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STRENGTHENING UTILITIES AND PROMOTING ENERGY REFORM (SUPER)

POWERING THE ELECTRIC VEHICLE FUTURE: UTILITY SOLUTIONS FOR INCREASING ADOPTION

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ACRONYMS

Acronym	Definition
AC	Alternating Current
AHJ	Authority Having Jurisdiction
AMI	Advanced Metering Infrastructure
ASEAN	Association of Southeast Asian Nations
BEV	Battery-Electric Vehicle
BLPC	Barbados Light and Power Company
CCS	Combined Charging System
DCFC	DC Fast Charging Station
E-bus	Electric Bus
E2W	Electric Two-Wheeler
E3W	Electric Three-Wheeler
EDGE	EVSE Grid Deployment and Grid Evaluation
EMDE	Emerging Markets and Developing Economies
ERAV	Electricity Regulatory Authority of Vietnam
EV	Electric Vehicle
EVN	Electricity of Vietnam
EVSE	Electric Vehicle Supply Equipment
IEC	International Electrotechnical Commission
IRP	Integrated Resource Plan
IRRP	Integrated Resource and Resilience Plan
ISO	International Organization for Standardization
kW	Kilowatt
kWh	Kilowatt-hour

OCPP	Open Charge Point Protocol
PG&E	Pacific Gas and Electric
PDP	Power Development Plan
PEA	Provincial Electricity Authority
PHEV	Plug-in Hybrid Electric Vehicle
PPP	Public-Private Partnership
PSE	Puget Sound Energy
SAE	Society of Automotive Engineers
SCE	Southern California Edison
SUPER	Strengthening Utilities and Promoting Energy Reform
TOU	Time-of-Use
UL	Underwriters Laboratories
USAID	United States Agency for International Development
V2G	Vehicle-To-Grid

EXECUTIVE SUMMARY

As the main supplier of the electricity that powers electric vehicles (EVs), utilities should play a major role in developing and implementing EV support systems and infrastructure. The specific role(s) of a utility in a given country and jurisdiction will vary and evolve based on the specific context—which includes the state of the EV and power markets, the policy environment, the type(s) of EVs and associated charging infrastructure in use, and what goals or mandates the utility is working towards regarding EV infrastructure rollout in their service territory. As with the adoption of any new technology, utilities around the world are encountering challenges while responding to or proactively planning for EV expansion. This report is a deliverable under the United States Agency for International Development (USAID)-funded Strengthening Utilities and Promoting Energy Reform (SUPER) program,[i] implemented by Deloitte Consulting LLP. It presents an analysis of the key challenges utilities may face as they prepare for and respond to the growth of EVs, and evaluates potential solutions and leading practices that could be applied or adapted to jurisdictions in earlier stages of EV adoption. These include:

- **Cost Recovery and Financing**: Utilities must recover the costs of infrastructure upgrades associated with increased EV deployment from a limited number of pathways. Each of these pathways carries regulatory and equity implications. Solutions to recovering the costs include rate adjustments (including tiered or differentiated tariffs), use of public funding to support infrastructure upgrades (if available), and partnerships with the private sector to leverage additional expertise and funding sources.
- **Peak Load and EV Charging Management**: As the number and diversity of EVs grows, utilities may face challenges with effectively managing the additional load from EVs. Solutions include the use of time-variable pricing to encourage off-peak charging, incentives or rebates for customers who charge during off-peak hours, and collaboration with the private sector to develop such programs.
- **EV Charger Grid Interconnection, Regulatory Permitting, and Stakeholder Coordination**: Delays in EV charger grid interconnection approvals can add months or years to a project's timeline and disincentivize private investment. To address this, utilities can develop a more efficient and transparent process by creating dedicated EV charger interconnection teams to review applications. Utilities can also actively engage with relevant government agencies to simplify and streamline regulatory permitting processes and lead the development of stakeholder coordination bodies.
- **Long-term Planning and EV Load Forecasting**: Utilities will need to forecast EV load and plan for the long-term impacts of EVs. However, utilities face challenges with collecting and analyzing the data required and often lack the technical capabilities and expertise to conduct accurate forecasts. Utilities can improve data management and collection through AMI, submetering, smart chargers, and private sector engagement. Utilities can also engage third parties to conduct long-term forecasting, as is commonly done in the United States.
- **Technical Standards and Rapid Technological Evolution of EVs and Charging Infrastructure**: Utilities seeking to add EV charging as a service may lack awareness of the range of technical standards that need to be considered when installing and operating charging stations. With EV and charging technologies rapidly evolving, it is difficult for utilities to fully future-proof their investments. Utilities can proactively adopt leading international technical and safety

[i] https://www.usaid.gov/energy/super

standards based on domestic EV trends and develop interoperable and universally accessible charging stations, using protocols like OCPP. Where appropriate, utilities can encourage the development of charging stations with multiple types of plug standards for maximum accessibility. Utilities should also maintain and update technical standards regularly to ensure they are adhering to the latest versions.

- **Consumer Awareness and Adoption of EVs**: Utilities often lack dedicated service lines and programs to support EV customers, potentially leading to negative customer experiences (e.g., if a utility-owned charger is not working and the customer is unable to contact an EV specialist at the utility to remedy the situation). Some utilities have created teams to address these issues. Additionally, in early-stage markets customers tend to have limited awareness of EVs, presenting an opportunity for utilities since they have regular communications with existing electricity customers. Utilities can conduct EV pilot programs in targeted markets (e.g., replacing government fleet vehicles with electric alternatives or partnering with a ride hailing company to electrify part of its fleet) and then expand programs based on lessons learned, create educational and outreach programs to inform customers about the benefits of EVs and utility incentive programs, and communicate EV-related information to their customer base. Utilities can provide such information with customers' electricity bills, create dedicated email and/or mail campaigns for their customers, host EV information pages on their websites, and organize EV fairs or other events to raise awareness.

Given the growing interest and anticipated rapid expansion of EVs in emerging and developing economies (EMDEs), there are many opportunities for USAID and other donors to provide targeted, strategic technical assistance to utilities and governments to scale up EV deployment and contribute to the long-term electrification of the transportation sector. Utilities are a key stakeholder for EV deployment, since the grid is the lynchpin for both vehicle charging and associated infrastructure development and therefore impacts EV market expansion. Donor assistance should therefore be tailored to the current status of the EV market and to the role of the utility in the EV charging ecosystem. Table 1 details areas and opportunities where USAID and other donors could provide technical assistance, mapped to the six major challenges discussed above.

Table 1: Recommended Support to Address Key Utility Challenges with EV Expansion

Challenge	Technical Assistance Recommendations
Cost Recovery and Financing	• Supporting the development of cost recovery models (such as the development of differentiated/tiered tariffs) for investments in grid infrastructure upgrades; • Working with governments to create public funding programs or grants for utilities that are investing in EVs and/or charging infrastructure; • Facilitating partnerships with the private sector to access additional expertise and funding sources: and • Conducting impact analysis and supporting design of new or adjusted tariff schedules for EV deployment.
Peak Load and EV Charging Management	• Conducting analyses of current and predicted EV impacts on the grid. This may require facilitating connections with the private sector to enhance real-time energy usage predictions for chargers and vehicles;

	• Sharing best practices and relevant case studies of how other utilities have successfully approached peak load management; and • Supporting design of programs to encourage off-peak EV charging, such as time-of-use (TOU) tariffs or rebates for charging in off-peak times.
EV Charger Grid Interconnection, Regulatory Permitting, and Stakeholder Coordination	• Convening key stakeholders through an EV working group to build their knowledge of the local interconnection and regulatory processes, connect them with the relevant managers, and develop common understandings and cultivate productive relationships; • Working with national/local government regulatory, permitting, and oversight agencies to streamline and expedite permitting, interconnection, and approval processes; • Providing advisory support to utilities in understanding relevant energy and transportation regulations and laws, building connections between the utility and policymakers where relevant; • Supporting the utility to understand and navigate their potential role (as applicable) in relevant regulatory processes; and • Helping national/local government agencies get feedback from utilities and EV users on EV-charging related policies and processes and update them as necessary.
Long-Term Planning and EV Load Forecasting	• Helping utilities improve data management and collection, including through advanced metering infrastructure (AMI), submetering, and smart chargers, facilitating partnerships with third parties where necessary to collect, manage, and analyze the data required to conduct long-term load forecasts; • Supporting utilities in conducting or obtaining an EV market outlook based on the data collected or third party research; • Advising on utility EV charging infrastructure investment strategy and goals following an assessment of EV market conditions and outlook; • Supporting utilities in developing or updating integrated resource plans (IRP), integrated resource and resilience plans (IRRP), and power development plans (PDPs) that account for the long-term impacts of EVs on electrical demand; • Working with governments to create publicly available load forecasting tools; • Helping to connect utilities with U.S. and other private companies to conduct load forecasts; and • Assisting utilities to create a transportation electrification plan, including planned investments both behind the meter and in charging station assets.
Technical Standards and Rapid Technological Evolution of EVs and	• Sharing leading practices for utility planning, operations, and management of EV charging infrastructure, including encouraging the development of charging stations with multiple types of plug standards for maximum accessibility, drawing on lessons from the

Charging Infrastructure	United States and other countries—this would be particularly helpful for utilities exploring the owner-operator business model; • Hosting joint national or regional workshops for utilities and international standards bodies to promote standardization and trade, as well as share information on leading and emerging technical standards and interoperability; and • Supporting peer exchange with utilities that have developed interoperable charging stations—this would be particularly helpful for utilities exploring the owner-operator business model. Donors can support market forecasts of EV adoption in a given service territory or market to advise on possible future trends; and • Helping the relevant government agency or industry group maintain and update technical standards regularly with enhancements to safety and performance. Donors can also support utilities in updating plans where necessary to adhere to the latest standards.
Consumer Awareness and Adoption of EVs	• Exploring opportunities for fleet vehicle electrification programs and small-scale EV pilot programs with select customers to demonstrate applicability and feasibility, which can stimulate customer interest; • Working with the relevant government agency or utility to implement education and outreach programs to inform customers about the benefits of EVs and any incentive programs the utility or government has; and • Designing customer engagement strategies with utilities to solicit feedback on EVs to help inform potential EV programs that the utility could present to the regulator.

I. INTRODUCTION TO ELECTRIC VEHICLES AND UTILITY ROLES IN ENCOURAGING EV DEPLOYMENT

This report is a deliverable under the USAID-funded SUPER program, implemented by Deloitte Consulting, LLP. It presents an analysis of the key challenges utilities around the world may face as they prepare for and respond to the growth of EVs and evaluates potential solutions to address them. This report begins with an overview of key EV market status, the common types of EVs and EV charging infrastructure, and possible roles of utilities in advancing EV uptake. It then discusses the major challenges that utilities face with EV expansion and provides examples of leading practice solutions to these challenges based on international experiences. Utilities in EMDEs can consider and adopt such practices when developing their own EV programs and strategies. This report concludes by recommending targeted technical assistance areas that address the main challenges faced by utilities in different stages of EV market development.

While the EV market has been growing steadily over the past few years, less than 17% of global sales occur in EMDEs,[1] and the market is dominated by China, Europe, and the United States. S&P expects EVs will account for 16.2% of global passenger vehicle sales in 2024, up from 12% in 2023, with most demand again coming from these three regions. Bloomberg similarly estimates that EVs will account for about 20% of global vehicle sales in 2024.

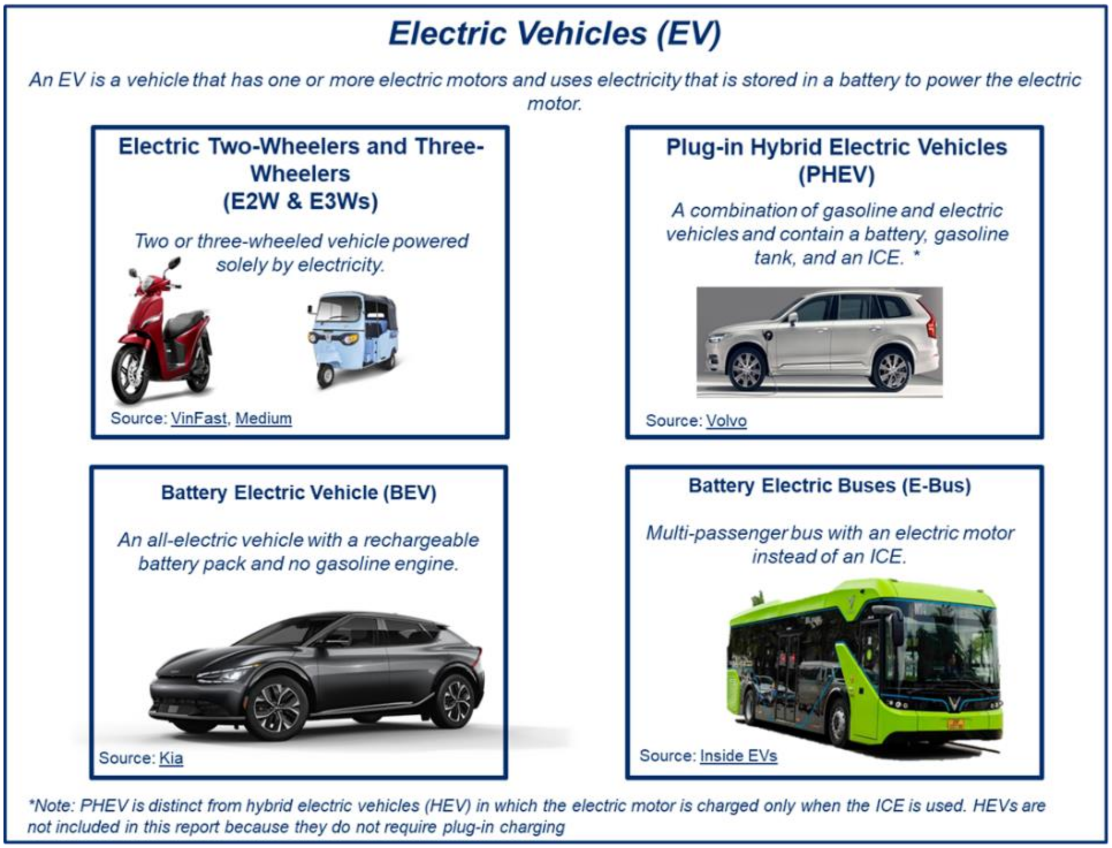
In the near-term, EV uptake is not expected to impact electricity demand significantly in EMDEs. According to a World Bank study of 20 EMDEs,[ii] the adoption of a 30% vehicle electrification target (for new vehicles) by 2030 would increase electricity demand by no more than one percent. However, the study notes that there could be exceptions in countries where the existing power system is limited such that any growth in power demand (from EVs or otherwise) would necessitate capacity expansion.[2]

By displacing internal combustion engine vehicles powered by fossil fuels,[iii] EVs have the potential to be a core pillar to decarbonizing the transport sector, which accounts for about 20% of global carbon dioxide emissions.[3] Figure 1: Common Classes of EVs shows several common classes of EVs that are commercially available in both developed countries and EMDEs, including fully-electric passenger vehicles called battery-electric vehicles (BEVs); plug-in hybrid electric vehicles (PHEVs), which have both an internal combustion engine and a battery; electric two-wheelers / electric three-wheelers (E2Ws / E3Ws); and electric buses (e-buses).

[ii] The World Bank study included Brazil, Cambodia, Egypt, Ethiopia, Chana, India, Jamaica, Jordan, Kazakhstan, Maldives, Nepal, Nigeria, Poland, Rwanda, Tajikistan, Türkiye, Ukraine, Uruguay, Vanuatu, and Vietnam.

[iii] In an internal combustion engine, fuel is ignited and combusted and the energy released from this reaction mechanically moves the vehicle. *Source: https://www.energy.gov/eere/vehicles/articles/internal-combustion-engine-basics*

Figure 1: Common Classes of EVs



There are different types of EV chargers with varying technical specifications, charging speeds, and costs, and charging needs differ based on the type of EV and typical vehicle use case (see Appendix B).[4] The speed and duration of the charging events will vary based on the size and specifications of the vehicle battery as well as the charger. For example, the most powerful charger, a direct current fast charger (DCFC), can charge a BEV in as little as 20 minutes, whereas alternating current (AC) Level 1 and Level 2 charging, which occur at lower power density, can take anywhere from over several hours to up to two days.[5]

EV markets in many EMDEs are at an earlier stage but are ripe for USAID support as these economies are seeking to begin stimulating their EV market and ecosystem. Interest in EVs in EMDEs can stem from different motivations, including desire to reduce reliance on imports of liquid fuels, increase domestic manufacturing of EVs and/or components, improve local air quality, and mitigate climate change. Barriers to greater EV adoption in EMDEs include higher upfront vehicle costs than combustion engine alternatives, lower purchasing power of consumers, limited charging networks, nascent policy and regulatory environments, and, in some jurisdictions, power reliability concerns.[6] The development of reliable and extensive EV charging networks is often a key prerequisite to widespread EV adoption; however, the business case for private charger development is weak in early-stage EV markets since returns on investment are low when there are very few EVs and thus chargers have low utilization. This creates a "chicken and egg" dilemma in which consumers are hesitant to purchase an EV due to perceived "range anxiety"[iv] and at the same time, the private sector is unwilling to invest in public charging infrastructure while EV adoption is low. This challenge is especially pronounced for DCFCs, which have significant upfront costs ranging from $20,000 - $150,000 (including the equipment, construction, and installation), but can also be a barrier to development of public Level 2 chargers, which generally cost $1,370 - $2,700.[7,8]

Despite the challenges of investing in EV charging infrastructure, in developed countries and EMDEs alike the private sector has typically led the initial development of charging infrastructure. For example, in the early stage of the EV market in the United States, Tesla developed what remains the country's largest charging network to gain market dominance of its vehicles and a similar trend is underway in Vietnam with EV-maker VinFast. The United States has experienced a rapid expansion of charging networks because of government subsidies, whereas most EMDEs have neither public funding for EV charging nor policies or regulations in place to encourage utilities to invest in charging stations.[9] For this reason, in many EMDEs the private sector is the main entity developing EV chargers, yet efforts may be limited to certain areas (e.g., cities) or certain customers (e.g., owners of a particular EV brand).

Utilities play a major role in developing the EV ecosystem since they supply the electricity that is necessary to power the chargers. They must manage the power system to avoid outages or imbalances in supply and demand, necessitating proactive, long-term planning for needed upgrades and attention to the demands on the grid from EV charging. Utilities will also play an important role in financing and permitting new infrastructure required to support EV deployment. At the same time, EV expansion can benefit utilities by providing additional revenue streams through additional customers as well as by offering charging as a service. In the long-term, as bidirectional charging systems mature, EVs have the potential of serving as power supply rather than just demand, which can provide utilities and grids with additional flexibility as variable renewable energy is integrated into an increasingly complex power system. The specific role(s) of the utility will vary and evolve based on the stage of the market in their service territory. This report defines EV market stages as follows:

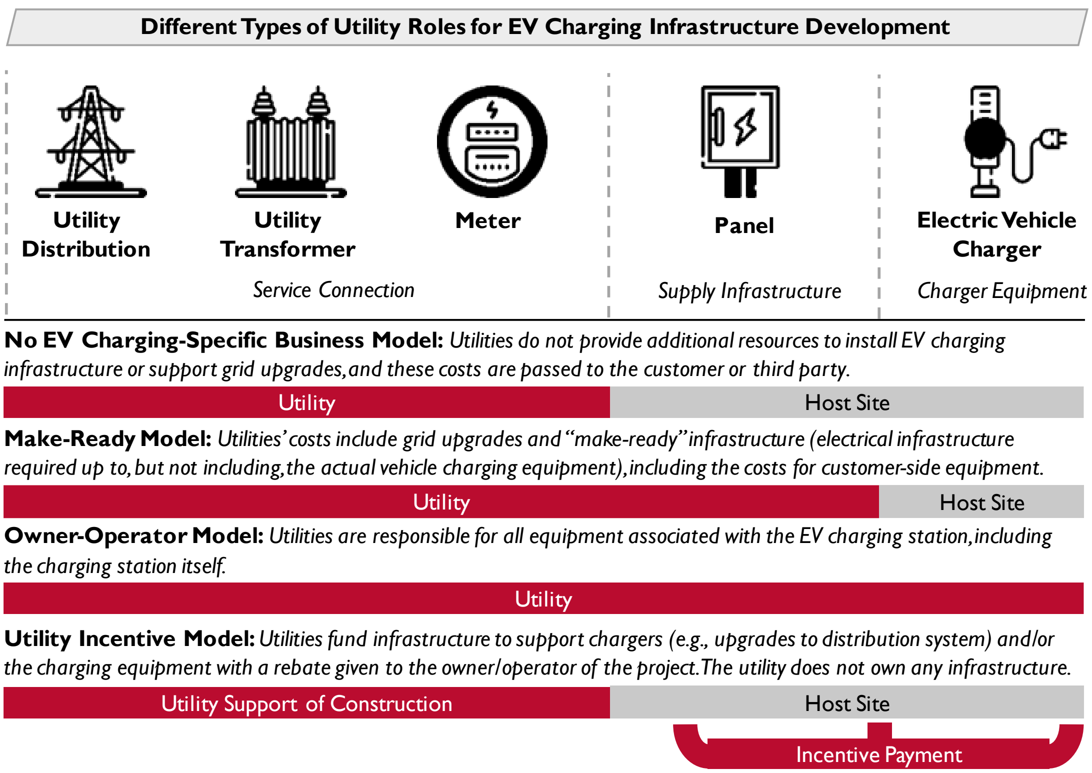
- **Early Stage** – the EV infrastructure market is nascent, characterized by minimal market penetration of EVs and charging infrastructure.
- **Medium Stage** – the EV infrastructure market is young but growing, with a wider variety of companies entering the market.
- **Late Stage** – the EV infrastructure market continues to grow with significant EV charging infrastructure deployment.

Depending on the stage of the EV market, the policy environment, the type(s) of EVs and associated charging infrastructure in use, and the goals or mandates on the utility regarding EV infrastructure rollout, utilities have played different roles in advancing EV charging (Figure 2). In most early-stage EV markets, utilities do not have an EV charging-specific business model; electricity supply for EV charging has simply been part of normal growth of electricity demand. As a result, grid investment costs are recouped from all grid users via regulated tariffs, with no investments geared specifically towards EV infrastructure. In medium- or late-stage EV markets, some utilities have implemented "make ready" programs in which the utility covers all grid upgrade costs including the distribution panel at the charging point, and a charge point operator or developer finances the cost of the chargers.

[iv] Range anxiety is the fear of driving an EV and running out of power without being able to find a charging station to recharge the battery in time. The range anxiety perception is typically exaggerated since most people do not drive farther than their battery's capacity on a daily basis, and overnight home charging can cover most people's driving needs. For example, in the UK, 99% of car journeys are under 100 miles, and in the United States, the average household covers 50 miles a day, both of which are well within the range of most EVs. *Source: https://www.theguardian.com/business/2023/dec/09/stranded-electric-car-ev-range-anxiety-charging-network*

Another model for EV charger deployment is the "owner-operator model," in which the utility invests in grid upgrades and installs, owns, and operates the charging station. Utilities have also supported EV infrastructure rollout through the "incentive model" in which the utility invests in grid upgrade costs in front the of meter and provides incentives either through payment or rebate to the charge point operator or developer to offset all behind-the-meter costs, including the upfront cost of the chargers. The funds for the rebate or incentives are usually obtained from the government in the form of public funding (i.e., from tax revenues). Rebates could also be funded by electricity ratepayers, though any rate increases need to be approved by the regulator.[10]

Figure 2: Utility Roles for EV Charging Infrastructure Development



In most EMDEs utilities do not have an EV charging-specific business model, and given the early stages of the EV markets, utilities have limited experience and familiarity with EV charging infrastructure installation processes and procedures. Such unfamiliarity can be a significant hindrance to the overall development of the EV charging ecosystem since navigating complex and lengthy EV charger grid interconnection processes (due to both technical and operational challenges) can be a major deterrent to private charge point operators, who almost always rely on electricity service from the utility.[11] There are some utilities in EMDEs that have pursued more active models in which the utility plays a larger role in supporting the installation and/or operation of EV chargers. For example, Meralco, the biggest utility in the Philippines, installed an EV charging station at a high-rise building to help promote EVs, which is an example of a utility following the owner-operator model.[12] This report details some of the challenges utilities may face as EV deployment expands in EMDEs, and provides examples of solutions from experiences of countries and utilities around the world.

II. KEY CHALLENGES UTILITIES FACE WITH EV DEPLOYMENT AND LEADING PRACTICE SOLUTIONS

As with the adoption of any new technology, utilities around the world have encountered challenges in scaling EV charging infrastructure. This report details six major challenges utilities have faced while responding to or proactively planning for EV expansion in order of importance: *cost recovery and financing; peak load and EV charging management; EV charger grid interconnection, regulatory permitting, and stakeholder coordination; long-term planning and EV load forecasting; technical standards and rapid technological evolution of EVs and charging infrastructure;* and *consumer awareness and adoption of EVs*. The report also discusses leading practice solutions to these challenges based on the experience of utilities around the world.

1. COST RECOVERY AND FINANCING

Introduction

Over time, widespread EV adoption will result in increased electricity demand, greater network management complexity, and power quality impacts, all of which require additional investment by utilities. At a minimum, utilities will have to invest more in grid infrastructure upgrades, including transformers and lines, to address these challenges. E2Ws and E3Ws require less power-intensive charging infrastructure due to their smaller batteries, so jurisdictions with high levels of E2Ws and E3Ws may require less costly infrastructure upgrades in the nearer-term compared to areas like the United States where BEVs as well as medium- and heavy-duty electric vehicles are the dominant classes of EVs. This is good news for many EMDEs in which two- and three-wheelers are currently a main form of transportation, since the lower cost of charging infrastructure for these smaller vehicle classes and higher demand for them presents a more attractive business case for the deployment of public E2W/E3W charging stations, eventually leading to greater EV adoption.

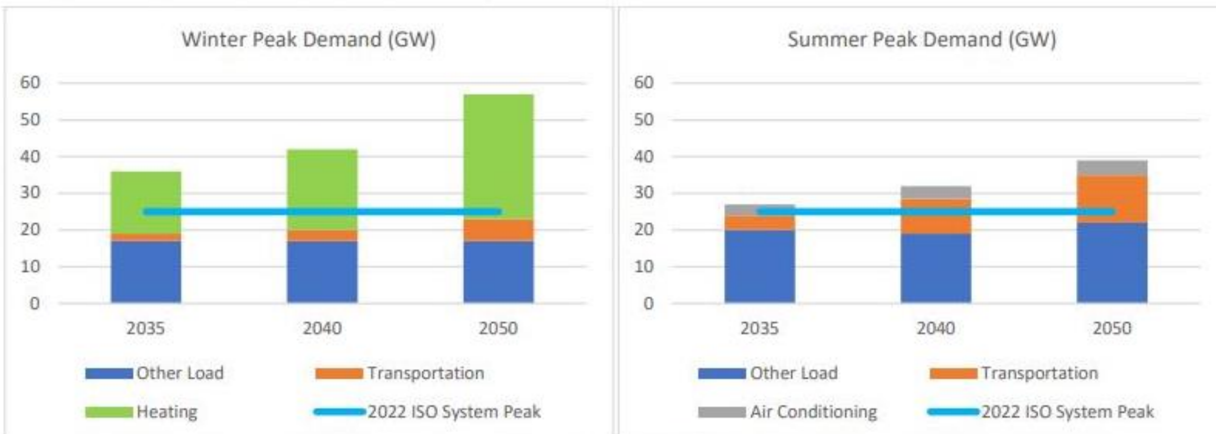
The level of utility investment and cost recovery needed for development of EV charging infrastructure is dependent on the business model the utility seeks to pursue. For example, utilities following the owner-operator model need to recover the costs of developing EV chargers and electrical grid upgrades, while utilities following the make-ready model only need to cover the costs of electrical grid upgrades. Irrespective of the selected business model, utilities should aim to recover capital and operating expenditures incurred for EV charging infrastructure to maintain the sustainability of their business.

Generally, utilities recover grid infrastructure investment upgrades by charging customers a predetermined rate approved by a regulator. Regulators have allowed multiple ways of recouping EV charging infrastructure costs across jurisdictions, and equitable and fair cost recovery for EV charging infrastructure is still a subject of great discussion. Electricity rates are based on a submission made by the utility to the regulator indicating prudent operating expenditure, capital expenditure, and the weighted average cost of capital of the infrastructure upgrade. The utility is then allowed a reasonable rate of return on the investment for business viability.[13] In the case of EV infrastructure cost recovery, passing costs onto all ratepayers has raised concerns about equity and regressive rate design. Some regulators have argued against this practice, stating that such rate hikes force low-income ratepayers to subsidize EV ownership for high-income customers who are more likely to own an EV.[14] Additionally, in most EMDEs, electricity rates for residential customers are subsidized, and rate increases to residential customers are generally unpopular, and in some cases, politically unviable.

As the number of EVs increases in the coming years, especially BEVs and medium-and-heavy-duty EVs, the need for investment into grid infrastructure upgrades will grow due to increased electricity demand. The

New England Independent System Operator, a regional transmission organization in the United States, projected peak electricity demand through 2050 in the winter and summer, including expected electricity demand due to EVs (shown in orange), forecasting a significant rise in electricity demand from transport, particularly in the summer (Figure 3). EMDEs may experience a similar trend as EV adoption increases significantly, and such growth necessitates proactive planning by the utility since rate case approval for grid infrastructure upgrades can take several years. For example, in California, substation upgrades take 5-7 years and new lines require 3-4 years, largely due to the length of the regulatory approval processes.[15]

Figure 3: New England Peak Electricity Demand[16]



Another EV infrastructure challenge is financing the cost of the EV chargers themselves in addition to the grid infrastructure upgrades. Most commonly in advanced EV markets, the cost of chargers has been subsidized through government funding, while in other instances costs have shared between utilities, EV users, and the charge point operator. In the United States, for example, many utilities and EV charger developers have access to government funding (derived from taxpayers) to offset the upfront cost of EV charging stations.

As most EMDEs may be unable to allocate such significant sums to EV chargers from public budgets, some EMDEs have spread costs across different stakeholders in the EV charging ecosystem—including charge point developers and operators, utilities, and EV drivers—in varying ways. This can reduce the financial burden on the utility and avoid rate hikes to ratepayers. For example, in Nepal, the charger developer is required to cover costs of the transformer, line extensions, and any civil works, while the utility pays for any additional generation, transmission, and distribution infrastructure needed to increase the capacity of the main line.[17] This poses a challenge, however, since allocating additional costs to the project developer can disincentivize investment in charging stations, resulting in less private development of public EV chargers. A lack of public EV charging infrastructure can in turn discourage EV adoption. Alternatively, if charge point operators did proceed with developing chargers in a jurisdiction or scenario where they must pay for some of the electrical infrastructure, they would likely pass those costs onto users to recover investments, making EV charging more expensive, which could also discourage EV adoption if users find charging costs too high.

Regulators can also set and approve dedicated EV-charging tariffs (i.e., what charge point operators pay the utility) and fees (i.e., what EV drivers pay the charge point operator), though this is not a very common practice. Limiting the amount that charge point operators can charge EV drivers can reduce the cost to consumers for EV charging and make EVs more attractive; however, setting artificially low fees can make operating charging stations uneconomical, which disincentivizes private sector participation in EV charging infrastructure development. In Jordan, for example, charge point operators are limited to receiving $0.05 per kilowatt-hour (kWh) for AC (Level 2) charging and $0.07 per kWh for DCFC charging. These fees are largely insufficient to cover the costs of financing and operating the EV charging station, especially for DCFCs given the high upfront cost and low utilization rate in early-stage markets. Consequently, this policy is limiting interest and investment in public EV charging station development, making home-charging the predominant method for charging.

Solutions and Leading Practices for Utilities to Recover Costs Associated with EV Charging Infrastructure Upgrades

There are multiple ways to finance EV charging infrastructure as more EV chargers are planned for installation. Globally, utilities have pursued multiple avenues to recover EV-related expenses, such as allocating costs across the ratepayer base, creating differentiated EV charging tariffs and fees, using public funding, and sharing costs with the private sector.

Grid Infrastructure Upgrade Cost Recovery Through Ratepayer Funds: As discussed above, utilities commonly recover costs associated with investment in grid infrastructure upgrades through rate adjustments or tariffs. These utilities usually gain approval from regulators to recover the costs through rate or tariff adjustment and can begin investing after given permission to do so. Historically, utilities have invested in EV charging infrastructure and programs in response to their customers' desire to have such programs, or to meet goals set by policymakers. Recovering EV-related costs through ratepayers is highly dependent on the regulatory and political environment, so utilities should consult with regulators and policymakers early on to understand the perspectives of key decisionmakers. In some jurisdictions in the United States and Europe, some national and state governments and regulators have deemed that service line extensions and distribution system upgrades resulting from EV charging and the deployment of public charging stations themselves provide a public good, and are therefore a justified expense to all ratepayers.[18,19,20]

Differentiated Charging Tariffs and Rates for EV Charging: Utilities and regulators can also create differentiated tariffs and rates according to the type of charging stations (i.e., Level 1, Level 2, or DCFC), if the charging station is publicly- or privately-owned, or if the station is considered residential, commercial, or industrial. In Egypt, the Ministry of Electricity and Renewable Energy set different rates based on ownership of the charging station (public or private) and type of chargers (AC or DC) at the charging station. The fees are:

- $0.055 per kWh for low voltage AC charging stations in public locations (or locations where the charge point operator does not have to pay rent for land usage);
- $0.061 per kWh for low voltage AC charging stations in private locations (or locations where the charge point operator must rent or lease the land); and
- $0.12 per kWh for DCFCs.[21]

The tiered approach acknowledges the varying costs of different charger types that charge point operators must recover to make owning and operating EV chargers viable. Similarly, having different fees for public chargers in private locations recognizes that the operators have higher expenses due to land rental and leasing, and therefore must charge customers a higher rate to have financially viable operations.

To recoup EV charging infrastructure investment and reduce system stress during peak periods, the Electricity Regulatory Authority of Vietnam (ERAV) is considering implementing differentiated EV charging rates based on time-of-use and voltage levels. Electricity consumed for EV charging during off-peak hours costs less, and tariffs for EV chargers connected at higher voltage levels are greater than those at lower voltages.[22] The difference in rates reflects the differences in cost of electricity delivery to the charging stations by the utility. Providing tariffs that reflect the nuances of electricity delivery helps avoid sweeping cost recovery from all ratepayers and instead allows costs to be recovered in a more targeted manner.

EV Charger Cost Recovery Through Ratepayer Funds: Rate recovery mechanisms sometimes also allow utilities to recoup the expenses associated with installing, operating, and maintaining EV charging stations. For example, Xcel Energy, a utility in Colorado, created a program to incentivize EV charging, thereby encouraging EV adoption, in response to state transportation electrification targets. The state's public utility commission authorized Xcel to recover the costs from ratepayers. Colorado residents largely support EV uptake – 68% of Coloradans had a positive attitude towards EVs in a poll.[23] Xcel was able to implement this program successfully given the political and customer support for it. Likewise, Ireland's energy and water regulator authorized ESB Networks, an Irish utility, to spend 25 million euros from ratepayer fees to build a national public charging network.[24] The Irish customer base is receptive to EVs – 70% of respondents in a poll indicated they would consider an EV as their next car, making this move more viable.[25] The state of Maryland in the United States allows utilities that own and operate EV charging stations to pass costs onto ratepayers regardless of whether they own an EV or not.[26] Since 76% of Maryland residents support an expanded EV charging network, this cost recovery was generally accepted by the customer base.[27]

Allowing utilities to pass EV charger costs on to all ratepayers raises concerns over equity. Utilities should carefully assess the impacts of applying sweeping rate hikes on their customer base and attempt to minimize inequitable impacts and financial burdens as much as possible, as this is something that regulators will also be looking to mitigate. Utilities can work with regulators to design rate increases and programs that minimize inequitable effects of rate hikes. Georgia Power, for example, has an EV make-ready program designed to incorporate equity concerns, such that the utility provides ratepayer-sourced funds for EV charging infrastructure with a priority to areas that lack EV charging stations.[28]

Public Funding and Grants: Subsidies, grants, and other government programs have largely supported the upfront costs of public EV chargers in countries with high levels of EV adoption. The primary driver for allocating public funding to support EV charging infrastructure has been the environmental benefits EV adoption will bring. In the United States, the Bipartisan Infrastructure Law provides $7.5 billion of public funding to offset initial capital costs of building a national network of 500,000 public EV charging stations. Of this amount, $5.5 billion has been allocated for the construction of high-speed chargers along U.S. highways, while the remaining $2.5 billion is to be awarded as grants through competitive processes to states and localities for public charging station deployment in places where people live and work.[29] The law also allocates $3 billion to improving the flexibility, efficiency, and reliability of the power system, with a focus on increasing the capacity of the transmission system and facilitating the integration of EVs and other technologies into the grid.[30] Likewise, the Netherlands created an auction system to fund public charging station installations, and utilities were allowed to bid for these funds.[31] In South Korea, the Ministry of Environment installed and operated charging stations in the early stages of its EV market development. Both the Korean Ministry of Environment and the Korea Energy Agency have provided subsidies to private companies building public charging stations to mitigate upfront investment costs.[32] The Korean state-run utility Korean Electric Power Corporation also installs and operates many EV charging stations across the country.[33] Meanwhile, Germany has allocated around $980 million for EV charging subsidies, some of which will go to utilities that are building charging stations.[34]

Public funding is key to spurring EV charging station deployment because it helps offset the high upfront costs of charging station infrastructure in the early stages of market development. This is particularly important to support the development of DCFCs along key cross-country corridors (a primary focus of EV networks in the United States and Europe) but has also helped support expansion of Level 2 chargers in residential and commercial areas. Government support also encourages private sector investment in EV charging station deployment by helping reduce some of the investment risks. Globally, most public EV charging networks have been supported by some amount of public funding.[35] To support EV market expansion, governments can consider providing funding to utilities and private sector charge point operators interested in deploying charging stations to help offset the upfront and operation and maintenance costs once chargers are operational. Use of public funding can also help to mitigate the need to pass costs for EV chargers onto ratepayers.

Private Sector Investment and Public-Private Partnerships (PPPs): PPPs bring together the resources, expertise, and investment capital of both public and private stakeholders to develop and operate EV charging networks and other EV-related initiatives. Private stakeholders involved in EV roll-out such as EV manufacturers are often willing to partner with utilities on charging station deployment. In Brazil, an electric utility company, Energias of Brazil SA, announced the construction of 30 fast-charging EV stations in partnership with Volkswagen, Audi, Porsche, Siemens, and ABB. Volvo Cars has also announced its intention to build recharging points at an average distance of 9.7 km apart in São Paulo, Brazil.[36] The state-owned utility in Barbados, Barbados Light and Power Company Limited (BLPC), is working with a private company known as Megapower to deploy public EV charging stations. Megapower installs the charging stations, while BLPC provides the electricity.[37] In El Salvador, Blink Charging Co., a global manufacturer, owner, and operator of EV charging stations, is working with private utility AES El Salvador to deploy public charging stations across the country.[38]

2. PEAK LOAD AND EV CHARGING MANAGEMENT

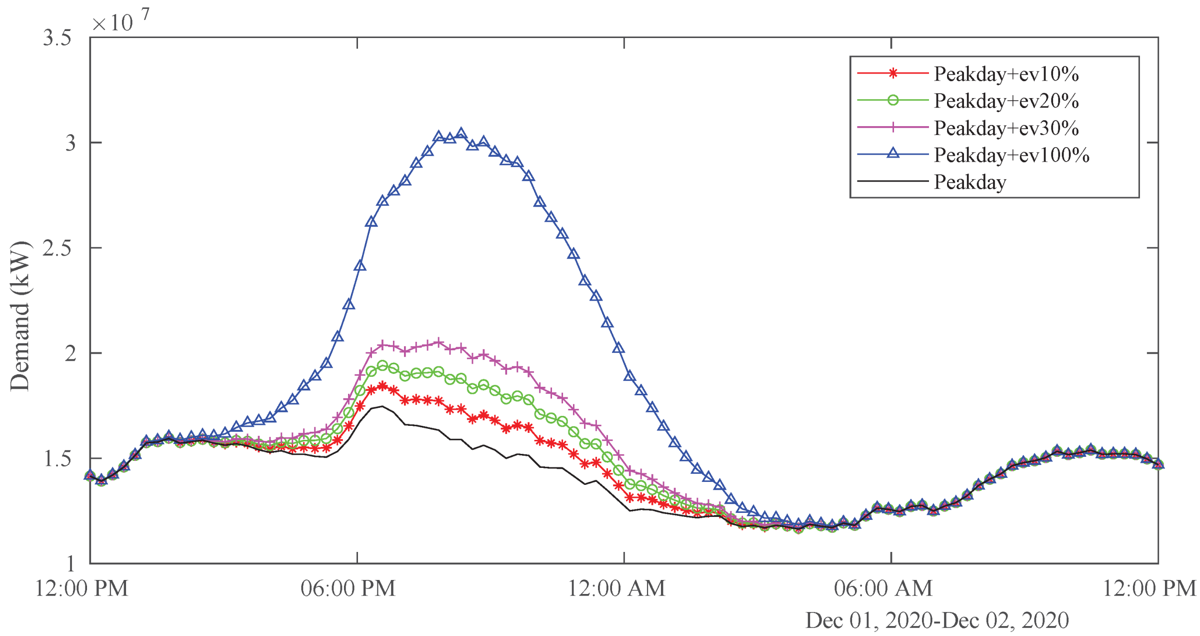
Introduction

Peak load management is the process of reducing or shifting electricity demand away from times with the highest electricity demand, which can reduce costs, improve electric grid performance, and reduce the need for costly investments in generation capacity. If left unmanaged, significant expansion of EV charging in concentrated areas will increase peak loads as people usually charge their EVs during the evenings after returning home from work. DCFCs, which pull a large volume of energy from the grid at once, present the greatest challenges for peak load management because of their high capacity. While a single Level 2 charger has minimal grid impact and does not require involvement from the utility (normally, installation is done by an electrician), EVs tend to concentrate initially in a few neighborhoods due to economic and social factors, such as income levels and socialization of EVs, which over time may result in a high concentration of Level 2 chargers in one area. Such concentration of additional load can necessitate local electrical upgrades from the utility, including adding more distribution capacity to accommodate higher peak demand.[39]

An example of peak load impact is shown below in Figure 4. University researchers modelled how different levels of EV penetration in Thai utility Provincial Electricity Authority's (PEA) service territory could affect peak load demand on the distribution system, if unmanaged. The analysis assumed that EVs are charged as soon as the user arrives home at the end of the day, which in a scenario of a peak demand day and 100% EV adoption leads to the significant spike in demand from around 6:00 PM until approximately 9:00 PM (see the blue line in Figure 4). Though this analysis is hypothetical and represents the effects of very high

EV penetration levels (which the PEA does not currently have in its jurisdiction), it demonstrates how unmanaged EV charging can potentially strain the distribution system, underscoring the importance of peak load management.[40]

Figure 4: Impact of EVs on Utility Peak Load[41]



Utilities face challenges managing EV-related peak load due to a lack of advanced technology, such as advanced metering infrastructure (AMI),[v] a challenge that is particularly acute in EMDEs. While some utilities with AMI have started leveraging it to monitor EV charger energy consumption, they encounter obstacles such as AMI meters' limited real-time data processing capabilities and the high costs involved. Utilities also frequently encounter regulatory hurdles in implementing policies to promote off-peak EV charging, including in EMDEs. Utilities undergo rate cases every 3 to 5 years (though the exact timeframe varies by jurisdiction) to get approval for such initiatives, which slows the process.[42] Furthermore, most EMDEs rely on the cost-of-service framework, which is based on volumetric sales and a return on capital invested. This framework drives utilities to focus on investments that will increase bulk electricity sales, including EV-related sales, rather than on policies to manage and reduce EV-related peak load and support grid reliability and efficiency.

EV charging station siting also impacts how utilities must manage peak load. If large numbers of charging stations are clustered together, they could overload distribution systems if their load is not managed properly. Additional load from EV charging can exceed the transformers' rated capacity, accelerating transformer ageing and causing damage. Even low levels of EV penetration and charger deployment can age and damage transformers because EV charging introduces significant and sometimes unpredictable demands on the electrical grid. The resultant spikes in electricity consumption, particularly when numerous EVs charge simultaneously within the same vicinity, may exceed the designed capacity of transformers, leading to accelerated wear and potential damage.[43] This situation highlights the critical need for grid modernization and the implementation of intelligent charging strategies to mitigate these impacts.[44] EV charging stations could also potentially overload substations if they are added to an area where the

[v] AMI is a two-way communication system to collect detailed metering information across a utility's service territory.

substation is already approaching peak capacity. Therefore, to avoid overloading and damaging their distribution assets it is necessary for utilities to manage peak load, and either lead or guide the appropriate siting of EV charging stations to minimize adverse impacts to the power system.

Effective grid management is necessary to meet the increased electricity demand that increased proliferation of EVs will add while maintaining grid stability and power quality. Without proper EV charging load management, utilities may be unable to meet overall electricity demand, can face high ramping needs due to sharp increases in power demand, risk congestion in transmission capacity, overload feeders and transformers, and have power quality issues.[45] Many utilities in EMDEs already face issues with load shedding and grid congestion, so they must be able to effectively manage additional load from EV charging without compromising grid reliability and integrity.

Peak load management is especially relevant when considering the impact that large EVs, such as e-buses, medium- and heavy-duty EVs, and BEVs, have on the grid when charging via DCFCs, since these vehicles consume a significant amount of power all at once due to their larger battery sizes (compared to PHEVs, E2Ws, and E3Ws, which have smaller batteries and therefore require less power-intensive charging). For example, Tesla V3 Superchargers, which almost exclusively charge BEVs, can deliver up to 250 kW,[46] compared to Level 2 charging stations, which deliver 6.2 – 19.2 kW.[47] It is also important for utilities to plan and coordinate with larger vehicle fleets that operate on tight schedules, since those vehicles may engage in rapid charging events at very high power in congregated areas.[48] Utilities in jurisdictions with many large EVs will need to be more proactive and careful about managing peak load to avoiding straining the grid.

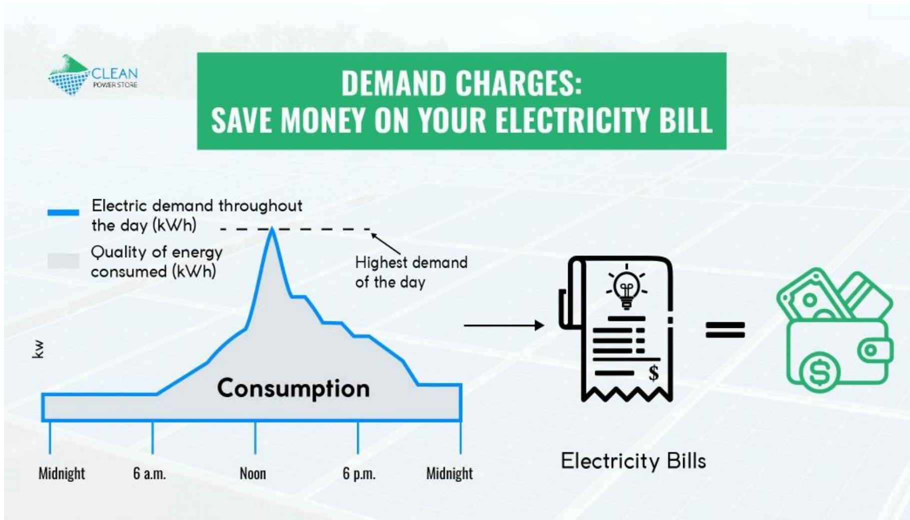
Solutions and Leading Practices for Peak Load and Charging Management

Attempts at minimizing the impact of EV uptake on utilities, charge point operators, and EV drivers using strategic control and optimization of EV charging processes have been pursued globally with varying impacts. These involve implementation of measures related to pricing and scheduling based on the temporal and locational distribution of grid demand. These measures include time variable pricing, demand charges, bidirectional charging [also called vehicle-to-grid (V2G)], and off-peak charging incentive programs.

Time Variable Pricing: Time variable pricing uses variable electricity prices to incentivize or penalize users that reduce or worsen stress on the electrical system during high demand periods. Under this mechanism, electricity prices depend on the level of demand and may vary according to the time of day, season, and electricity market conditions. Electricity prices are higher during periods of peak demand and lower during periods of low demand. There are several types of time variable pricing, such as time-of-use (TOU) rates, real-time pricing, day-ahead hourly pricing, and block-and-index-pricing.[49] TOU rates have been employed by utilities to encourage off-peak EV charging, and have the mutual benefits of reduced EV charging cost for users and optimized grid utilization for utilities. In some instances, utilities have created EV-specific TOU charging tariffs. For example, Thailand's PEA has created two distinct periods of TOU rates for EV charging: on-peak (Monday through Friday from 9:00 AM to 10:00 PM) and off-peak (Monday through Friday from 10:00 PM to 9:00 AM, as well as Saturdays, Sundays, and public holidays), to avoid grid congestion from EV charging. The off-peak charging rate is $0.067/kWh while the on-peak rate is $0.16.[50] TOU rates are more effective when customers awareness of the pricing schemes is high.

Demand Charges: Electricity demand charges for EVs are implemented by utilities to manage the highest aggregated level of electricity used during a billing cycle. These charges are intended to recover the stress that EV charging places on the grid by highly consumptive activities (e.g., charging via DCFC) during periods of peak demand.[51] These charges aim to encourage customers to avoid high energy consumption during peak hours. Demand charges are common globally, though they are usually only applied to commercial and industrial customers.[52] Figure 5 below provides a theoretical example of how utilities charge customers for electricity consumed during times of peak demand.

Figure 5: Demand Charges[53]



While demand charges help manage peak load, they pose economic challenges for DCFC stations since they require high power over short periods of time, resulting in very high demand charges for DCFC charge point operators. Demand charge expenses are particularly acute for DCFCs with low utilization rates – in some cases, demand charges account for 90% of a site host's electric bill, which are not offset as incoming revenue from EV charging is too low, leading to uneconomical charging station operation. Implementing demand charges for EV charging requires a delicate balance between benefits accruing to the distribution grid operator, charging station operator, EV driver, and the environment. To mitigate this issue, some utilities in the United States have started offering DCFC-specific rates and programs for EV charging. For example, Florida Power & Light Co is piloting a charging tariff that has no demand charge and instead uses a flat volumetric rate of $0.30/kWh for DCFC charging. This tariff applies only to charging stations operated by Florida Power & Light Co.[54] Also, China, for example, has exempted public charging stations from demand charges since 2014, an exemption which will continue until 2025.[55]

Utility Charging Management Programs: In addition to rates and tariffs, utilities can create programs and other incentives to encourage off-peak charging. Utilities can either create these programs independently, or collaborate with the private sector. Duke Energy, a utility with operations across the United States, offers customers in certain service territories credits to charge their EVs during off-peak hours. Duke Energy provides customers who charge their EV with a Level 2 charger during off-peak hours a $10 credit to their monthly electricity bill. Off-peak hours are considered Monday through Friday from 10:00 AM to 6:00 PM and 9:00 PM to 5:00 AM, as well as holidays and weekends. Duke Energy is collaborating with a third-party technology company, Itron, which collects charging data through its proprietary automated demand response management system and enables Duke Energy to connect to the car to see its charging profile.[56,57]

Siting and Peak Load Management: Unmanaged load from EV charging stations clustered near each other can cause overloaded transformers and power lines. During the planning phases of EV charging station deployment, as possible utilities should consult with stakeholders such as city planners, property owners, and EV charging providers to strategically site charging stations in a manner that distributes the electrical load more evenly across the grid, thereby mitigating the risk of overloading transformers and power lines. Some utilities and governments have developed and published capacity maps that show distribution lines and their current and planned grid capacity. Charging station developers can use these maps to identify locations to site their charging stations that do not require grid infrastructure upgrades, which reduces project costs and timelines. For example, the U.S. Department of Energy has a public website that consolidates distribution system hosting capacity maps to help with planning and siting of new energy infrastructure.[58] One utility featured on DOE's atlas is Dominion Energy, which has published an EV capacity map tool to provide information about which parts of its electric distribution system are more suitable for EV charging station installation.[59] Such strategic and proactive guidance on the siting of charging stations, coupled with the adoption of peak-load mitigation strategies, will be essential in ensuring that the grid can accommodate the growing demand for EV charging without compromising grid reliability and performance.

Vehicle-to-Grid (V2G): V2G technology is an emerging smart charging solution that allows two-way flow of electricity between the EV battery and the grid rather than the conventional one-way flow of electricity from the grid to the vehicle. Successful implementation of V2G requires a complex suite of advanced technologies on both the vehicle and charger side. V2G at scale in the future presents the possibility of offering enhanced grid stability, supporting the integration of intermittent renewable energy into the electric grid by providing grid balancing services, and helping manage peak loads.[60]

To date, V2G deployments have been limited to demonstration and pilot projects, and only a small subset of commercially-available EVs are V2G compatible (e.g., Nissan LEAF and Ford F-150 Lightning).[61] An ongoing V2G pilot in Germany involves Nissan, TenneT (a transmission system operator in Germany), and Mobility House (a German EV charging technology company) that are using Nissan LEAF vehicles as mobile energy storage systems to reduce local overload in power supply and demand. Mobility House provides the load and energy management software, reducing the amount of electricity interference needed from TenneT and lowering costs.[62] V2G is still in the early stages of market development and will require more research, investment, and development to be a mainstream solution. Prices for V2G chargers are high given the nascency of the industry – a bidirectional Level 2 EV charging station can cost around $4,500 - $5,500, while adding V2G capabilities to an EV can add $200 - 400 to the vehicle price.[63] V2G also requires more complex charging connection processes than traditional EV charging stations, and currently can only be delivered through a limited number of standards.[64]

3. EV CHARGER GRID INTERCONNECTION, REGULATORY PERMITTING, AND STAKEHOLDER COORDINATION

Introduction

Utilities face challenges with EV charger grid interconnection, regulatory permitting, and stakeholder coordination, which can involve lengthy timelines that cause delays for the utility and other stakeholders involved (e.g., charge point operator, EV site host). Inefficient processes can deter interest in EV charger development, thereby slowing EV adoption more broadly. Common utility challenges include effective processing of EV charger grid interconnection approvals (which is sometimes referred to as energization[vi]), participating in time-consuming and complex regulatory permitting processes, and coordinating with

[vi] Energization is the process to connect a new load to the distribution system.

multiple stakeholders, such as the charge point operator, the site host, the charger developer, and local authorities having jurisdiction (AHJs),[vii] such as zoning boards and fire safety departments.

Utilities' EV charger grid interconnection processes to energize a charging station vary by utility and location, but the major steps typically include:[65]

- Charging station developer submits application for utility service;
- Utility designs electric distribution infrastructure and completes final drawings;
- Charging station developer constructs its portion of the infrastructure; and
- Utility constructs and installs electrical infrastructure.

Delays can arise for various reasons, including already-present large interconnection queues and slow utility evaluation and approval processes.

Separately, the regulatory permitting processes for EV chargers can be complex, as codes, standards, and regulations vary by jurisdiction. There can also be several AHJs each with different permitting requirements, making the process lengthy. In some cases, zoning reviews require a public hearing, which adds more time to the project schedule. Regulatory permitting delays primarily affect the entities that are developing, owning, and operating charging station, which include utilities following the owner-operator business model.

Stakeholder coordination and communication is a critical part of EV charger development more broadly as well as for both regulatory permitting and EV charger grid interconnection. If there are unclear lines of communication and a lack of coordination amongst stakeholders, the project can experience significant delays, which add costs. In a survey of U.S. EV charging station developers and operators conducted by U.S. think tank RMI, poor communication between charge point operators and utilities was cited as one of the biggest issues they faced, leading to delays in project development.[66]

Regulatory permitting and EV charger grid interconnection processes can add months or years to a project's timeline with varying cost implications, adversely impacting private sector investment in EV charging infrastructure and delaying EV charger rollout. Delays in project development extend the time required to achieve a return on investment, making the project less financially attractive to investors. In addition, these delays can slow and hinder development of public EV charging stations, which in turn could limit EV sales since having a robust public charging network has historically been a key factor for increased EV adoption.[67]

The following section includes several examples from California, which is one of the most advanced EV jurisdictions in the world due to strong private sector investment coupled with significant policy and regulatory support. Although California's unique circumstances (e.g., political, socioeconomic, financial, etc.) differ (at present) from most other jurisdictions in the world, aspects of the state's policies can provide useful examples and lessons learned which may be applicable elsewhere now or in the future.

Solutions and Leading Practices for Reducing Delays

Utilities will have varying levels of ability and influence to implement solutions to these challenges. Utilities have the most control over the interconnection process as they can facilitate improvements in internal processes to energize the EV chargers. Regarding regulatory permitting, utilities may have a limited ability

[vii] AHJs are "organizations, offices, or individuals responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or procedure." *Source: https://www.newpig.com/expertadvice/know-your-authority-having-jurisdiction/*

to influence the process, which is controlled by the AHJ, but the utility can play a proactive and leading role by convening stakeholders, providing technical guidance and advice, and recommending improvements to processes.

Streamline and Clarify EV Charger Interconnection Process: Utilities should aim to develop processes that provide transparency and support charging station developers in the EV charger grid interconnection process. For example, utilities should clearly communicate requirements and timelines for successful EV charger interconnection to project developers. California utility Southern California Edison (SCE) has published a detailed flowchart and timeline for the EV charging station interconnection process and is explicit about what information developers need to provide. EV charging station developer EVgo praised SCE's transparent process, stating that it was able to install six charging stations in six weeks.[68] Utilities should also proactively communicate with developers about any possible EV charger grid interconnection delays, which can help developers adjust their planning processes accordingly.[69]

To accelerate and enhance the EV charger grid interconnection process further, utilities can develop dedicated teams to connect EV charging stations to the grid. For example, California utility Pacific Gas and Electric (PG&E) has a standalone team to support the interconnection process for EV charging stations which includes account representatives and construction crews. Some EV charging station developers stated that having a team dedicated to supporting EV charging station interconnection improved the efficiency of the process. PG&E also has an online portal where project developers can easily check the status of their projects' implementation.[70] Uniquely, SCE has a dedicated EV charging station team for multi-site EV developers within its service territory. Single EV charging station applicants go through SCE's standard local planning districts.

Even utilities that may not be actively promoting EV adoption should be prepared to respond to interconnection requests from EV customers in the immediate term, and for the possibility of government regulations looking ahead. For example, the state of California, a global leader in EV promotion, passed a law in 2023 requiring its electricity sector regulator to establish average and maximum target energization time periods by September 2024. This law enables faster interconnection times for EV charging stations and increases transparency for utilities so they can accelerate wired connections to the grid.[71] This policy was praised by EV stakeholders and advocacy groups as a critical step to accelerating EV uptake in the state.[72]

Encourage Government(s) to Improve Regulatory Permitting Processes: Regulatory permitting processes are governed by the AHJ and other government agencies, so policies to improve lengthy or inefficient processes are often needed to stimulate change. In 2015, California passed a law requiring all cities and counties to develop expedited and streamlined regulatory permitting processes to facilitate deployment of all types of EV charging stations.[73] In response, city governments in California have been revising and simplifying their regulatory permitting processes, making it clearer and easier for charging station developers to obtain the necessary local permits and establish charging stations. To date, 317 (out of 540 total) jurisdictions have finished streamlining their permitting processes, while 89 jurisdictions are in the process of doing so.[74] The state government has supported local governments' efforts to streamline the regulatory permitting process by creating a permitting guidebook that provides detailed information on optimal regulatory permitting processes. The state also created tools to track which jurisdictions within the state have streamlined regulatory permitting processes so project developers can identify where they can most easily develop charging stations.

Engage Key Stakeholders in an EV Working Group: Utilities in early-stage markets could prioritize convening key EV stakeholders, including the energy regulator, ministries of energy, transportation, environment, and economic affairs, relevant local government entities, automotive importers and dealers, domestic manufacturers of EVs and EV chargers, charge point operators, and consumer organizations. Through working groups or other forums, utilities can solicit inputs on improvements to EV charger grid interconnection processes and regulatory requirements with all stakeholders involved, and together promote policies and regulations that encourage EV adoption and infrastructure deployment.

4. LONG-TERM PLANNING AND EV LOAD FORECASTING

Introduction

In addition to nearer-term issues with peak load management from EV charging (discussed in Section 2), many utilities in early-stage markets are not adequately forecasting long-term electricity demand or planning for the power sector impacts of widespread EV adoption. Accurately forecasting EV-related electricity demand allows utilities to manage grid stability and plan for long-term infrastructure investments. It is also very important for cost efficiency – one study of the British power system estimated that a 1% increase in load forecast error would result in tens of millions of dollars in additional operating costs.[75] Utilities may forecast EV load over various timeframes, ranging from short-term (1-5 years) to long-term (5-10 years) based on their planning needs and rate of EV adoption in their jurisdiction. The frequency of the forecasts also varies, with some utilities updating their forecasts each year while others update forecasts every five years or less.

By rigorously estimating future electricity demand trends, utilities can make informed decisions about upgrading or expanding their infrastructure, such as upgrading distribution networks and increasing generation capacity. These forecasts are important inputs to utility budgeting and ultimately the regulatory filings for rate cases (discussed in Section 1).[76] Failure to accurately forecast long-term EV load growth can result in electricity demand exceeding capacity, damages to equipment, and reduction in power quality.[77] For example, researchers found that South African utility Eskom underestimated the strain that EVs would place on its grid in its 2023 IRP, and that under its current projections and plans Eskom would not be able to manage all the electricity demands in its service territory.[78]

Accurate EV load forecasting is challenging to perform for a variety of reasons. First, new forecasting techniques need to be developed, as current methods do not account for the uncoordinated charging and different load profile of EVs.[79] Additionally, in early-stage EV markets there is no historical EV charging data to inform load forecasting models and methods, and utilities often lack data on current EV charging habits and preferences of consumers in their service territories.[80] Finally, effective long-term forecasting requires collection and management of data which may be challenging, and the design and use of data inventories, models, and analyses that are different from those required for near-term peak load management. Utilities often also do not have the in-house expertise and skills to make precise long-term EV load forecasts.[81] In the United States, utilities typically engage third parties to conduct long-term forecasts, yet researchers have observed that even many U.S. utilities are not incorporating EV load growth or projections into their distribution planning processes; those that do typically lack sophisticated methods for this task.[82]

Solutions and Leading Practices for Long-term Planning and Load Forecasting

Utilities can perform load forecasts themselves or engage third parties with expertise in data analytics and modelling to do so. To conduct these forecasts, data on EV charging habits and behaviors need to be properly collected and analyzed. However, collecting and managing this data is often a challenge. This section lays out approaches utilities can take to improve data collection and management and discusses leading practices for long-term planning conducting EV load forecasts.

Data Collection and Management. There are multiple ways utilities can obtain data, which each have their own considerations, advantages, and disadvantages.

- **Use Advanced Metering Infrastructure (AMI)**: Utilities may have existing AMI and networks, which they can use to assess EV charging loads that require the installation of a new service line. While this approach provides less detailed energy consumption data than submetering (because AMI cannot analyze energy use per charger), it remains a viable option. Challenges and limitations with using AMI arise in locations where a new service line is not required to serve new EV chargers (meaning there is sufficient existing capacity to support the new chargers). Distinguishing EV-related load through the AMI network is therefore challenging as it blends with other loads on the existing meter. Though not all utilities in EMDEs have AMI, the technology is becoming more prevalent. For example, Electricity Vietnam (EVN) deployed an AMI centralized meter reading system in 2017. Costa Rica's utility ICE has 45% customer coverage with AMI,[83] and India is prioritizing the development of AMI across the country.[84,85]

- **Install Submeters**: Utility submeters are devices that are installed downstream of the main meter to measure the electricity consumption of a specific unit or area within a larger system. Submeters can be installed at every charger or at more aggregated levels (e.g., aggregated submetering can be used in instances where AMI does not provide sufficient detail, such as if a new service line is not established). Submetering provides both the utility and the charge point operator with more granular data on EV charging behaviors and profiles, but is more expensive. Many utility companies lack the requisite expertise in submeter installation, compelling them to engage third-party service providers for this specialized task.

- **Promote Use of Smart Charging**: Many newer EV chargers are equipped with features to collect and share data on EV charging activities, which eliminates the need for a separate meter.[86] Xcel Energy Minnesota, a private utility, started a Residential EV Service Pilot in 2018 to assess opportunities to reduce the upfront costs needed to participate in the utility's dedicated EV charging rate. It found that on average it cost $2,196 less per customer to install a smart EV charger than to install a separate meter.[87]

- **Engage Private Sector for Data Migration and Management**: Regardless of how the charger data is collected, it must be transferred or migrated to a data center or server. This data migration is often challenging for utilities. They must effectively manage the influx of data, program meters for interval data transmission, and monitor peak loads and consumption patterns based on historical data. This often requires capital investment in new equipment to support data transfer and migration, system adjustments for data acquisition, and staff training, leading many utilities to engage third-party contractors for data processing and analysis. Additionally, regulatory and jurisdictional constraints may limit utilities' direct involvement in electrical line work after meter installation, further justifying the need for qualified third-party services. Utilities might explore forming alliances with EV charger operators to access data from charging stations, a strategy that has been seen in the United States and Europe, though it remains largely in the pilot phase.[88] Often, it is more straightforward for manufacturers to establish a mesh-wireless network among their chargers, which then transmits energy consumption data to an on-site data collection center. Then, the data could be sent to the utility, either as raw data or following some preliminary analysis, based on the software capabilities of the chargers.

ChargeHub, a North American EV software management company, has a service called ChargeHub Central which collects and visualizes EV charging station usage data in a single web portal and is capable of consolidating charging data across multiple charging operators. This platform is being used by utilities across North America, including Hydro Quebec and BC Hydro.[89] EVConnect, an EV charging services company, partners with utilities to provide insights into customer segment charging patterns and offers advanced EV charging data services to support the ability to accurately forecast EV loads. EVConnect works with utilities such as SCE, PG&E, and DTE Energy.[90] In these examples, the utilities elected to partner with the private sector to get enhanced data and data analytics capabilities as they lacked the internal expertise and technology. These systems face cybersecurity risks and vulnerabilities, so utilities, contractors, and charge point operators also need to ensure they have the appropriate cybersecurity measures in place to protect data and systems.[91]

Load Forecasting and Long-term Planning: Once the data has been collected and transferred to the appropriate data center or collection facility, it must be analyzed to conduct forecasts. The following are leading practices for incorporating EV planning into load forecasting and long-term planning efforts.

- **Improve Load Forecasting and Charging Station Siting**: Load forecasting plays an important role in optimally siting EV charging stations. By forecasting expected EV charging load, utilities can identify locations where grid upgrades are most needed and plan accordingly. For example, the New York-based utility Central Hudson is mapping home charging and public charging station forecasts to substations to understand how these charging stations could impact the electric grid and inform whether upgrades to distribution assets are needed.[92] The type of EVs in a utilities' jurisdiction will also impact how charging stations are sited. Larger classes of EVs engaging in fast charging in a concentrated area will strain distribution assets, so utilities should proactively plan and coordinate with stakeholders to understand anticipated future needs to plan for any necessary grid infrastructure years in advance of anticipated growth of EV charging stations in specific locations.

- **Integrate EVs into Long-term Plans**: To properly plan for the long-term impacts of EVs on the grid, utilities should factor expected EV load forecasts into long-term, cross-sectoral energy planning processes, such as integrated resource plans (IRP), integrated resource and resilience plans (IRRP), and power development plans (PDPs). Incorporating EV load into long-term planning processes allows utilities to understand possible future electricity needs and plan for necessary infrastructure upgrades, so the grid meets customer demands in the long term. Historically, EVs have not played a significant role in utility IRPs/IRRPs/PDPs due to low EV adoption, but EVs are expected to increase in many markets around the world so it is important for utilities to comprehensively plan for the impacts of EVs in their long-term planning processes.[93] California utility PG&E models and quantifies the impact of high EV adoption, enabling it to sufficiently plan for the grid impacts of increased EVs.[94]

- **Partner with Third Parties on Modelling**: Utilities that lack the technical capabilities, resources, and data points required to make an accurate and sophisticated modelling tool can form partnerships with other stakeholders who have these capabilities. An example of this is the EVs2Scale 2023 – a collaborative founded in part by electric utilities and energy companies across the United States with the goal of readying the electric grid to support EV charging station deployment. Partners include data and IT companies such as Daimler Truck North America, PACCAR, and Amazon. Key initiatives of this collaborative include creating a comprehensive visualization to identify EV loads, grid impacts, and utility lead times and a secure data exchange platform for fleet operators and charging providers that allows energy companies to plan and prioritize investments in grid upgrades.[95] Utilities can also partner with private entities on a more individual level. BSES Rajdhani Power Limited, a Delhi-based distribution company in India, worked with the non-profit organization World Resources Institute India to create a tool that quantifies the impacts of growing EV fleets at a distribution transformer level. It is an online interactive tool that calculates total EV loads at grid levels, based on variables like fleet numbers, trip lengths, and charging behaviors.[96]

- **Leverage Publicly Available Forecasting Tools**: In some cases, government agencies or other public entities will develop tools to forecast energy demand to inform utility grid planning efforts. The California Energy Commission, which is the primary energy policy and planning agency for the state of California, developed and released a tool called electric vehicle supply equipment (EVSE) Grid Deployment and Grid Evaluation (EDGE). This tool helps users deploy EV chargers based on available grid capacity and expected energy demand. EDGE compares EV charging demand to grid capacity data sources from utilities. A constraint with this tool is the limited data on primary distribution circuits from utilities – the tool developers note its capabilities could be improved with better data, underscoring the need for utilities to track and provide relevant data.[97] Partnering with public entities or donor organizations, or using already-developed, open-access tools can be especially helpful if the utility does not have enough resources to perform the analysis itself or cannot afford to outsource it. This is also a place where governments can play a role in EV charging deployment as they can provide utilities with forecasting tools.

5. TECHNICAL STANDARDS AND RAPID TECHNOLOGICAL EVOLUTION OF EVS AND CHARGING INFRASTRUCTURE

Introduction

Utilities seeking to add EV charging as a service may lack awareness of the range of technical standards, protocols, and practical elements of operating EV charging infrastructure that need to be considered when installing and operating charging stations. Additionally, as technology improves and advances rapidly, it is difficult for utilities to fully future proof their investments since both EV and charging technologies are constantly evolving. This challenge is made especially difficult in EMDEs that are importing used or new EVs that follow standards and protocols from different countries (e.g., North America, Europe, Japan, and China), such that the EVs on the roads require different chargers and are not compatible with each other. The rapidly evolving EV technology landscape, coupled with the heterogeneous vehicle standards ecosystem, deters utilities and private developers from investing in EV charging infrastructure, since the EVs of tomorrow may not be compatible with the EV chargers of today.

Technical standards govern the design and manufacture of EVs, EV batteries, and EV charging stations, and impact the safe and reliable operation of the EV and charging equipment. EV charging standards define technical specifications which facilitate safe connection between the electric grid and vehicle. Major categories of EV charging standards include:

- **Plug standards**, which are a set of technical specifications that define the physical characteristics (such as pin configuration) and electrical characteristics (such as voltage and current rating, power output) of plugs used to connect an EV to a charging station;
- **Safety standards**, which are requirements manufacturers must follow so their charging systems meet safety requirements such as insulation, overcurrent protection, and protection against electric shock; and
- **EV charger communication standards,** which guide how information is conveyed from the EV to the EV charging station. In addition to the hardware compatibility, communication between the EV charging station and the EV is a critical software component that dictates if the EV and chargers can communicate with one another. Consistent and uniform communication standards allow for interoperability, making EV charging available to all vehicle types.

Table 2 provides an overview of select major EV charging standards.

Table 2: Select EV Charging Standards

Standard	Title	Description	Link to Standard
Plug Standards			
Society of Automotive Engineers (SAE) J1772	SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler	SAE J1772 covers physical, electrical, functional, and performance requirements to support EV/PHEV charging in North America.	SAE
International Electrotechnical Commission (IEC) 62196 Series	Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles	The IEC 62196 series covers the mechanical, electrical, and performance requirements for plugs, socket-outlets, vehicle connectors, and vehicle inlets for connecting EV charging stations to EVs. This series, which consists of six parts, defines Type 1, Type 2, and combined charging system (CCS) connectors. Type 1 connectors are physically the same as SAE J1772 plugs but are defined by the IEC. CCS plugs are configured with either a Type 1 or Type 2 plug on top and DC pins on the bottom. CCS2 is the most common DCFC plug type globally.	IEC
SAE J3400 (North American Charging Standard)[viii]	North American Charging System for Electric Vehicles	An EV charging connector standard based on the Tesla connector. The standard provides the physical, electrical, functional, safety, and performance requirements for conductive power transfer to an EV using this connector.	SAE
IEC 61851 Series	EV Conductive Charging System	This standard series covers the mechanical, electrical, communications, electromagnetic compatibility, and performance requirements for EV supply equipment used to charge EVs, including light EVs. This series is known as CHAdeMO.	IEC

[viii] This standard is currently in the process of being standardized. SAE expects it to be released in fall 2024. *Source: https://www.sae.org/news/2023/12/sae-j3400-tir-released*

Safety Standards			
Underwriters Laboratories (UL) 2594	UL Standard for Safety Electric Vehicle Supply Equipment	UL 2594 applies to conductive EV supply equipment with a primary source voltage of 1000 volts AC or less, with a frequency of 50 or 60 hertz, and intended to provide AC power to an EV with an on-board charging unit.	IHS Markit Standards
UL 2202	UL Standard for Safety DC Charging Equipment for Electric Vehicles	UL 2202 covers safety requirements for charging equipment intended to be supplied with a maximum input voltage of 1000 volts AC or 1500 volts DC.	IHS Markit Standard
UL 2231-1	UL Standard for Safety Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits; Part 1: General Requirements	These requirements cover devices and systems intended to reduce the risk of electric shock to the user from accessible parts, in grounded or isolated circuits for charging EVs. These circuits are external to or on board the vehicle.	IHS Markit Standards
EV Charger Communication Standards			
International Organization for Standardization (ISO) 15118 Series	Road vehicles — Vehicle to grid communication interface	This standard series specifies terms and definitions, general requirements, and use cases for conductive and wireless communication for EV charging.	ISO
Open Charge Point Protocol (OCPP)	Open Charge Point Protocol	OCPP is a standard open application protocol that allows charging stations and charging station networks from different manufacturers to communicate with each other.	OCPP

For an EV charging station to be successfully installed and operated, it must adhere to the appropriate standards and systems in place to function properly and communicate with the EV. However, there are several challenges to implementing these standards. In many jurisdictions with low EV adoption technical standards have not yet been established by the government, so utilities and charge point operators are unsure which standard to use. Even in jurisdictions where the power sector regulator specifies standards, other agencies and private sector stakeholders may not be aware of these standards, resulting in charge point operators not complying with them. Additionally, not all vehicles are compatible with all types of charging equipment, so in early-stage EV markets (especially in EMDEs that import second-hand, older EVs using first generation technology), there may be a mix of EVs that use different plug standards and specifications, making it difficult for the utility (and charge point operators) to determine what chargers to purchase and offer to the market. Although adapters exist for many types of EV chargers and EVs, it is critical to ensure they are certified by a credible international standards body to avoid malfunctions with the EV chargers and/or vehicles as well as fire and safety risks. This has been a challenge in several EMDEs.

Solutions and International Experience with Technical Standards and Rapidly Evolving Technology

Adopt Leading International Standards. Utilities can proactively adopt and implement leading international standards based on the domestic EV market and national and regional trends. Adopting international standards sends a signal to manufacturers, retailers, and consumers to help inform production and purchasing decisions and create market consistency. For example, the PEA in Thailand adopted international standards to govern the installation of EV charging stations, such that the equipment must have a dedicated branch circuit, be installed with overcurrent protection devices and residual current devices, and meet specifications for ground equipment.[98]

Develop Interoperable Charging Stations. Utilities should also make all their charging stations open to the public and interoperable with various vehicle types and payment systems to allow for maximum accessibility. Utilities can achieve this by adopting interoperability protocols like OCPP when developing charging stations. For example, for PEA's Volta charging system, the utility partnered with Mitsubishi and Delta Electronics to provide a network of charging stations that follow OPCC and include AC Type 2, CHAdeMO, and Combined Charging System (CCS) 2 plug standards to enable maximum compatibility and interoperability to consumers.[99,100] Baltimore Gas and Electric (BG&E) in Maryland offers charging stations with multiple plug types, including SAE J1772, CHAdeMO, and CCS 1.[101] In these cases, utilities in various market stages developed charging stations with maximum interoperability so these stations would be as accessible as possible to the greatest number of EV drivers. Another important component of developing accessible and interoperable charging stations is confirming that charging stations can accept multiple forms of payment, including both physical credit cards and mobile payment mechanisms.

Promote Regional Coordination of Technical Standards. Utilities and relevant government agencies can participate in national or regional efforts to promote standardization, cross-border interoperability of charging stations, and trade among member countries. For example, leaders of the Association of Southeast Asian Nations (ASEAN), an intergovernmental organization of ten southeast Asian countries, are looking to establish a unified standard for EVs that includes charging stations.[102] This approach can be useful in jurisdictions and regions with high amounts of cross-border car traffic to allow vehicles originating in one country to be compatible with EV charging networks in neighboring countries.

Maintain and Update Requirements and Standards. Technical standards are routinely updated by the body that issues them to improve their safety and performance. Utilities should stay up to date on the latest standards and update their procedures, infrastructure, and processes accordingly. Adhering to the latest version of technical standards allows for the safe operation of charging stations and compatibility with EVs.

6. CONSUMER AWARENESS AND ADOPTION OF EVS

Introduction

Utilities have a unique opportunity to encourage EV adoption due to their large existing customer base, established infrastructure, and expertise in electrification. In several U.S. EV markets, customers consider their utility to be a trusted advisor when it comes to EV charging infrastructure. Leveraging their direct access to and strong relationship with customers, utilities can develop and implement educational initiatives and marketing campaigns to increase awareness about EVs and promote uptake. State-owned and private utilities usually have different roles and priorities when it comes to fostering EV adoption. State-owned utilities may operate under mandates and government directives to support EV uptake, and thus may take a proactive approach to investing in EV charging infrastructure. By contrast, privately owned utilities take a market-driven approach to investing in EVs and EV charging infrastructure, targeting areas with higher demand and higher potential return on investment.

Utilities, particularly those with a policy mandate or requirement to promote and facilitate EV adoption, must grapple with their customers' frequent limited awareness of EVs and EV programs in their jurisdictions, requiring utilities to create programs to support education and awareness activities. Another challenge for utilities in early-stage EV markets is that they lack dedicated customer service lines and programs to support potential EV adopters. This is problematic because if many EV drivers encounter issues with a utility-owned charger and there is not dedicated support or staff to respond to customer service inquires or complaints, it can discourage EV adoption. Often, resource constraints and uncertain market demand deter utilities from setting up EV-specific programs and campaigns. Having dedicated EV customer service programs and contact channels such as phone lines and websites can provide specialized support and resources to customers seeking information and guidance related to EV ownership and charging infrastructure, making the transition to EVs easier and more attractive to customers.

Solutions and International Experience with Increasing Consumer Awareness and Adoption of EVs

There are several ways utilities can set up campaigns, programs, and service lines to encourage EV uptake, discussed below.

Implement Pilot Programs: Utilities facing uncertain EV market demand can start with small pilot programs and then expand based on lessons learned and program successes and challenges. For example, SCE launched a Charge Ready pilot program and partnered with businesses, local governments, and other organizations to deploy around 1,800 EV chargers at over 100 sites. The program was successful and was expanded to add 38,000 new chargers throughout the utility's service territory in a second phase.[103] Utilities can also make different programs targeting different types of EVs, starting with their own fleets that can be highly visible to the public. For example, Exelon, a utility based in the United States, is working to electrify its vehicle fleet, planning to electrify 30% of its fleet by 2025 and 50% of its fleet by 2030.[104] Utilities can also partner with high visibility fleets (e.g., bus companies and ride hailing companies) to increase the number of individuals experiencing EVs first-hand, which is an effective way to increase awareness. SCE collaborated with a school district in its service territory to deploy e-buses in a pilot program.[105]

Communicate EV-Related Information to Customers: Utilities can also support EV awareness and adoption by sending mailings with utility bills, advertising about EVs in public places, and creating dedicated webpages and websites that contain information related to EVs, such as the process to install an EV charger, a comprehensive list of all EV programs, incentives, and rebates available, benefits of purchasing an EV, and other relevant information. BESCOM, a utility based in Bangalore, India, has a webpage with information and guidelines on how to set up EV charging stations for BEVs, E2Ws, and E3Ws.[106] Figure 6 shows a portion of BESCOM's website with guidance on how to set up an EV charging station.

Figure 6: BESCOM Guidelines for Setting up an EV Charging Station[107]

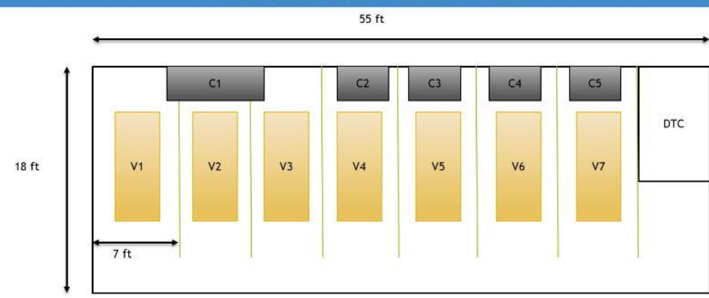
SPACE REQUIRED PER CHARGING STATION

One Equivalent Car Space (ECS) is defined as space required for parking one car and is approximately 2.5m x 5m in dimensions in a community parking.

THE SPACE FOR DIFFERENT TYPES OF VEHICLES

VEHICLE TYPE	ECS
CAR	1.00
TWO WHEELER	0.25
AUTO RICKSHAW	0.50

SAMPLE LAYOUT DIAGRAM OF EVCS



REGULATIONS & GUIDELINES ISSUED BY CENTRAL / STATE GOVERNMENT

PG&E has a dedicated EV webpage as well with information on its EV programs for both residential and commercial customers and the benefits of EVs.[108] Having such information readily available online makes it easier for prospective customers to inform their decision about purchasing an EV or investing in EV charging infrastructure.

Create Educational and Outreach Programs: Utilities can develop outreach programs and campaigns, utilizing their existing customer base to encourage EV adoption and uptake. Utilities can organize workshops and conduct community outreach and education to support EV deployment. For example, Puget Sound Energy (PSE), a utility based in Washington state, engaged organizations, agencies, and residents (including those from marginalized backgrounds) to hear and discuss how PSE could help develop the most beneficial EV programs for all of its customers. Through its engagements with the community, PSE was able to identify six major concerns or barriers to EV uptake.[109] Austin Energy in Texas launched a pilot program called EVs for Schools, which educated students and teachers in disadvantaged areas about the benefits of EVs and their role in sustainability. Following a successful pilot program in four schools, the program curriculum is now offered at 122 schools in multiple languages for further accessibility.[110]

Involve the Private Sector: Utilities can partner with private sector entities such as automakers and car dealers in their campaigns to increase outreach since private entities have their own customer bases and resources to support any campaigns or initiatives. This further enhances the customer experience and encourages greater EV adoption. For example, Austin Energy works closely with several car dealerships to make the EV shopping experience easier and more effective for customers. It has a list of dealers it works with on its website for customers to easily access.[111]

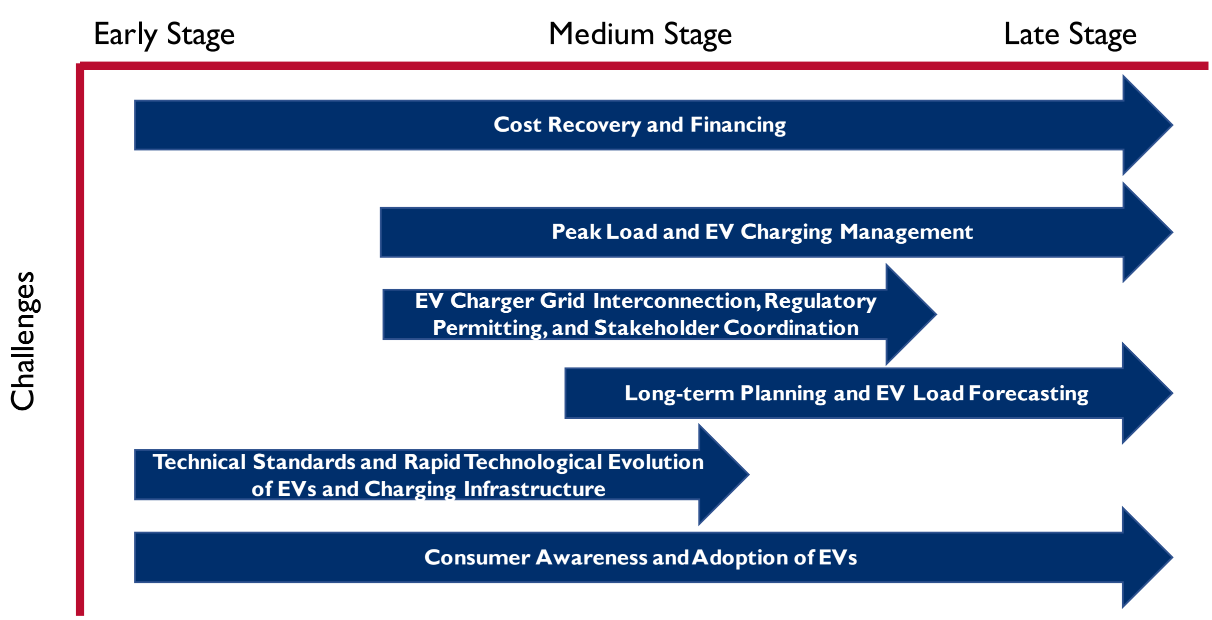
III. CONCLUSION

Utilities have a critical role in supporting EV charging deployment as they manage electrical infrastructure, provide power to charging stations, and regularly interface with their customers. At a minimum, utilities must perform the required grid infrastructure upgrades associated with increased electricity demand from EVs, but their role can be larger, such as owning and operating charging stations themselves.

Utilities have much to gain from a well-planned transition to EVs. In addition to the additional revenue generation from new product and service markets, utilities should profit from capacity expansion investments in their distribution infrastructure if they can shift charging away from peak demand periods. Utilities also play a critical role in planning and siting new charging infrastructure, permitting and installing new connections/meters, and identifying financing options and/or incentives for EV consumers. Utilities can also support the equitable deployment of EV charging infrastructure, either directly or in partnership with public or private sector developers, to further EV market expansion in their service territory (which is especially important since charging infrastructure development is likely to be concentrated in high-income areas where early EV adopters are located). Overall, providing charging services (if done well) can strengthen and improve utility-customer relationships (e.g., if utility-branded chargers are helping to increase EV access among customers).

Utilities planning for and responding to EV charging infrastructure development commonly face challenges with *1) cost recovery and financing, 2) peak load and EV charging management, 3) EV charger grid interconnection, regulatory permitting, and stakeholder coordination, 4) long-term planning and EV load forecasting, 5) technical standards and rapid technological evolution of EVs and charging infrastructure,* and *6) consumer awareness and adoption of EVs.* Different challenges will be more prominent and imperative in early-, middle-, and late-stage EV markets, though most challenges will be relevant across multiple EV market stages. Figure 7 shows how the six different challenges are applicable across the EV market stages, though this may vary depending on the exact circumstances of a given jurisdiction.

Figure 7: The Six Challenges Mapped Across EV Market Stages



Utilities in markets with significant EV adoption provide examples and lessons learned of the potential solutions to these challenges, though solutions for other markets, especially those in EMDEs, require tailored approaches. Table 3 below details some ways that USAID and other donors can provide targeted, strategic technical assistance to utilities and governments to address each of the six challenges discussed in this report.[ix]

Table 3: Recommended Support to Address Key Utility Challenges with EV Expansion

Challenge	Technical Assistance Recommendations
Cost Recovery and Financing	• Supporting the development of cost recovery models (such as the development of differentiated/tiered tariffs) for investments in grid infrastructure upgrades; • Working with governments to create public funding programs or grants for utilities that are investing in EVs and/or charging infrastructure; • Facilitating partnerships with the private sector to access additional expertise and funding sources: and • Conducting impact analysis and supporting design of new or adjusted tariff schedules for EV deployment.
Peak Load and EV Charging Management	• Conducting analyses of current and predicted EV impacts on the grid. This may require facilitating connections with the private sector to enhance real-time energy usage predictions for chargers and vehicles; • Sharing best practices and relevant case studies of how other utilities have successfully approached peak load management; and • Supporting design of programs to encourage off-peak EV charging, such as time-of-use (TOU) tariffs or rebates for charging in off-peak times.
EV Charger Grid Interconnection, Regulatory Permitting, and Stakeholder Coordination	• Convening key stakeholders through an EV working group to build their knowledge of the local interconnection and regulatory processes, connect them with the relevant managers, and develop common understandings and cultivate productive relationships; • Working with national/local government regulatory, permitting, and oversight agencies to streamline and expedite permitting, interconnection, and approval processes; • Providing advisory support to utilities in understanding relevant energy and transportation regulations and laws, building connections between the utility and policymakers where relevant;

[ix] Additionally, Table 4 in Appendix A provides an overarching summary of the main challenges, solutions, and opportunities for donor agencies to support utilities with EV infrastructure development discussed throughout this report.

	- Supporting the utility to understand and navigate their potential role (as applicable) in relevant regulatory processes; and - Helping national/local government agencies get feedback from utilities and EV users on EV-charging related policies and processes and update them as necessary.
Long-Term Planning and EV Load Forecasting	- Helping utilities improve data management and collection, including through advanced metering infrastructure (AMI), submetering, and smart chargers, facilitating partnerships with third parties where necessary to collect, manage, and analyze the data required to conduct long-term load forecasts; - Supporting utilities in conducting or obtaining an EV market outlook based on the data collected or third party research; - Advising on utility EV charging infrastructure investment strategy and goals following an assessment of EV market conditions and outlook; - Supporting utilities in developing or updating IRPs/IRRPs, and PDPs that account for the long-term impacts of EVs on electrical demand; - Working with governments to create publicly available load forecasting tools; - Helping to connect utilities with U.S. and other private companies to conduct load forecasts; and - Assisting utilities to create a transportation electrification plan, including planned investments both behind the meter and in charging station assets.
Technical Standards and Rapid Technological Evolution of EVs and Charging Infrastructure	- Sharing leading practices for utility planning, operations, and management of EV charging infrastructure, including encouraging the development of charging stations with multiple types of plug standards for maximum accessibility, drawing on lessons from the United States and other countries—this would be particularly helpful for utilities exploring the owner-operator business model; - Hosting joint national or regional workshops for utilities and international standards bodies to promote standardization and trade, as well as share information on leading and emerging technical standards and interoperability; and - Supporting peer exchange with utilities that have developed interoperable charging stations—this would be particularly helpful for utilities exploring the owner-operator business model. Donors can support market forecasts of EV adoption in a given service territory or market to advise on possible future trends; and

	• Helping the relevant government agency or industry group maintain and update technical standards regularly with enhancements to safety and performance. Donors can also support utilities in updating plans where necessary to adhere to the latest standards.
Consumer Awareness and Adoption of EVs	• Exploring opportunities for fleet vehicle electrification programs and small-scale EV pilot programs with select customers to demonstrate applicability and feasibility, which can stimulate customer interest; • Working with the relevant government agency or utility to implement education and outreach programs to inform customers about the benefits of EVs and any incentive programs the utility or government has; and • Designing customer engagement strategies with utilities to solicit feedback on EVs to help inform potential EV programs that the utility could present to the regulator.

Overall, there is a significant opportunity for utilities to support the expansion of EVs to advance progress towards national and local energy, transportation, development, and economic growth objectives, and to contribute to global greenhouse gas reduction efforts. As a cross-sectoral technology, EVs bring together stakeholders from across the energy and transportation sectors, and USAID and other donors can support utilities and stakeholders in EMDEs to help them realize their electricity and transportation sector goals.

IV. APPENDIX A

Table 4: Summary of Challenges and Solutions for Utilities Regarding EV Charger Deployment

CHALLENGE	DESCRIPTION OF CHALLENGE	POTENTIAL SOLUTIONS	TECHNICAL ASSISTANCE RECOMMENDATIONS
Cost Recovery and Financing	Utilities must recover costs of infrastructure upgrades associated with increased EV deployment from a limited number of pathways that have regulatory and equity implications.	• Recover costs through rate adjustments (including creative cost recovery mechanisms such as the development of differentiated and/or tiered tariffs). • Utilize public funding to support infrastructure upgrades. • Partner with the private sector to leverage external expertise, access additional funding sources, and spread costs.	• Supporting the development of cost recovery models (such as the development of differentiated/tiered tariffs) for investments in grid infrastructure upgrades; • Working with governments to create public funding programs or grants for utilities that are investing in EVs and/or charging infrastructure; • Facilitating partnerships with the private sector to access additional expertise and funding sources; and • Conducting impact analysis and supporting design of new or adjusted tariff schedules for EV deployment.
Peak Load and EV Charging Management	Utilities face challenges with effectively managing the additional load that EVs will add, which can also impact EV charging station siting. Utilities may not have programs or methods in place to sufficiently encourage off-peak charging.	• Use time-variable pricing such as TOU rates to encourage off-peak charging and mitigate peak load. • Develop other charging management programs (such as providing incentives or credits to customers who charge during off-peak hours). • Collaborate with the private sector to enhance real-time energy usage predictions for chargers and vehicles, focusing on improving grid stability and reliability.	• Conducting analyses of current and predicted EV impacts on the grid. This may require facilitating connections with the private sector to enhance real-time energy usage predictions for chargers and vehicles; • Sharing best practices and relevant case studies of how other utilities have successfully approached peak load management; and • Supporting design of programs to encourage off-peak EV charging, such as TOU tariffs or rebates for charging in off-peak times.
EV Charger Grid Interconnection, Regulatory Permitting, and Stakeholder Coordination	Utilities may delay EV charger grid interconnection approvals. These delays can add months or years to a project's timeline	• Develop streamlined, transparent interconnection processes for quicker approval by creating dedicated EV charger	• Convening key stakeholders through an EV working group to build their knowledge of the local interconnection and regulatory

	and will disincentivize private investment as it wastes money and time.	interconnection teams to review applications. • Work with relevant government agencies to simplify and streamline regulatory permitting, interconnection, and approval processes. • Create or participate in multi-stakeholder EV working groups.	processes, connect them with the relevant managers, and develop common understandings and cultivate productive relationships; • Working with national/local government regulatory, permitting, and oversight agencies to streamline and expedite permitting, interconnection, and approval processes; • Providing advisory support to utilities in understanding relevant energy and transportation regulations and laws, building connections between the utility and policymakers where relevant; • Supporting the utility to understand and navigate their potential role (as applicable) in relevant regulatory processes; and • Helping national/local government agencies get feedback from utilities and EV users on EV-charging related policies and processes and update them as necessary.
Long-Term Planning and EV Load Forecasting	Utilities need to be able to accurately forecast EV load and plan for the long-term impacts of EVs. However, utilities face challenges with collecting, migrating, and analyzing the data required to make accurate load forecasts, often lacking the technical capabilities and expertise to conduct these forecasts.	• Improve data management and collection (required to conduct the forecast) through AMI, submetering, smart chargers, and private sector engagement. • Partner with third parties to conduct the forecasts if utilities lack in-house capabilities to do so. • Integrate EV charging demand into IRPs and other long-term plans. • Utilize publicly available forecasting tools, if available.	• Helping utilities improve data management and collection, including through AMI, submetering, and smart chargers, facilitating partnerships with third parties where necessary to collect, manage, and analyze the data required to conduct long-term load forecasts; • Supporting utilities in conducting or obtaining an EV market outlook based on the data collected or third party research; • Advising on utility EV charging infrastructure investment strategy and goals following an assessment of EV market conditions and outlook; • Supporting utilities in developing or updating IRP / IRRP / PDPs that

			account for the long-term impacts of EVs on electrical demand; • Working with governments to create publicly available load forecasting tools; • Helping to connect utilities with U.S. and other private companies to conduct load forecasts; and • Assisting utilities to create a transportation electrification plan, including planned investments both behind the meter and in charging station assets.
Technical Standards and Rapid Technological Evolution of EVs and Charging Infrastructure	Utilities that seek to add EV charging as a service may lack awareness of the range of technical standards that need to be considered when installing and operating charging stations. As technology improves and advances rapidly, it is difficult for utilities to fully future-proof their investments since both EV and charging technologies are constantly evolving. Additionally, early-stage EV markets can be composed of a mix of EVs with different standards, making it difficult to select which standards to adopt.	• Proactively adopt leading standards based on domestic EV markets and trends (if clear trends are emerging) and develop interoperable and universally accessible charging stations using protocols like OCPP. Develop charging stations with multiple types of plug standards for maximum accessibility. • Promote regional coordination of technical standards to support standardization, cross-border interoperability of charging stations, and trade amongst neighboring countries. • Maintain and update technical standards regularly. Technical standards are routinely updated with enhancements to safety and performance, and utilities should adhere to the latest version.	• Sharing leading practices for utility planning, operations, and management of EV charging infrastructure, including encouraging the development of charging stations with multiple types of plug standards for maximum accessibility, drawing on lessons from the United States and other countries—this would be particularly helpful for utilities exploring the owner-operator business model; • Hosting joint national or regional workshops for utilities and international standards bodies to promote standardization and trade, as well as share information on leading and emerging technical standards and interoperability; and • Supporting peer exchange with utilities that have developed interoperable charging stations—this would be particularly relevant for prospective owner-operator utilities. Donors can support market forecasts of EV adoption in a given service territory or market to advise on possible future trends; and • Helping the relevant government agency or industry group maintain

			and update technical standards regularly with enhancements to safety and performance. Donors can also support utilities in updating plans where necessary to adhere to the latest standards.
Consumer Awareness and Adoption of EVs	Utilities often lack dedicated customer service lines and programs to support potential EV customers, while consumers tend to have limited awareness of EVs and EV programs in their jurisdictions, hindering overall EV adoption rates. Utilities have a unique opportunity to support EV deployment due to their large existing customer base.	• Conduct EV pilot programs in targeted markets and then expand programs based on lessons learned. • Communicate EV-related information to customers. Modes of communication include mailings with utility bills, EV advertisements in public places, and dedicated webpages and websites with EV information. • Create educational and outreach programs to inform customers about the benefits of EVs and any incentive programs the utility may have.	• Exploring opportunities for fleet vehicle electrification programs and small-scale EV pilot programs with select customers to demonstrate applicability and feasibility, which can stimulate customer interest; • Working with the relevant government agency or utility to implement education and outreach programs to inform customers about the benefits of EVs and any incentive programs the utility or government has; and • Designing customer engagement strategies with utilities to solicit feedback on EVs to help inform potential EV programs that the utility could present to the regulator.

V. APPENDIX B

Table 5 summarizes the common EV charger types, the ranges of their typical capacity, charging speed, and cost, as well as the general use cases for these chargers.

Table 5: Typical Charging Types and Characteristics

Charger Type	Charger Capacity	Charging Speed	Average Cost of EV Charger	Use Case
Level 1 AC Charger (sometimes called "trickle charging")	1.3-2.4 kilowatt (kW)	3-5 miles per hour of charging[112]	N/A – typically provided with vehicle	Can fully charge most E2Ws and PHEVs within 6 hours & partially charge BEVs overnight
Level 2 AC Charger	3-43 kW[113]	5-80 miles per hour of charging	$1,370 - $2,700[114]	Can charge E2Ws in a few hours and BEVs overnight
Direct Current Fast Charger (sometimes called "Level 3")	20-350 kW[115]	3-20 miles per minute of charging	$20,000-$150,000[116]	Can charge BEVs ~80% full within 20-60 minutes[117]

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