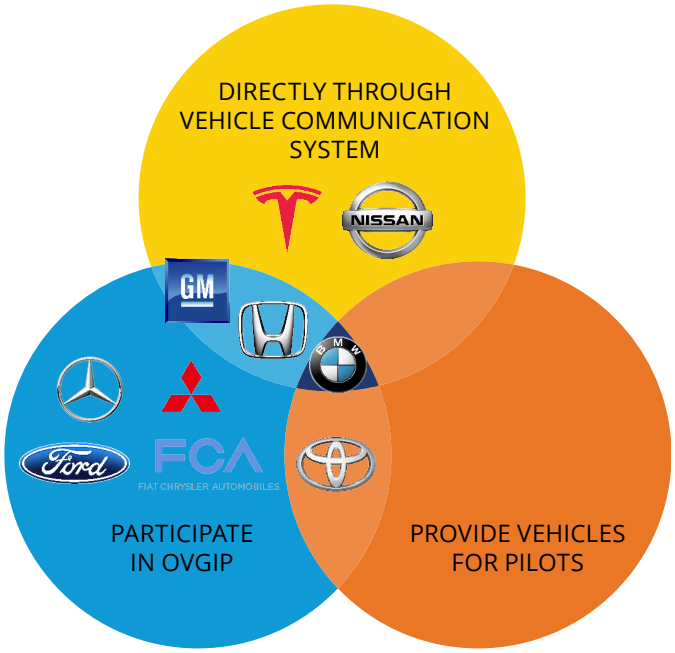
To date, there has been little uniformity among manufacturers in application protocols or preferred network communications, representing an interoperability challenge to utilities. This is a similar issue for other DR solutions, such as smart thermostats or water heater controls, offered to utilities. The table includes the application/ messaging protocols as well as the network communication interfaces (also known as the transport layer protocols) for each EVSE device and/or platform.

ORIGINAL EQUIPMENT MANUFACTURERS

Original Equipment Manufacturers (OEMs) are also entering the managed charging space primarily through existing vehicle communication systems, such as GM's OnStar, or through utility pilot programs. Other OEMs have also endorsed or participated in open standards processes, such as EPRI's Open Vehicle-Grid Integration Platform (OVGIP) and Green PHY.

There are a number of demonstration projects that have shown how a utility can send charging signals to a vehicle. One example includes a pilot project with BMW and Pacific Gas & Electric (PG&E) to offer over $1,500 for participants in an 18-month demonstration pilot program, called the iChargeForward Program.[56] This pilot program allowed BMW to manage at-home charging of participants (based on consumer preferences) and could delay vehicle charging for up to one hour based on PG&E signals. Drivers could also opt-out of participation on a day-by-day basis. A challenge with OEM-provided integrated telematics-based managed charging is the monthly subscription cost paid by the utility or EV owner to the vehicle OEM.

FIGURE 7: OEM APPROACHES TO MANAGED CHARGING



Source: Smart Electric Power Alliance, 2017

53 https://www.itron.com/na/technology/product-services-catalog/products/a/3/4/electric-vehicle-smart-charging-station.

54 http://news.usa.siemens.biz/press-release/low-and-medium-voltage/siemens-introduces-versicharge-sg-first-wi-fi-enabled-cloud-bas.

55 Interview with Thomas Ashley, Greenlots.

56 http://content.bmwusa.com/bmwi_pge/index.html.

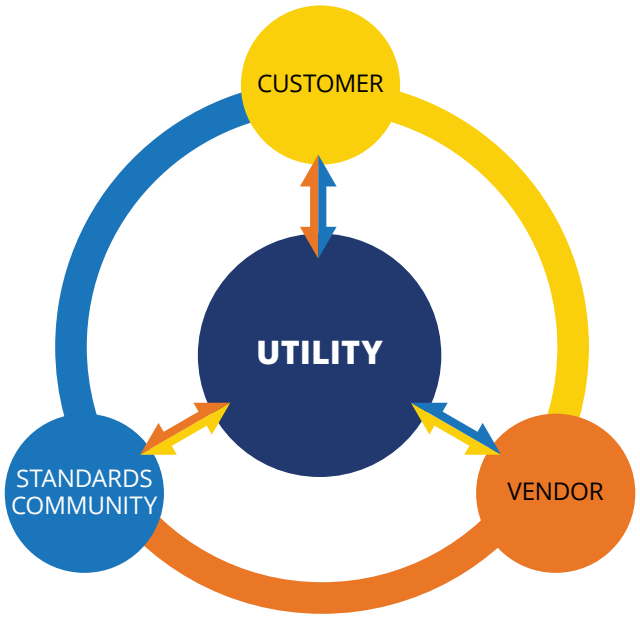
PG&E also partnered with American Honda Motor Company and IBM in 2012 to test the ability to delay or adjust vehicle charging based on grid conditions (particularly peak hours) and the vehicle's state of charge.[57] The demonstration project showcased how individualized charging plans could be developed for Honda's Fit EVs using IBM's cloud based software platform via the vehicle on-board telematics system.

Figure 7 describes the interrelationships among OEM approaches to managed charging, which include providing direct control via the vehicle communication system, developing the Open Vehicle-Grid Integration Platform (OVGIP) with EPRI, and providing cars for utility pilot programs. Though these examples don't reflect all of the OEM approaches to managed charging to date, they provide some insights into how OEMs are becoming more actively engaged with the utility sector.

Conclusion

As more EVs hit the road in the coming years, we will likely see widespread grid and business impacts across multiple levels of utility operations, from distribution planning, to load management, to demand response programs, and even generation and transmission teams. Though the U.S. is still in the early years of EV deployment, it is important for utilities to engage with these possibilities now, in order to be involved and developing plans which will optimize policies, regulations, and standards for the future.

FIGURE 8: UTILITY ROLE IN MANAGED CHARGING



Source: Smart Electric Power Alliance, 2017

Many EVSE and vehicle manufacturers have already begun to integrate managed charging capabilities into their products to better meet utility needs. Communication standardization, cost-effectiveness, and reliability are key variables of managed charging success. Utilities have an important role in the outcome of these variables by:

- Participating in the managed charging communication standards development process
- Collaborating with industry to develop standards and best practices
- Engaging vendors to share utility needs and learnings from other comparable DR efforts,
- Providing a test bed or pilot effort for new solutions
- Developing protocols to deploy solutions into the SCADA or DR systems
- Providing EV education and awareness to their consumers

57 http://www-03.ibm.com/press/us/en/pressrelease/37398.wss.

- Considering alternative rate structures that could better leverage renewable energy production, particularly flexible incentives
- Encouraging greater deployment of charging infrastructure—particularly in multi-unit family dwellings and businesses, long-distance DCFC, and residential home charging programs
- Influencing advantageous charging habits through managed charging programs/options

As shown in Figure 8, utilities can play a central role in steering a path which will balance the needs and expectations of customers, communicate customer and grid requirements to vendors, and relay the most cost-effective and efficient strategies for common messaging protocols to the standards community.

Of the three external stakeholder groups identified in Figure 8, however, getting customer buy-in for managed charging programs is likely the most important and may require utilities to develop a range of outreach and engagement strategies. After all, most consumers buy an EV not to improve grid health, but to meet their transportation requirements and, in some cases, environmental values.

Utilities will need to keep customer considerations front and center by developing programs with user-friendly features, flexibility, and incentives. A customer-centric approach might include opt-out and override features, messaging and alerts based on customer preferences, smart phone functionality for control and management, and rewards, rebates, and other perks to keep customers happy and engaged.

EVs are only one of many DER technologies that can be leveraged to develop a smarter, more reliable grid. As consumers evolve to become prosumers, utilities must keep pace with their demands and expectations through experimentation and continual self-assessment of the traditional utility business model.

Despite some initial growing pains, managed charging could prove to be a gateway for consumer adoption of other utility-managed DERs. It could also provide an innovative, highly replicable solution as our nation's fleet transitions from conventional fuels to electricity.

KEY CONSIDERATIONS:

- Further work is needed to understand what types of incentives and management strategies will shift load effectively, while maintaining a satisfactory user experience for drivers.
- Defining the value of managed charging will enhance the business case and provide greater visibility to the need in certain regions.
- To keep costs low, least-cost communication solutions should be strongly considered. For example, Wi-Fi-connected EVSE communicating to the utility through the homeowner's router could significantly improve the economics to the utility of a managed charging program.
- Getting the business model for managed charging right is important—defining the costs and payback for both the utility and EV driver—and establishing industry standards will reduce costs, barriers, and complexity.

Appendix: Recommended Reading

Electric Power Research Institute, May 2016, *The Value of Transportation Electrification: Three Preliminary Case Studies of Impacts on Utility Stakeholders,* http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=3002007751

Electric Power Research Institute, June 2016, *Vehicle-to-Grid: State of the Technology, Markets, and Related Implementation (V2G),* http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002008935

Electric Power Research Institute, June 2016, *Open Vehicle-Grid Integration Platform: Systems Approach to Standards and Interoperability,* http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002008866

OpenADR, 2016, Using OpenADR with OCPP: *Combining these two open protocols can turn electric vehicles from threats to the electricity grid into demand-response assets,* https://openadr.memberclicks.net/assets/using%20openadr%20with%20ocpp.pdf

Rocky Mountain Institute, October 2016, *Driving Integration: Regulatory responses to electric vehicle growth,* http://www.rmi.org/ev_integration

Rocky Mountain Institute, 2016, *Electric Vehicles as Distributed Energy Resources,* http://www.rmi.org/Content/Files/RMI_Electric_Vehicles_as_DERs_Final_V2.pdf

SilverSpring Networks, July 2013, *How the Smart Grid Enables Utilities to Integrate Electric Vehicles,* http://www.silverspringnet.com/wp-content/uploads/SilverSpring-Whitepaper-ElectricVehicles.pdf

SilverSpring Networks, December 2010, *The Dollars - and Sense - of EV Smart Charging,* http://www.rmi.org/Content/Files/DollarsandSense.pdf

Smart Electric Power Alliance, May 2016, *Can Electric Vehicles Offset Solar Losses for Utilities?,* https://sepa.force.com/CPBase__item?id=a12o000000MMIblAAH

Vermont Energy Investment Corporation and the Regulatory Assistance Project, *In the Drivers Seat: How utilities and consumers can benefit from the shift to electric vehicles,* https://www.veic.org/documents/default-source/resources/reports/veic-rap-utilities-consumers-ev-benefits-report.pdf?sfvrsn=2.

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