Smart Electric Power Alliance

The State of Managed Charging in 2021

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In Partnership with

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EnergyHub

E4 The Future

The State of Managed Charging in 2021

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About SEPA

The Smart Electric Power Alliance (SEPA) is dedicated to helping electric power stakeholders address the most pressing issues they encounter as they pursue the transition to a clean and modern electric future and a carbon-free energy system by 2050. We are a trusted partner providing education, research, standards, and collaboration to help utilities, electric customers, and other industry players across three pathways: Electrification, Grid Integration, Regulatory and Business Innovation. Through educational activities, working groups, peer-to-peer engagements and advisory services, SEPA convenes interested parties to facilitate information exchange and knowledge transfer to offer the highest value for our members and partner organizations. For more information, visit www.sepapower.org.

Disclaimer

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ev.energy is the world's leading software platform for residential managed charging, providing utilities and retailers with an end-to-end service across marketing and customer engagement, direct load control and optimization, front-line customer support, and real-time data analytics. Its hardware-agnostic platform provides utilities with direct control of EV charging via either vehicle telematics or networked EVSEs, maximizing load coverage for the utility while maximizing eligibility for customers. Through an award-winning mobile application that can be white-labelled to the utility, ev.energy ensures customer enrolment and retention in residential EV charging programs by providing the customer with transparency over their optimized charging schedule, consumption and savings while delivering behavioral nudges via in-app notifications and email. On the back end, ev.energy's algorithm intelligently schedules charging according one or multiple dispatch signals according to price, carbon, or grid signals provided directly by the utility or a DERMS platform —all while ensuring the driver's vehicle is ready by the time they need it. Launched in 2018, ev.energy manages the charging of over 50,000 EVs worldwide on behalf of utilities including National Grid, Southern Company, Madison Gas & Electric, UK Power Networks, and AusNet Services. To learn more, please visit https://ev.energy

The **OpenADR Alliance** is a nonprofit corporation created to foster the development, adoption and compliance testing of the OpenADR standard. The OpenADR standard supports secure communications to certified systems that manage changes in load shape, energy inputs and power characteristics. Optimizing and simplifying demand side management (DSM) programs continues to be an overarching goal of the OpenADR Alliance. Connectivity and interoperability of customer owned resources are critical requirements for smart grid modernization. As utilities continue to manage the growing industry of customer-provided energy resources including renewable energy, battery storage, DSM assets, and managed EV charging solutions, there will be continue to be growth in interest and adoption of the OpenADR standard. For more information please visit www.openadr.org.

ICF (NASDAQ:ICFI) is a global consulting services company with more than 7,500 employees worldwide. ICF specializes in strategic planning, program implementation, analytics, digital services, and stakeholder engagement. ICF combines unmatched industry expertise with cutting-edge engagement capabilities to help organizations solve their most complex challenges. Since 1969, public and private sector clients have worked with ICF to navigate change and shape the future.

ICF's involvement in the clean transportation industry spans multiple decades supporting federal, state, and utility clients. From the Alternative Fuels Data Center to ENERGY STAR® to a multitude of electrification assessments and programs, ICF draws upon deep subject matter expertise and experience when designing and implementing transportation electrification programs. ICF leverages the full-scale of services in its arsenal and experience with EV-related technologies, market dynamics, driver behavior and adoption trends, policy barriers and opportunities, infrastructure demand, and utility considerations to solve complex, multifaceted issues for our clients.

EnergyHub is the grid-edge DERMS provider. Utilities rely on EnergyHub's Mercury DERMS platform to manage all distributed energy resources to serve grid and market objectives. EnergyHub works with over 60 utilities nationwide to manage more than 2,900 MW of flexible load. We empower utilities and their customers to create a clean, distributed energy future.

EnergyHub empowers utilities to adopt a customer-centric approach to leverage EVs as flexible assets. The Mercury DERMS platform allows utilities to monitor, coordinate and orchestrate EV charging in concert with other distributed energy resources (DERs) across the grid hierarchy, all while enabling customer choice and accounting for customer preferences. The Mercury DERMS platform enables all aspects of EV management—from customer acquisition and data monitoring to managed charging. EnergyHub's EV suite of solutions are built to support the dynamic and iterative nature of EV programs. They enable customer choice, manage multiple brands and classes of DERs at scale, and integrate with complementary utility systems to unlock value across the utility enterprise. The Mercury DERMS also delivers the ability to manage EVs as part of a multi-DER grid service strategy. Some key managed charging clients include National Grid, Eversource, Baltimore Gas and Electric, and Potomac Edison. For more information, visit www.energyhub.com.

E4TheFuture is a small nonprofit with a big mission. We are dedicated to bringing clean, efficient energy home for every American. E4TheFuture promotes energy solutions to advance climate protection and economic fairness. Our four key focus areas—reflected in our name—are: Energy, Economy, Equity, and Environment.

Smart Electric Power Alliance

About This Report

This report aims to provide an overview of major developments in the EV managed charging landscape that have occured since the publication of the 2019 SEPA report "A Comprehensive Guide to Electric Vehicle Managed Charging." New readers are encouraged to review the introductory chapter of the 2019 report for a basic overview of managed charging. This 2021 report provides an update on the utility perspective on managed charging and what has shifted since 2019, a review of existing managed charging programs, an update on managed charging technology and vendors, and a set of managed charging case studies that highlight the major advances made since 2019. This report does not provide a detailed review of managed charging communication protocols. Readers interested in communications protocols are encouraged to explore our 2020 publication "Guidelines for Selecting a Communications Protocol for Vehicle-Grid Integration" for an in-depth review of the subject.

SEPA published a complementary report in October 2021 "Managed Charging Incentive Design: Guide to Utility Program Development" that provides a detailed review of managed charging incentives, program design best practices, key insights and lessons learned from utilities, and recommendations for incentive structure and program recruitment.

Table 1. Report Overview

Section	What Is in This Section
Chapter One: Introduction	Provides an overview of the US electric vehicle market and an introduction to managed charging. Also defines the different approaches to managed charging.
Chapter Two: Utility Outlook On Managed Charging	Presents the results of SEPA's national utility survey on managed EV charging. Further defines the managed charging program design options including optimization strategies, resource considerations, customer segment selection, and program motivations. Assess trends in the utility approach to managed charging and what has changed since 2019.
Chapter Three: Managed Charging Case Studies	Reviews seven managed charging programs that highlight the different approaches covered in this report. Each case study is based on a set of interviews and presents a summary of the program, program goals, program partners, approach, incentive structure, successes, challenges, and key takeaways.
Chapter Four: Managed Charging Technology and Vendors	Provides a review of the current vendor landscape and what has shifted since 2019. Defines the most common EVSE technology classes and presents a review of the number of vendors offering each technology class. Also presents a summary of EVSE messaging protocols and the number of vendors utilizing each. Defines vehicle telematics and addresses the benefits and limitations of telematics in the context of managed charging.
Chapter Five: Conclusion	Summarizes the key recommendations for utilities, regulators, solution providers, and other stakeholders to design, implement, and expand managed charging programs.
Glossary	Includes a comprehensive list of terms used in this report related to managed charging.
Appendix A: Utility Run Managed Charging Programs	Includes a comprehensive list of utility-run managed charging programs.
Appendix B: Equipment Manufacturers	Includes a comprehensive list of EV charging equipment manufacturers with managed charging-capabilities.
Appendix C: Network Service Providers	Includes a comprehensive list of Network Service Providers.

Source: SEPA, 2021

Chapter One: Introduction

According to the World Resources Institute's 2020 State of Climate Action Report, the global electric vehicle (EV) stock will need to increase by a factor of 22 by 2030, compared to 2017 levels, to keep global warming below a 2° C rise. That would mean that roughly 50 million of the nearly 300 million vehicles in the US need to be electric by the end of the decade. While the rate of EV adoption is challenging to forecast, and the projections of EVs on American Roads by 2030 (IHS, Brattle Group, IHS Markit) range from 10 million to 35 million or more, it is clear that American EV adoption has taken off. The market share of EV sales in the US increased from 1.5% in H1 of 2020 to 2.5% in H1 2021, and according to the Veloz Sales Dashboard, EV sales in Q2 2021 made up 3.6% of total vehicle sales volume in the United States and more than 6.5% globally. Using an average of those forecasts, the impact of 25 million EVs on the US power system will generate roughly 100 terawatt-hours of new electricity demand annually, or an approximately 2.5% increase from today's annual electricity consumption.

From an energy generation perspective, utilities are unlikely to have issues meeting this additional demand. However, when considering the potential impacts of coincident system- and feeder-level peaks, the need for managed charging becomes clear. Managing EV charging is a key tool that utilities, network operators, and retailers can use to avoid distribution upgrade bottlenecks and mitigate unnecessary stresses on and costs to the power grid. However, managing the charging behavior of millions of disparate private and publicly-owned vehicles will require significant effort on the part of the utility, the Original Equipment Manufacturers (OEMs), Network Service Providers (NSPs), and customers.

This report provides an overview of how the managed charging ecosystem has evolved since the 2019 SEPA managed charging report 'A Comprehensive Guide to Electric Vehicle Managed Charging.' For a definition of terms related to managed charging, please refer to the Glossary at the end of the report.

The Opportunity for Managed Charging

Over 99.5% of US drivers have never charged an EV, and as a result they are unlikely to have any default charging preference other than what appears convenient to them. For some, that may mean following the gas-fueling norm of recharging their battery when it approaches a near-zero state of charge by driving to a public charging station and recharging quickly. For others, it may mean plugging their car in every time they arrive home to keep the battery level consistently topped up. Some EV drivers may choose to plug in at work or at retail parking areas when they are off running errands. While these are all common methods of charging an electric vehicle, none of these charging approaches are optimal for the power system and simple changes in the ways people charge their vehicle can have significant cost savings, improve grid stability, and reduce carbon impacts for both utilities and their customers. Implementing managed charging programs before grid impacts materialize and before unfavorable charging habits develop will save both utilities and customers money and hassle in the long run.

Most personal vehicles are stationary for 22 or more hours daily and are likely within a few hundred feet or less from existing electrical infrastructure.[1] Combined with the fact that the typical EV requires 15 kWh (PHEV) and 22 kWh[2] (BEV) or less per residential charging session on average, which can be delivered in 2-3 hours on a level 2 charger, there is a massive potential to manage residential charging. Importantly, this can be done without any disruption in the driver's ability to meet their transportation needs. Similarly, many fleet vehicles operate on a fixed or predictable schedule that leaves them unused for significant portions of the day. For example, school busses are in use in the morning and afternoon hours and sit unused during the day and at night and are largely unused during the summer. Other fleets may operate in shifts where the vehicle is in use for 8-10 hours and then returns to a depot for the rest of the day. These periods when fleet vehicles are not in use represent a similar level of charging flexibility to residential charging.

1 Data from a Department of Transportation Volpe Center report in 2017 on American Driving Habits.

2 Data from 53,000 sessions in Avista's 2019 EVSE pilot final report indicated 7.6 kWh per residential session; Data provided by ev.energy based on 1 million sessions indicated 22 kWh per session; Data from OPPD indicated 73% of residential Level 2 charging sessions were 15 kWh or less per session.

Residential, workplace, public Level 2, and public DC fast charging (DCFC) have different levels of load flexibility. Residential charging has the longest potential connection time from after work through the next morning (roughly 12-14 hours), and represents the greatest potential for shifting load. Workplace charging is slightly shorter duration and typically occurs during the day (roughly 8 hours). While this offers a shorter window of charging, it has good overlap with potential excess solar generation for people who work a 9-to-5 schedule. It is important to note that not everyone operates on a 9-to-5 schedule and working hours occur during all times of day, residential and workplace charging programs need to consider a diverse range of working schedules. Public charging offers the lowest level of flexibility, especially DC fast charging which typically requires the EV owner to make a dedicated trip and is expected to be completed in the shortest possible time. Each EV charging application and customer segment will have different price elasticities and therefore will offer different degrees of managed charging potential.

To capture these different levels of load flexibility, utilities and OEMs are exploring various approaches to shift and optimize EV charging on their systems. Research in this report shows in large part that managed charging programs have been successful at changing charging behavior to meet utility objectives. Many managed charging programs are often described as pilots or are designed with customer participation caps. There is increasing consensus that well designed and implemented programs will result in a more streamlined and cost efficient transition to electrified transportation and will deliver a long-term return on investment.

The Evolving Approach from Passive to Active Managed Charging

Utilities have been exploring managed charging for several years now. SEPA has tracked and documented over 90 utility managed charging pilots and programs over the past 5 years (2017 - 2021). Over this period, managed charging programs have grown in number, program size, sophistication, and diversity in approach. In the mid 2010s, Time-of-Use rates (TOU) and behavioral or passive managed charging was the norm, and pilots were designed to explore customer responsiveness to on- and off-peak pricing, with the customer responsible for charging off-peak.[3] In recent years as EV adoption has increased significantly and the prevalence of connected devices, or Internet of Things (IOT) technology, has become standard, managed charging programs are moving towards a more sophisticated form of active managed charging through direct load control. Utilities are increasingly interested in implementing active demand response programs or continuous orchestration of EV charging through multi-layer optimization. Utilities having more experience with managed charging are interested in moving away from "event-based" managed charging.

Since the last SEPA managed charging report was published in 2019, the concept of managed charging has continued to mature and is now widely accepted as a fundamental component of planning for electric vehicles. While the state of the art has evolved, the basic categorization of passive and active charging remains the same.

Passive managed charging (also known as behavioral load control) relies on customer behavior to affect charging patterns. For example, EV TOU rates[4] provide predetermined price signals to customers to influence when they choose to charge their vehicles. The customer determines when to charge the vehicle. An EV owner may manage their charging session by delaying when they physically plug their vehicle into the charger or by setting a predetermined charge start-time for their vehicle or charger.

TOU rates can be an effective second step (after understanding EV charging loads) to manage regular, predictable charging behavior. TOU rates may be appropriate for residential charging for Level 2 stations but may not be appropriate for public DC fast charging stations, where it is more difficult for drivers to plan their routes or change charging behavior or time to avoid higher priced rate periods. Additionally, as demonstrated in more detail below, TOU pricing may lead to "timer peaks" or "snapback" events due to the uniformity of signal sent to drivers.

Active managed charging (also known as direct load control) relies on communication (i.e., "dispatch") signals sent from a utility or aggregator to a vehicle or charger, in order to optimize EV load by turning charging on and off. Active managed charging can take the form of an events-based approach where the load is controlled during a limited number of events (e.g., demand

3 See the glossary for a definition of time-of-use rates. The interested reader can learn more about effective TOU rate design in SEPA's 2019 publication "Residential Electric Vehicle Time-Varying Rates That Work: Attributes That Increase Enrollment."

4 At present, 39 states and the District of Columbia have concluded that the provision of EV charging services is not a public utility function and therefore are not regulated entities. EV charging station site hosts and operators have the ability to establish pricing and pricing policies for EV charging services located on their premises.

response) in a given time period (season or annually) or a continuous management approach where the load is controlled continuously when the EV is plugged in (e.g., shifted to off-peak hours). Active managed charging enables a centralized entity or the customer to take direct control of charging load. These approaches allow utilities or aggregators to start, limit, or stop the rate of charge temporarily during times of high demand without materially impacting overall EV charging.

Event-based load management can be scheduled to expire after a period of time, returning the equipment to normal maximum power output, or the event can be immediately rescinded. Demand response events can be programmed to occur for individual charging ports or a desired group of ports.

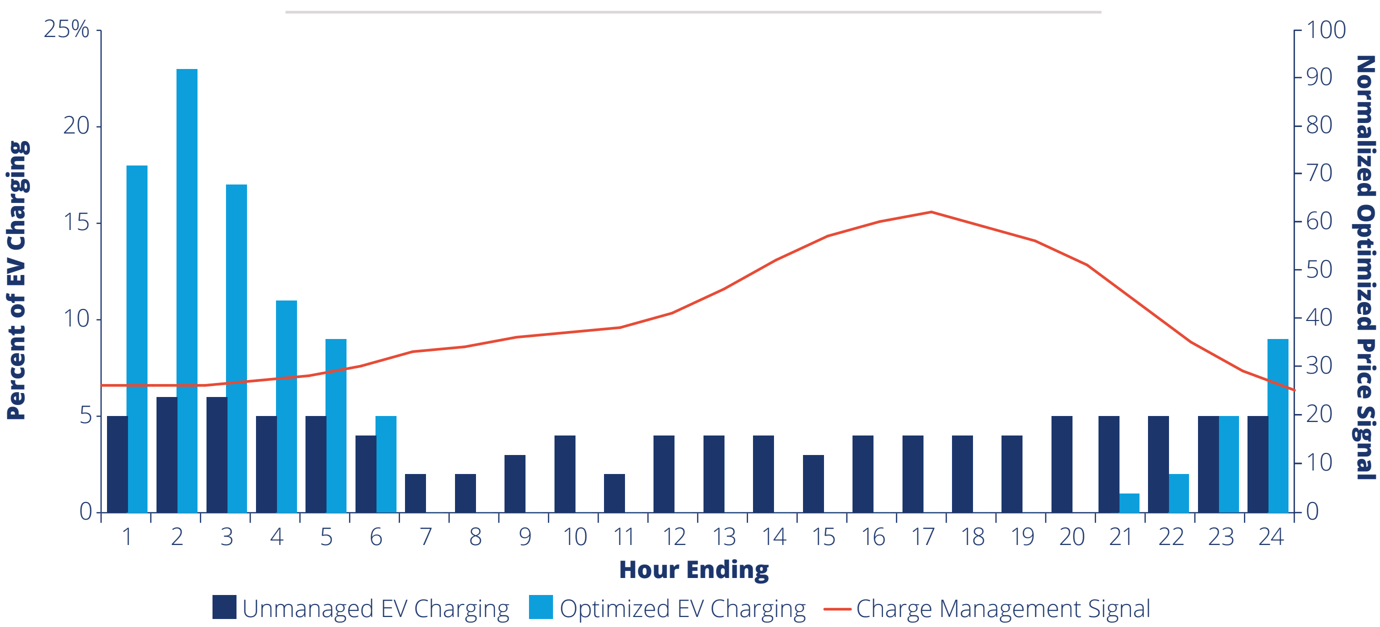
Continuous managed charging, also known as dynamic managed charging, considers real-time or near real-time grid conditions to continuously adjust the EV load to maximize value or minimize costs. Dynamic managed charging optimizes EV charging schedules in coordination with variable utility signals (e.g., wholesale energy prices, carbon intensity of the generation mix, or network constraints from a Distributed Energy Resource Management System (DERMS) platform) while ensuring driver needs for range and departure time are met. This optimization can avoid "timer peak" and "snapback" effects which may occur with traditional time-of-use rates or Demand Response (DR) events. Figure 1 shows an example of how an arbitrary price signal (red line) is used to optimize unmanaged charging profiles (dark blue bars) continuously to a dynamic charging profile (light blue bars). In this example, the red line could represent carbon intensity or price and the dynamic optimization shifts load to minimize cost or carbon emissions while meeting drivers' charging needs.

Multi-layer optimization is an approach to managed charging that considers system constraints at both the bulk level and at the distribution circuit level while simultaneously considering the driver's charging preferences. Grid conditions vary across time and location, and what may be optimal for the bulk system may increase congestion on segments of the distribution network. Multi-layer optimization can help identify potential challenges with high EV penetration and orchestrate individual EV charging schedules that co-optimize for driver preferences, distribution constraints, and bulk system considerations.

Figures 2 and 3 show how bulk system optimization can create overload conditions at the distribution level (Figure 2) and how multi-layer optimization can mitigate those conditions (Figure 3).

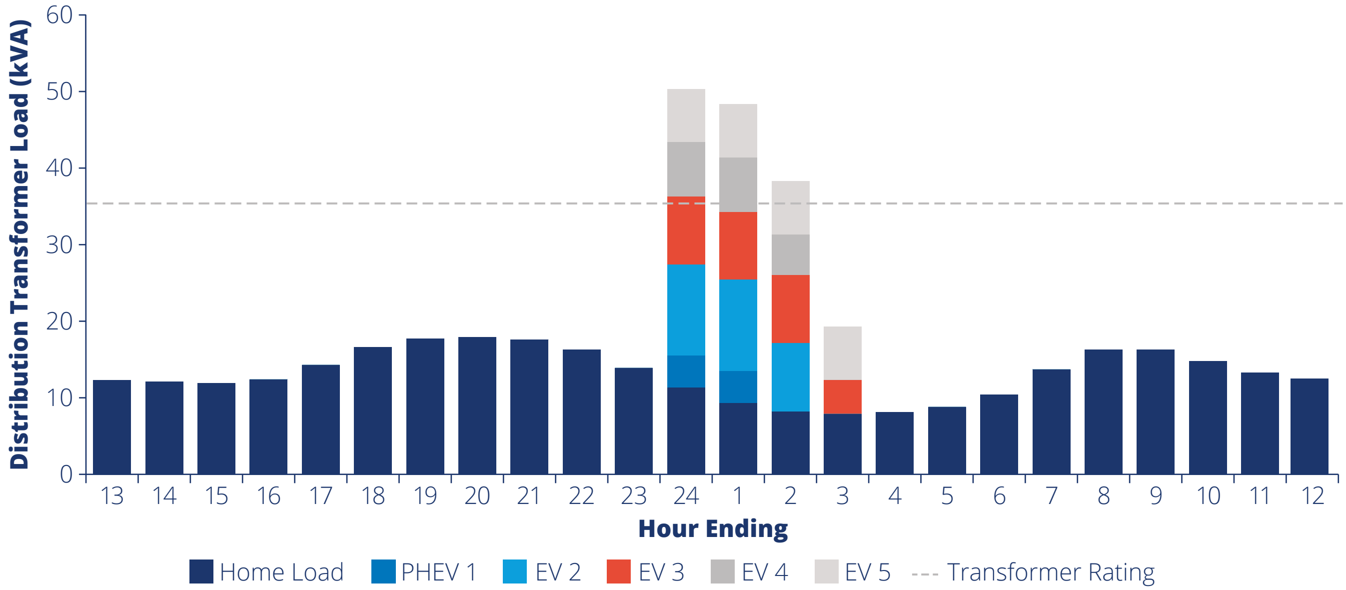
In the next chapter we explore how the landscape has evolved over the past several years and identify key trends in how utilities are approaching managed charging.

Figure 1. Using Dynamic EV Managed Charging to Optimize Charging Behavior



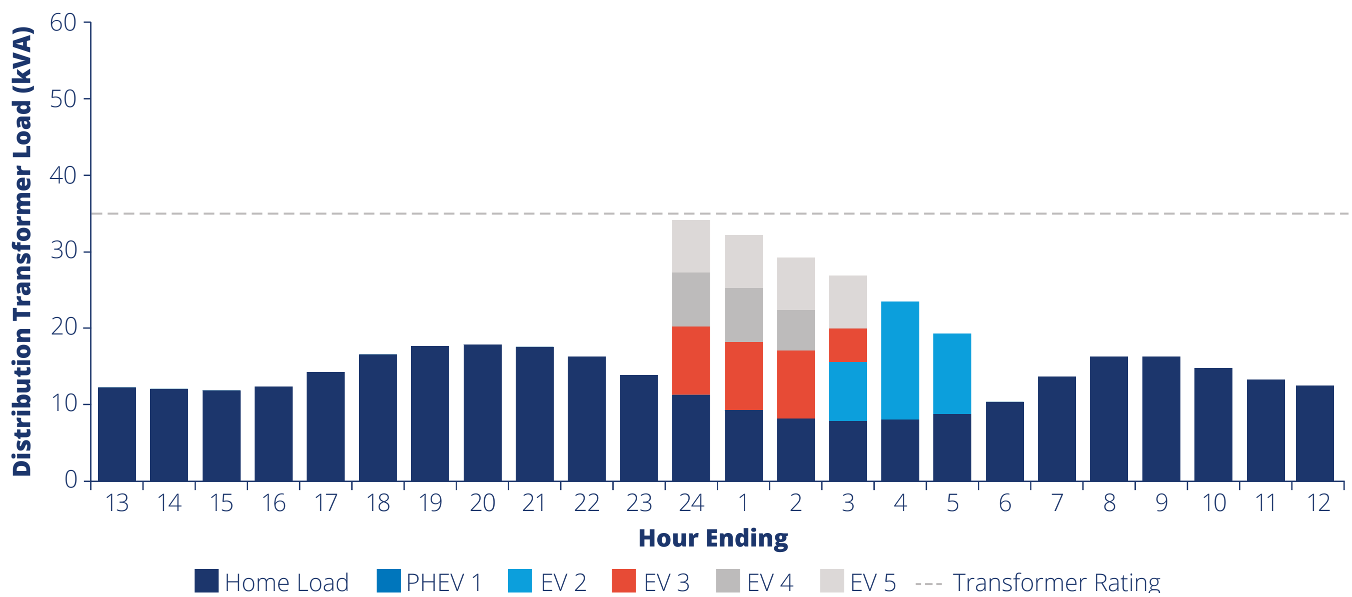
Source: Data and charts provided by WeaveGrid, Inc.

Figure 2. Illustrative Example of How Time-of-Use Optimization at the Bulk System Level can Create Overload Situations at the Distribution Transformer Level



Source: Data and charts provided by WeaveGrid, Inc.

Figure 3. Illustrative Example of How Multi-Layer Optimization can Co-optimize for Bulk System Time-of-Use Signals and Distribution Level Constraints and Maintain Driver Charging Needs



Source: Data and charts provided by WeaveGrid, Inc.

Chapter Two: Utility Outlook on Managed Charging

Managed Charging Program Options

At the date of publication, SEPA identified 58 utilities with managed charging programs, several of which have two or more unique programs, resulting in 71 ongoing managed charging programs in the United States (Figure 4). This is a notable increase from the 26 active programs identified in 2019. Programs are one of four types:

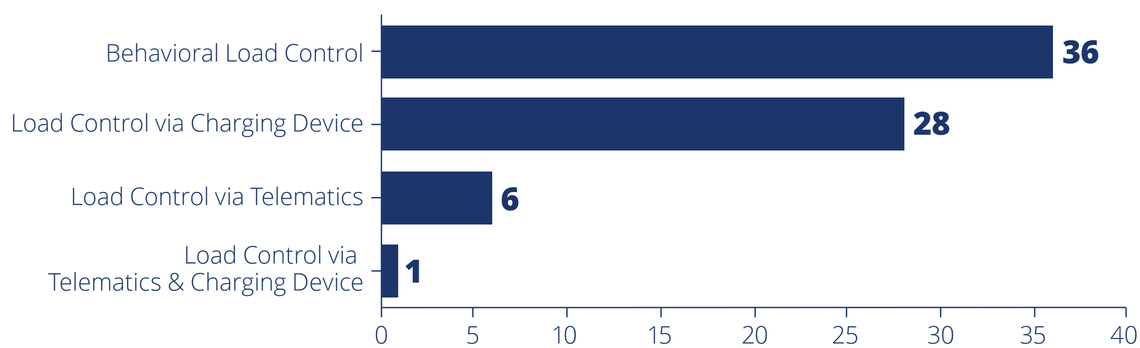
1. Utility-run load control via the charging device;
2. Utility-run load control via vehicle telematics;
3. Customer load control via behavioral changes; and
4. Customer load control via 3rd-party charging optimization.

The differences among the four archetypes above are primarily due to whether they support active or passive managed charging and what technology type the charge management relies on. Utility-run load control via the charging device or vehicle telematics are active managed charging archetypes, typically seen in demand response and dynamic/continuous load control programs. Customer load control via behavioral changes or 3rd-party charging optimization are passive archetypes, typically seen in TOU and simple off-peak programs, although some of these programs have evolved to include active load control. See Appendix A for further details on utility programs.

Active Utility Control

Utility-run load control via the charging device, known as active networked charging, involves the utility actively interacting with networked electric vehicle chargers.[5] Of note, utility control can occur by sending charge signals through a Network Service Provider (NSP) platform or through a utility system, such as a DERMS platform (See Chapter 4 and Appendix C for more details). As of this report, 29 programs exist with active control through the EVSE, an increase from the 17 in 2019. Of the 29 active networked charger programs, 72% of them included subsidization of the networked EV chargers either through customer rebates or direct utility ownership of the devices. Load control via vehicle telematics, known as active telematics, involves coordinating the EV charging through the vehicle's on-board system and connection to the OEM's cloud-based data system. Since 2019, 4 additional utilities have adopted telematics programs and one pilot program ended, which results in 7 telematics programs compared to the 4 in 2019. Many of the ongoing active telematics programs feature compatibility with OEMs, such as BMW, Chevrolet, Ford, General Motors, Honda, Land Rover, Jaguar, Nissan, Tesla, and Volkswagen, to optimize the charging. Both active networked charging and active telematics are heavily associated with demand

Figure 4. Ongoing Managed Charging Programs in the US



N=71. Note: Some utilities have multiple programs.

Source: SEPA, 2021.

5 In designing a managed charging program, consideration should be given to the value of maintaining ability for site hosts to opt out of utility-managed/controlled actions (e.g., calling a demand response event)

response programs. 79% of the active networked charging programs are demand response programs. Similarly, 4 out of the 7 active telematics programs are only demand response, one of the active telematics programs uses both demand response and dynamic load shifting, and two are pilots studying off-peak charging behaviors.

Passive Behavioral Control

Customer load control via behavioral changes, known as behavioral load control, utilizes financial incentives and/ or behavioral feedback to encourage customers to change their daily charging habits. Behavioral load control relies on customers either programming or manually plugging in their EV to charge during the utility's identified off-peak times, or unplugging their EV during a demand-response event. Incentives include one-time enrollment bonuses, monthly participation payments, and off-peak rebates that vary according to the amount of off-peak charging the customer employs. It is important to note that passive behavioral control programs can make use of networked chargers and vehicle telematics by encouraging the customer to program the device directly, through a mobile app, or through a web application. Since 2019, behavioral load control offerings have increased, with 36 programs in 2021 compared to the 5 in 2019, indicating a growing increase in utility interest in encouraging customer behavioral changes (Figure 4). In part, the growing number of behavioral load control programs, especially TOU, is due to regulatory support and mandates. Some states have adopted more comprehensive measures to promote behavioral load control. As part of a push for cleaner energy usage, the California Public Utilities Commission mandated that all customers be automatically opted into a TOU rate, with the transitions occurring between 2019-2022.[6]

Customer Led Cost Optimization

Third-party optimization has been primarily targeted towards vehicle fleets and largely relies on existing price signals such as customer TOU rates and demand charges. Third-party optimization does not necessarily need utility oversight to create a charging schedule and has historically been outside the scope of utility managed charging programs. Since our 2019 report, more utilities have entered the fleet charging space, primarily targeting electric school bus fleets (see case studies section for details). Both utilities and fleet customers typically partner with NSPs that have charging optimization software and offer mobile apps for end-user usage (see Appendix B for list of NSPs). These charging archetypes differ as to whether or not the utility has direct input into the program design and remains an active partner (see case studies for examples of utility- and customer-led fleet programs).

It is important to note that active and passive managed charging are not mutually exclusive and often complement each other. Approximately 25% of the identified utilities utilize both passive and active managed charging strategies in their program offerings. Seven of the fifteen utilities with passive and active programs have integrated their passive TOU offerings with their demand response programs. Since our 2019 report, there has been a trend to include both behavioral load control and active load control in utility offerings rather than treating them as an "either-or" option. Many utilities see behavioral load control as a first step in creating a managed charging program (see utility survey section).

Managed Charging Economic Structures

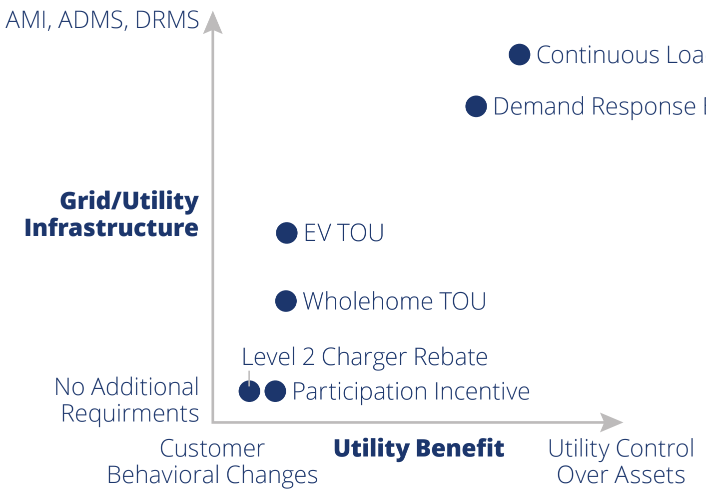
All of the managed charging types use a variety of economic structures to incentivize participation. Passive incentive types like rebates and TOU programs can be stacked with more active incentive types like per event or monthly demand response credits. Incentive stacking can occur in any type of program, but is most extensively used by utilities with both active and passive managed charging. Utilities with dual programs often take one of two approaches: either mandate participation in both programs or market the passive program as supplementary to the active program. Consumers Energy uses the mandated approach by automatically enrolling its Level 2 charger rebate customers in both its demand response and residential wholehome TOU programs. In contrast, Marin Clean Energy (MCE) does not enforce enrollment onto TOU or EV rates as a condition of participation for its MCE Sync program, but does allow TOU customers to enjoy additional bill credits for demand-response participation on top of their off-peak savings. Of note, some utilities do not allow program stacking and have separate tariffs for their demand response and EV-TOU programs. Green Mountain Power markets its Level 2 charger program as supplementary to either its EV-TOU or its EV-DR tariffs.

Utility Resource Considerations

Demand response and dynamic programs may require more utility infrastructure such as AMI, ADMS, DERMS, and DRMS systems and may not be feasible for every utility (Figure 5). Instead, a combination of rebates and simple off-peak incentives/ TOU incentives can encourage behavioral load control to obtain a reduction in on-peak demand. For utility programs without TOU tariffs,

6 CPUC Decision 15-07-001 adopted mandates for transitioning to TOU rates. Includes community choice aggregators and the state's IOUs.

Figure 5. Utility Program Design vs Benefit



Source: SEPA, 2021

alternatives such as flat monthly charging subscriptions, as used by Xcel Energy[7] in its EV Charging Subscription Pilot, or monthly incentives for providing proof of programming for off-peak times, as used by Concord Municipal Light's EV Miles Program, have proven successful. For utilities planning for a managed charging program, program participation rewards are commonly used to encourage EV customers to share their charging data with the utility and to incentivize them to charge during beneficial times. Over ten utilities throughout the US use either program participation rewards, such as enrollment incentives or anniversary bonuses, or networked Level 2 charger rebates to attract customers to their charging data collection programs. Appendix A includes further detail on utility managed charging programs and their included economic structures.

Utility Managed Charging Survey

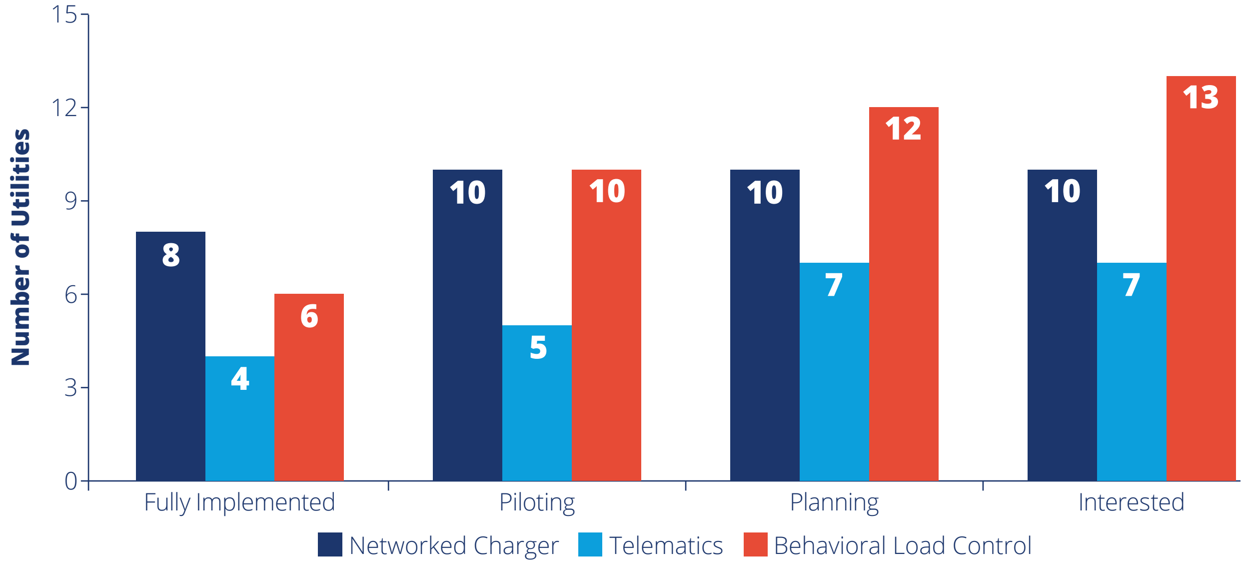
Utility Program Progress and Interest

To gain additional information about utility-run managed charging programs, SEPA fielded a Managed EV Charging survey in June & August of 2021. The survey was designed to repeat the questions from the 2019 report survey with new questions on issues related to regulatory changes and vehicle-to-grid integration. Of 50 unique utility respondents[8] representing more than 30% of US utility metered accounts, **19 identified as either having a fully-implemented managed EV charging program or were conducting a managed charging pilot. The remaining 31 respondents identified as either planning or were interested in having a managed charging program.** Respondents included 18 IOUs, 10 cooperatives, 17 public power utilities, and 5 municipal utilities. Utilities identified the types of managed charging programs in which they were interested, indicating respondents heavily favored behavioral load control and active networked charging (Figure 6). Fifteen of the thirty-one respondents without current programs indicated a desire to have both active and passive offerings, further signaling a shift to having diversified managed charging programs.

7 Xcel MN has other offerings, including an uncapped EV-only TOU that uses alternative technologies to a separate meter

8 Austin Energy, AvanGrid, Baltimore Gas and Electric, Bartholomew County REMC, Belmont Light, Big Bend Electric Cooperative, Inc Brunswick Electric Membership Corporation, City of Lompoc, City of Tallahassee Electric & Gas Utility, City Utilities of Springfield, Commonwealth Edison, Concord Municipal Light Board, Consolidated Edison Company of New York, Consumers Energy, Dominion Energy, DTE Energy Company, Energy Northwest, FirstEnergy, Flint EMC, Glendale Water and Power, Green Mountain Power, Hawaii Electric Light Company, Heber Light & Power, Holy Cross Energy , Hoosier Energy Rural Electric Cooperative, Lincoln Electric System, Littleton Electric Light and Water Departments, Memphis Light, Gas and Water Division, Northern Indiana Public Service Company, Northwest Rural Public Power District, Nova Scotia Power, Omaha Public Power District, Orlando Utilities Commission, Pasadena Department of Water and Power, PECO, Pepco Holdings- DC, Pepco- MD, Plumas-Sierra Rural Electric Co-op, PPL Electric Utilities Company, Public Service Company of New Mexico, Public Service Enterprise Group, Rappahannock Electric Cooperative, Salt River Project, San Diego Gas & Electric Company, Snohomish County PUD, Southern California Edison, Trico Electric Cooperative, United Power, National Grid, Seattle City Light

Figure 6. Utility Outlook on Managed Charging Programs by Program Type

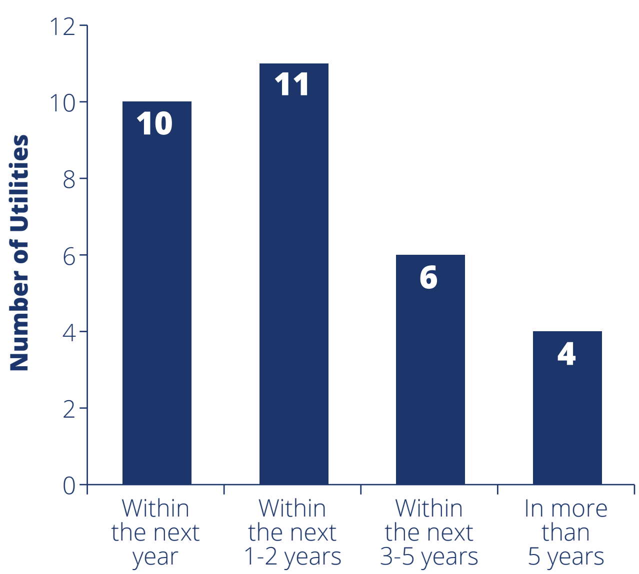


N=50.

Source: SEPA, 2021

The 31 respondents without a current managed charging program were further asked when they planned to establish a managed EV charging program (Figure 7). **67% of the 31 respondents indicated that they were planning to implement a new managed EV program within the next 2 years, with less than 13% of the utilities indicating they were planning to do so in more than 5 years.** The 19 respondents with a managed charging program were further asked about the number of EVs targeted for participation. The average program was designed for 10,000 EVs with outliers ranging from 30 EVs to 100,000 EVs.

Figure 7. Utility Outlook on Implementing New Managed Charging Programs



N=31.

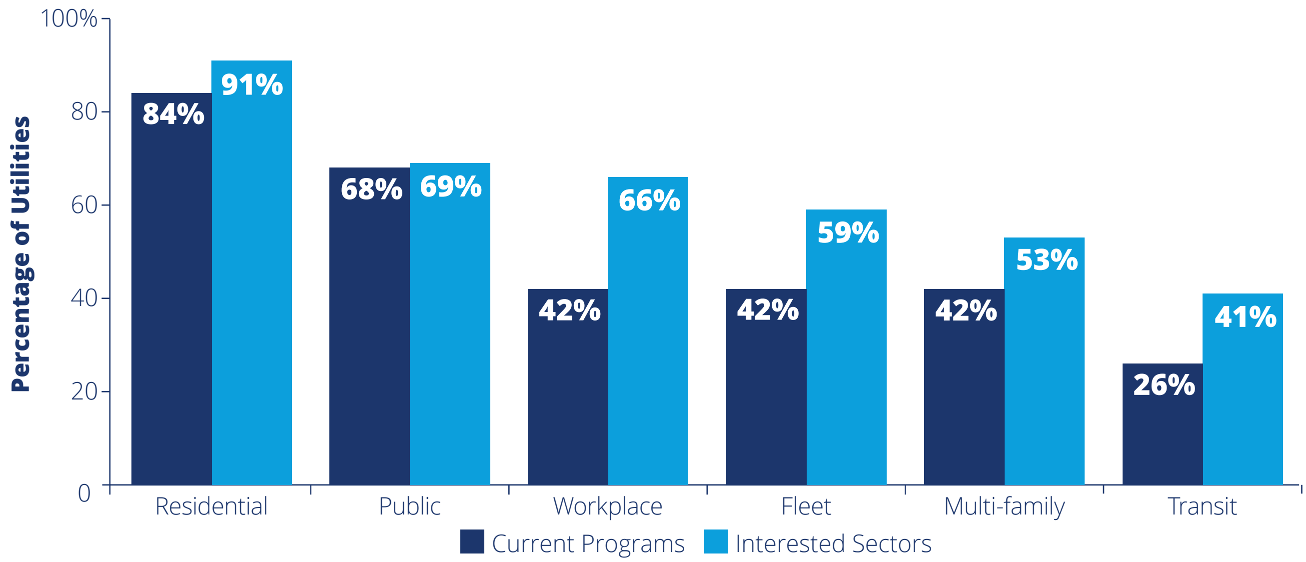
Source: SEPA, 2021

Targeted Sectors for Managed Charging Programs

All respondents were asked which electric vehicle sectors they currently target, or were planning to target with their managed charging programs. Residential is the most-targeted sector, a trend that has continued since 2019, with the rise of networked Level 2 chargers and growing market share of personal-use electric vehicles (Figure 8). Residential programs have been supported by a number of government grants and subsidies, including state subsidies such as Delaware's Clean Transportation Incentive Program that provides residential, commercial, and workplace rebates for EVSE and the District of Columbia's tax credit of up to $1,000 for residential EVSE. Furthermore, many utilities have shown success with their residential programs, which could make residential a more attractive offering for utilities entering the managed charging space (see Appendix A for a full list of utility managed charging programs).

Public managed charging programs, using mainly Level 2 rather than DCFC, have increased in both current

Figure 8. Utility Outlook on Target Sectors for Managed Charging Programs



N=50

Source: SEPA, 2021

applications and in interest. In 2019, 43% of respondents targeted or planned to target public sectors, compared to 68% in 2021, showing a significant increase in the past two years in both applied and interested applications of public charging. **Workplace, fleet, and multi-family were noticeably more popular for those utilities that were interested in creating new programs, but all three remained relatively low for the current applications.**

Effective load management techniques, including managed charging, need to consider the charging customer's needs and preferences.

Two questions should be prominent when considering the relative value of a load management program in different EV charging use cases: (1) how will it impact the driver experience, and (2) is this the best use case for energy management?

Residential charging[9] is suited for load management programs due to the long dwell times available for charging, beneficial overnight grid conditions, and the EV driver typically serving as their own "site host." EV drivers charge their vehicles at home over 80% of the time.

Fleet charging can be an ideal use case to support demand-side management and smart charging of EVs. This is due to the direct relationship between the vehicle's owner and the charging station's owner, the fleet owners focus on operational costs, predictable and constant operating cycles, potentially long dwell times, and an existing familiarity with optimizing around vehicle operational needs

Workplace charging presents opportunities to shape charging during the day, due to the extended dwell times and repeat users of such charging stations. Workplace charging can be incentivized to avoid early morning peaks or to serve as a "sponge" for overgeneration of solar in the middle of the day.

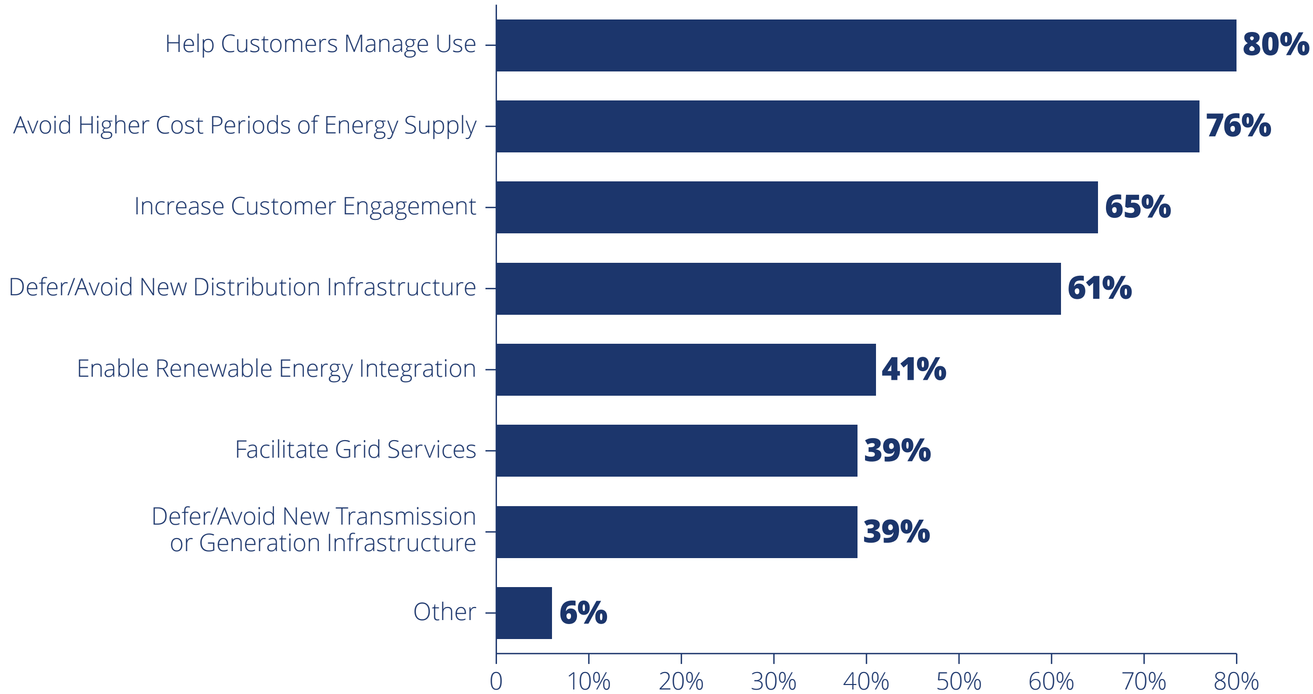
Public charging (such as those deployed at retail or destination sites) is not always well-suited for load management programs due to much more unpredictable utilization, the inelastic demand for charging at public stations (i.e., at a highway rest stop), and the inability for a driver to change their charging behavior to align with the rate schedule.

Motivations for Implementation

All respondents were asked about their motivations for using a managed EV charging program. **Helping customers manage electricity use, avoiding higher cost periods of energy supply, and increasing customer engagement remained the top three utility motivations from the 2019 to the 2021** surveys (Figure 9). These options were not considered "either-or" for the utility, but rather additive motivations that went into the program design.

9 Additional resources and analysis on residential charging behavior can be found in the following resources: https://www.nrel.gov/docs/fy19osti/73303.pdf, https://www.nrdc.org/experts/patricia-valderrama/electric-vehicle-charging-101

Figure 9. Utility Motivations for Managed EV Charging Programs



N=49. Note: Utilities selected all that applied.

Source: SEPA, 2021

Barriers to Implementation

When asked about the barriers to implementing a managed EV charging program, **60% of the respondents indicated that the uncertainty around EV customer participation was the most significant barrier, an increase from the 42% of respondents that indicated this barrier in 2019** (Figure 10). While 46% of respondents in 2019 indicated that the uncertainty around the availability of EVs to manage was the most significant constraint, this concern dropped to 35% in 2021. These results suggest that utilities have become more confident that there will be a significant number of EVs to manage within their territories and now are looking at how to effectively engage those customers. Utilities were offered an "Other" option to state further concerns, in which respondents cited concerns around the cost of EV metering and monitoring equipment, total program cost effectiveness, and the need for cohesive software solutions. One utility noted that an active managed charging program was not suitable for their region and behavioral load control through a TOU program was the most effective option for them.

Desired Industry & Regulatory Changes

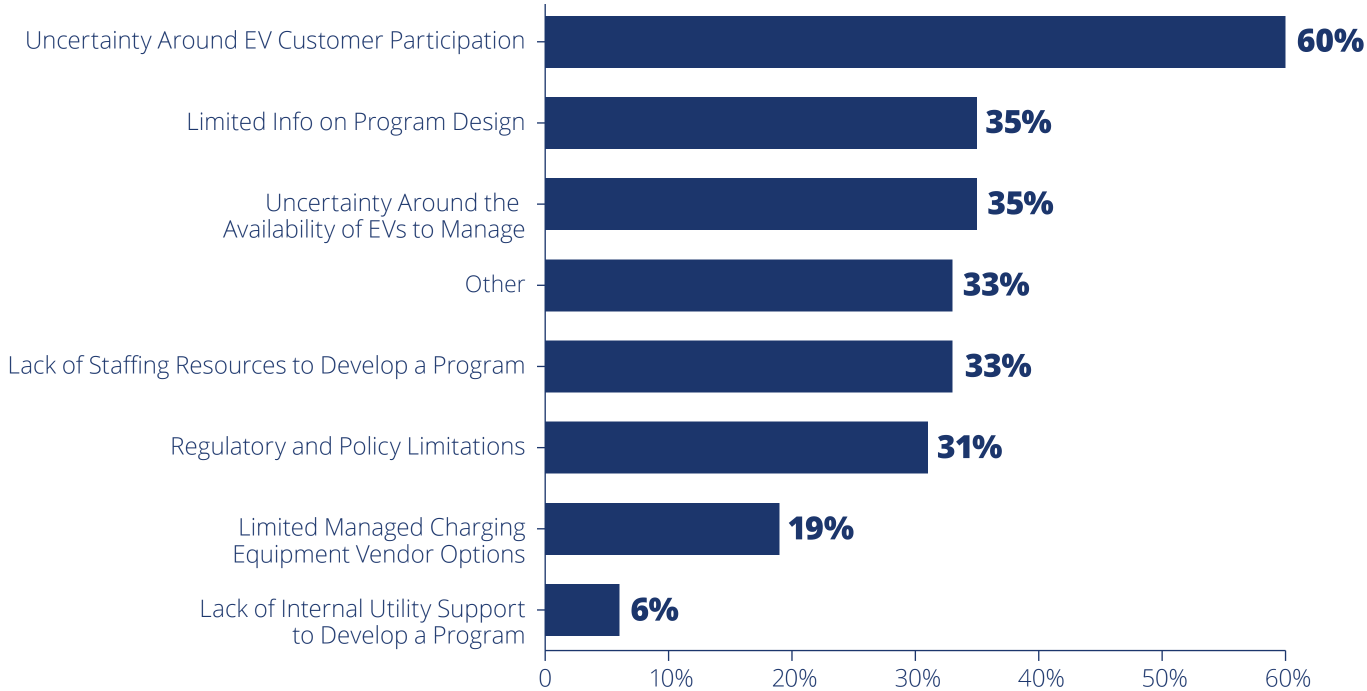
When asked about which three industry developments would most significantly help in facilitating new program implementation, respondents primarily chose **industry consensus around a managed charging protocol,[10] a managed charging program design guide,[11] and regulatory support for managed charging as the three most impactful activities** (Figure 11). The rise of a need for industry consensus around a managed charging protocol is a notable change from 2019, when respondents favored a program design guide as the most important activity. This change could be indicative of a maturing market in which utilities are looking to expand beyond behavioral load control towards a more actively managed EV charging landscape.

Another major change from 2019 was the decrease in priority for improved marketplaces that educate and offer qualifying solutions to customers. Many established

10 The interested reader is encouraged to review SEPA's 2020 publication "Guidelines for Selecting a Communications Protocol for Vehicle-Grid Integration"

11 SEPA's 2021 publication "Managed Charging Incentive Design: Guide to Utility Program Development" provides a six-step process to managed charging program design along with a detailed assessment of existing incentive structures and incentive values.

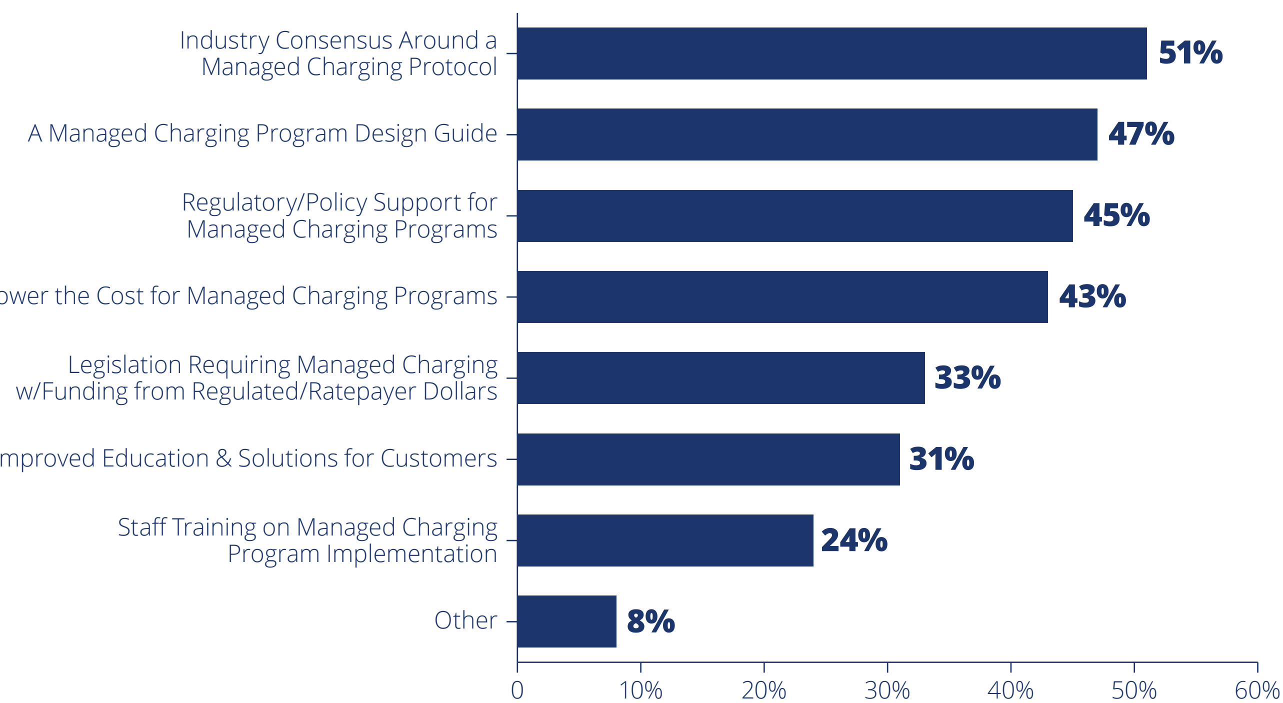
Figure 10. Barriers to Implementing a Managed EV Charging Program



N=48. Note: Utilities selected all that applied.

Source: SEPA, 2021

Figure 11. Industry Activities that would Facilitate Program Implementation



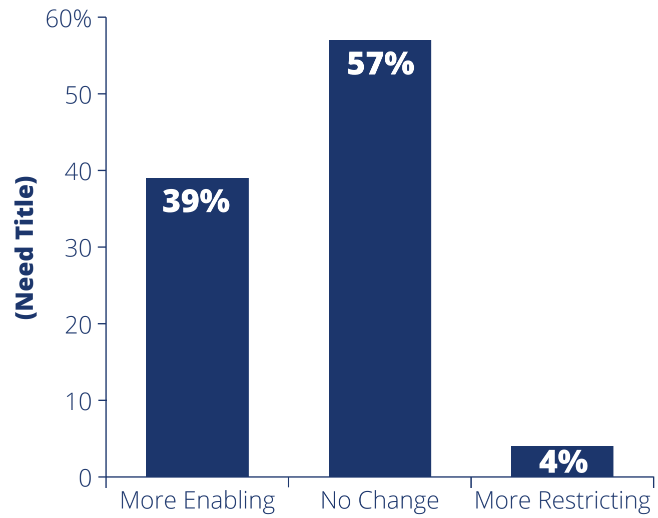
N=49. Note: Utilities selected up to 3.

Source: SEPA, 2021

managed EV charging programs, especially those that offer rebates, have customer enrollment portals that both educate the customers on the devices and provide utility-approved vendor solutions. Customer enrollment portals can also be used for pre-managed charging implementation to allow customers to self-identify as an EV owner and submit data on their vehicle and current EVSEs. Opening customer portals early can assist with more directly targeting the appropriate customers for the managed charging programs.

Utilities were further questioned on how they viewed the regulatory environment over the last few years (Figure 12). **39% of respondents indicated that the regulatory environment had become more enabling of managed EV charging programs, while 57% of utilities saw no change.** Of the 19 respondents that indicated the regulatory environment had become more enabling, 10 of them also indicated that further regulatory and policy support is needed (Figure 11). Among surveyed utilities, a consensus exists that further regulatory actions are needed.

Figure 12. 3-year Change in Regulatory Environment



N=49.

Source: SEPA, 2021

Vehicle-to-Grid

Lastly, utilities were questioned on their plans for vehicle-to-grid (V2G). Twenty-five percent of the utilities responded that they were planning for V2G, where 9 of the 12 respondents planning for V2G are currently piloting V2G technologies and 1 of the respondents is in the process of proposing a pilot to their commission. Of the pilot programs, both school bus pilots and microgrid applications are popular among the surveyed utilities. V2G is a relatively new technology that needs to be tested with utility systems, and many of the pilots are not yet conclusive on scaling the technology. Two of the utilities indicated that they are not yet at the V2G level, with one utility favoring vehicle-to-load for peak shaving energy arbitrage and another favoring developing vehicle-to-home before transitioning to vehicle-to-grid. One of the primary motivations for the pilots is to test the cost effectiveness of V2G and what value the technology adds to the grid. Additionally, V2G standards and market requirements are being developed by these utilities, and there is not yet a standard for how the interconnection agreements and pricing settlements will look.

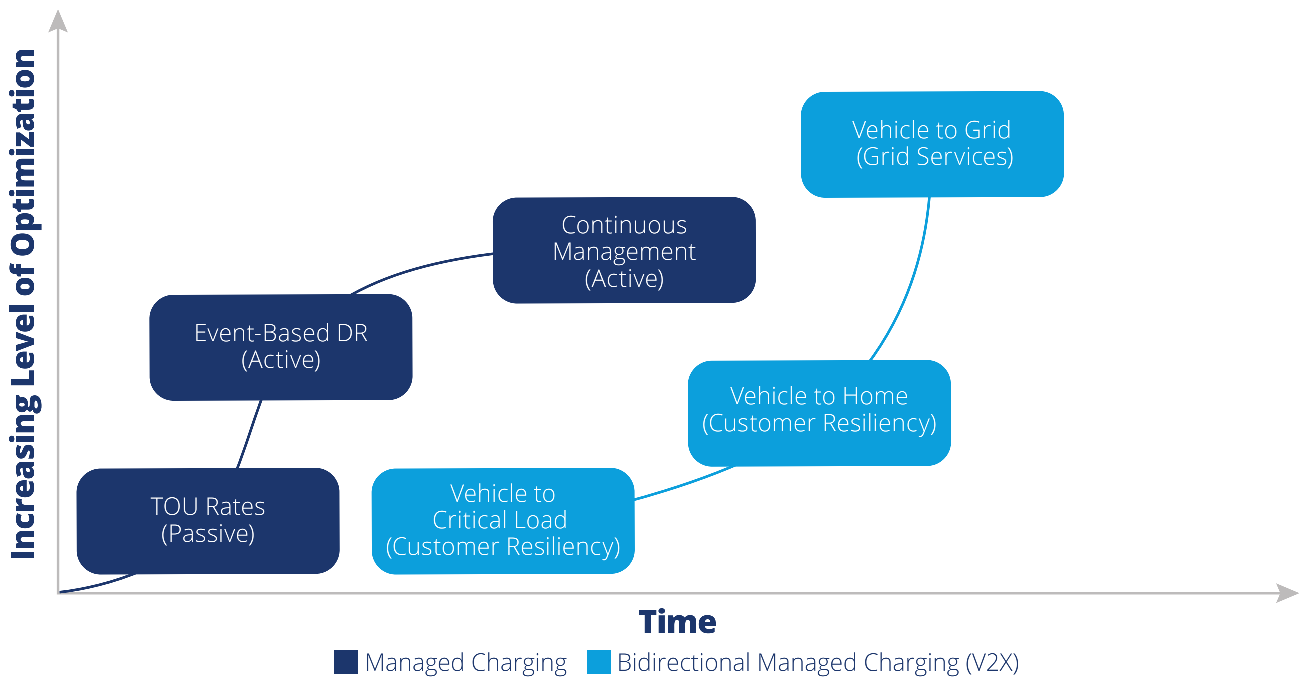
How Managed Charging Has Changed

Since 2019, utilities have maintained their interest in developing some form of a managed charging program. We have seen significant increases in the number of managed charging programs throughout the US, with significant growth in both behavioral load control and active networked charging. Even as we see an acceleration of utilities implementing new programs, managed charging is still in a developmental phase. **This is visible clearly in three major trends: the evolution of programs from passive to active managed charging, the shift from residential to other vehicle applications, and the shift from pilots to full-scale implementation of managed charging programs.**

First, utilities have only recently begun to have multiple program offerings as a result of evolving from passive to active managed charging. The implication being that utilities need to consider what role whole home and EV-TOU programs play in other offerings such as DR and dynamic programs. **Current data suggests that utilities go through multiple stages of program implementation. Due to the lower infrastructure requirements, TOU programs are seen as the first stage of managed charging. Active managed charging is the second stage, implemented when utilities need further peak demand reductions and/or solutions for capturing excess solar generation.** Over half of the utilities with managed charging programs have implemented demand response capabilities. Currently, a third stage is beginning to emerge, as some utilities pilot continuously managed charging programs where a software platform dynamically optimizes the charging schedule depending on demand conditions and dynamic market prices. Individual utilities may stop at any one of these stages, but **the industry is moving toward more dynamic and continuously managed charging**. The natural progression beyond continuous managed charging is bi-directional load control that is eventually integrated into a DERMS that provides real-time, continuous load and forecasting data to the utility enterprise systems. Figure 13 shows an illustrative example of how managed charging is evolving.

Second, utilities are beginning to shift from a primary focus on residential charging to fleet and public applications. As discussed in Chapter 1, vehicles of all classes are moving towards electrification and opening new avenues for utilities to participate. **Third, utilities are beginning to move away from piloting demand response and EV-TOU programs to full implementation and scaling of these programs.** Active managed charging using networked chargers is seen as less of an emerging technology and more as a fully-tested technology. Now, utilities are starting to look to new technologies like V2G as the next generation of managed charging programs to pilot.

Figure 13. The Evolution of Managed Charging



Source: SEPA, 2021

From Pilots To Scale

Moving from a pilot program to scale can sometimes require regulatory approval for utilities. In this case, utilities can use the resulting pause in programming productively to evaluate the results of the pilot program. For example, National Grid changed technology solutions during its transition from pilot to scale-up of its Massachusetts Off-Peak EV Charging Rebate program, shifting from C2 devices to a combination of vehicle telematics and networked EVSEs. This technology change allowed the utility to serve more customers at lower cost, while laying the groundwork for active load shifting to off-peak hours to both save customers money and improve the reliability of its network. The utility plans to expand the program from an initial 500 customers to 1,100 customers within the first 12 months of growth, eventually reaching 11,000 customers within the three-year pilot.

For load-serving entities that fall outside of the remit of state-level regulatory bodies, such as Community Choice Aggregators, moving from pilot to scale can happen quickly. For example, Silicon Valley Clean Energy (SVCE) collected continuous customer feedback and testimonials during the pilot phase of its GridShift: EV Charging program to enable it to quickly scale from 100 to over 1,000 enrolled customers within months (see example at right).

Source: SVCE, 2021

Chapter Three: Managed Charging Case Studies

A managed charging pilot may be designed to showcase the most innovative emerging technologies in the industry and illuminate the challenges and opportunities associated with those technologies. A pilot may also be designed to test or demonstrate customer willingness to participate or the effectiveness of different price signals and messaging approaches. Ultimately, pilots are the first step in a phased approach to implementing a long-term managed charging strategy that meets customers' charging needs while delivering grid and cost benefits. Utilities that have not yet implemented managed charging pilots or programs can learn from peer utilities to potentially skip the pilot phase to move directly into larger program development.

This chapter describes six examples of utility-led managed charging programs and one example of a customer fleet initiated managed charging program that is also participating in a utility demand response program. The programs included represent the various approaches to managed charging and cover multiple customer segments. A more comprehensive list of ongoing managed charging programs can be found in Appendix A. Table 2 provides a summary of the communication approach, incentive structure, and customer segmentation of the 7 programs.

Table 2. Summary of Managed Charging Case Studies						
Program Name	**Utility**	**Participants**	**Communi-cation**	**Incentive Structure**	**Customer Segment**	**Highlights**
Smart Charge Hawaii	**Hawaiian Electric**	300 Residential	Networked L2	Charger rebate, Juice Points (Juice Points are reward points redeemable for cash)	Residential, no vehicle constraint	▪ Daytime optimization for PV consumption ▪ Multiple marketing channels
GridShift	**SCVE**	100-1000	Networked L2, L1, and Telematics	Monthly bill credits, Hardware rebates, TOU rates	Residential, no vehicle constraint	▪ Hardware agnostic to allow both telematics and networked chargers ▪ Multi-layer optimization for DR and RE integration ▪ Seasonal events to respond to dynamic grid conditions
DTE Smart Charge	**DTE**	100-1000	Telematics	$50 enrolment gift card, $50 after year 1	Residential, Ford, Chevrolet	▪ Telematics via OpenADR, Location agnostic for DR calls ▪ DR and RE Events (excess renewables)
Connected-Solutions EV & PHEV Program	**National Grid**	100	Telematics	Enrollment incentive, per DR event incentive	Residential; BMW, Chevrolet, Ford, Honda	▪ Greater than 20% enrollment rate for some OEMs ▪ Successful application of telematics for DR
Connected Solutions	**Eversource**	600 residential	Networked L2	New charger rebate, existing charger enrollment incentive, annual participation incentive	Residential, no vehicle constraint	▪ Applies a bring-your-own-device (BYOD) model to level 2 (L2) residential chargers ▪ Demand response as a path to dynamic load shaping
Stockton Unified School District	**PG&E**	11 buses, 4 DCFC, 10 L2	Networked L2 and DCFC	Bill management	Commercial; School District	▪ Future proofing the site so it is ready for V2G Capabilities ▪ Fleet covers 54 schools and educates approximately 40,000 students per annum.
Revel	**ConEd**[12]	50 Teslas, 25 DCFC	Telematics, Networked DCFC	Bill management	TNC Fleet, Tesla, Public Charging	▪ Fleet and public shared charging infrastructure with utility demand response ▪ All electric ride hailing fleet with real time charging optimization

Source: SEPA, 2021

12 ConEd was not directly involved in this project. They are the utility that serves the fleet charging depot.

Case Study—Smart Charge Hawaii: Residential Active DR

Summary of Program

The Smart Charge Hawaii program was a Hawaiian Electric residential Demand Response program that was active from Sept. 2019 to Aug. 2020. The program engaged 300 residential customers in 19 DR events and had over 1,000 unique charging sessions. The pilot aimed to accelerate EV adoption and test the boundaries of EVs as a demand response resource. The program shifted EV load to times of day when cleaner, renewable energy was available and tested technical, operational, and customer participation.

Project Goals

1. **Data Collection:** Collect load profile data from each customer to better understand residential charging behavior. Inform the utility of the potential role of managed charging in ongoing grid modernization and how to maximize the use of renewable resources.
2. **Refine Forecasted Load:** Measure, compare, and refine forecasted load reduction by using actual delivery to inform future managed charging programs.
3. **Validate Technical Feasibility:** Test the technical feasibility of fulfilling applicable service requirements for capacity grid services.
4. **Determine Effectiveness of Incentives:** Determine the incentives that will encourage customers to participate in an EV-reliant DR program.

Program Partners

- **Enel X:** Producer of JuiceBox charger and JuiceNet charging platform.
- **Elemental Excelerator:** Funds companies that support solutions for climate change.

Managed Charging Approach

Enel X delivered load reduction capacity to Hawaiian Electric by managing EV consumption levels during a 4-hr DR event window. They delivered a daily kW capacity estimate in 15-min intervals during the 5 pm-9 pm window. Hawaiian Electric called DR events based on available capacity. Provisions were added so that JuiceNet could autonomously opt-out of events, based on the mobility requirements pre-set by the participant.

Program Incentive Structure

The program offered a charger rebate, enrollment incentive, and ongoing participation incentives. The charger rebate consisted of a free Level 2 Juicebox home smart charger. The enrollment incentive included JuicePoints, which were redeemable for cash and was equivalent to $30 for activation of the system. The participation incentive consisted of JuicePoints equivalent to $0.01/kWh for Load Reduction Events. Customers earn JuicePoints by letting the utility optimize the charging schedule and can redeem them for cash via PayPal at a specified exchange rate though the online account or via the mobile app.

Program Successes

- **Load Reduction Capacity:** Enel X was able to deliver Load Reduction Capacity to Hawaiian Electric by managing the consumption levels of participating charging stations. More than half of survey respondents did not notice any events. DR events had an average 92% participation.
- **Upgraded EVSEs:** Pre-launch, 54% of participants used Level 1 chargers and 28% used non-networked Level 2 chargers. Post-program, 100% of participants adopted networked charging equipment.
- **New EV Adoption:** 22% of surveyed participants said the program influenced their decision to acquire an electric vehicle. From Hawaiian Electric's analysis of the program, "offering the free JuiceBox charger, valued at $600 each, was an effective way to incentivize electric vehicle adoption in Hawaii".

Program Challenges and Recommendations

- **Customer Education:** Customer education is important to the success of the program. Partner with organizations that provide dedicated support and education for customers. Education extends to ensuring customers understand the permitting and installation process and possible barriers to proper installation and participation.

- **Installation Delays:** Customers experienced setup and installation delays due to: the lack of familiarity with IOT tech., permits and electric service upgrades, finding the proper installer and scheduling an appointment, and lack of Wi-Fi access for outdoor installations.
- **Marketing:** Utility led and branded marketing is the most effective way to recruit participants. When Smart Charge was launched, the marketing was pushed through Enel X's channels and recruitment was slow. Subscription increased after Hawaiian Electric used its marketing channels, especially advertising through billing inserts.
- **Performance Impacts:** Several factors impact load reduction performance: negative impacts from poor or intermittent Wi-Fi, and customer overrides of smart charging events. Customer overrides were relatively small, but had an impact on total load reduction. On average, 8% of charging participants manually opted out of events.

Key Takeaways

- Managed charging programs can be designed to help **consume excessive solar generation** in the middle of the day.
- Utility-sponsored programs can **increase local EV adoption** and customer interest in vehicle electrification.
- **Customer education is vital to ensure the enrollment of qualifying participants** and for the timely installation of the EVSEs.
- **Using multiple marketing channels** is extremely helpful to achieve full enrollment for the managed charging program.

Case Study—GridShift: Residential Load Control via Telematics and Networked EVSE

Summary of Program

Silicon Valley Clean Energy (SVCE) partnered with ev.energy to launch the GridShift program targeted at residential EV customers. The initial pilot featured 100 customers who enrolled with vehicle telematics; the program is now scaling up, targeting over 500 customers by the end of 2021 and has expanded to include networked EVSEs as compatible devices.

Project Goals

1. **Provide CAISO Benefits:** Aimed to support summertime grid resiliency by actively curtailing EV charging during "Flex Alert" hours, to mitigate the duck curve by shifting EV charging to daytime solar generation hours, and to avoid a "rebound timer peak" around 9 pm in the SVCE service territory.
2. **Provide SVCE Benefits:** Create a physical hedge from the EV Virtual Power Plant to reduce risk to wholesale energy price volatility. Meet resource adequacy requirements by shifting charging outside of the 4 to 9 pm window.
3. **Provide Customer Benefits:** Reduce customer energy bills through a "set it and forget it" solution for off-peak charging. Offer customer bill credits for charging during "low-carbon events" and for opting into demand response events. Use mobile app to track all home EV charging consumptions, costs, and grid carbon.

Program Partners

- **UtilityAPI:** Single API for customer verification
- **WattTime:** Marginal grid emission forecasts
- **Enervee:** Marketplace for GridShift-compatible chargers and rebates

Managed Charging Approach

Program utilizes a two-fold approach: automatic software optimization and customer behavioral nudges. The GridShift mobile app shifts EV load through both the vehicle telematics and networked EVSEs based on the off-peak time of the customer's TOU rate structure, demand response events, and indicators for high renewable generation periods. Automatic shifting and curtailing take into account the customer's desired departure time as set in the app. In addition, customers receive in-app push notifications encouraging managed charging enablement, highlighting bill savings for charging off-peak and participating in DR events, and alerting them to forecasted hours of high renewable energy generation.

Program Incentive Structure

In addition to $100-$200 per year in TOU bill savings, the GridShift program also offers bill credits for event participation (averaging $5/month) and may eventually include EVSE hardware rebates for income-qualifying customers.

Program Successes

- **Hardware-Agnostic:** Allowed multiple pathways for participation and maximized customer enrollment across different customer classes.
- **Multi-layered Optimization:** Optimized for both off-peak and grid conditions; aligned charging with renewable generation hours and for summertime grid resiliency, without the need for customer actions
- **Deep-Grid Integration:** Effectively used network stability signals, system generation signals, and weather conditions to sync charging to daily/seasonally changing grid conditions
- **Customer Engagement:** Retained 80% of customers after 12 months, with over 70% of customers participating in low-carbon or demand-response events. Simplified app enrollment and on-boarding process reduced customer drop-outs.
- **Customer Savings:** Customer bills reduced by $100-$200/year through TOU optimization; on top of this customers earned up to an additional $100 in bill credits for event participation.
- **Reliable Load-Shifting:** On average, 90% of customer charging is shifted to TOU off-peak hours. 42% of EV loads were shifted to low-carbon events, where the average carbon intensity during the event is on average 72% lower than the rolling 24-hour average.

- **Scalability:** Through entirely app-based enrollment and automated customer verification using UtilityAPI, the GridShift program was easily able to scale beyond the size of the initial pilot.

Program Challenges and Learnings:

- **Event Fatigue:** Event participation dropped 30% below average when events occurred within 24 hours of each other.
- **3rd-party DR Programs:** Dual participation rules prevent customers from being enrolled in more than one DR program. 3rd-party programs like OhmConnect can be at odds with utility and community choice aggregators (CCA) programs such as this one, even though some elements of the programs can stack (such as customer TOU optimization).
- **Customer Battery Needs:** Customers with large batteries charging on L1 cannot charge entirely during off-peak hours before the scheduled departure times.

Key Takeaways

- Creating a **hardware agnostic program increases the potential participant pool** and maximizes load control for the utility.
- **Multi-layered optimization** maximizes grid benefits through off-peak charging, intermittent renewable energy generation alignment charging, and responds to real-time grid conditions.
- **App-based customer engagement** and compelling incentives support program satisfaction and customer retention.

Case Study—DTE Smart Charge: OVGIP

Summary of Program

In an expansion of previous work, DTE continues to partner with EV automotive manufacturers to assess the effectiveness of the Open Vehicle Grid Integrated Platform (OVGIP) concept. OVGIP integrates EV charging with grid objectives through Demand Response mechanisms. The program uses OpenADR dispatch to send DR events to the OVGIP, which then distributes the dispatch to the EV OEMs. The OEMs, Ford & General Motors (Chevrolet), use the telematics communication abilities to pause EV charging during the DR event window. This program requires **no** networked EVSE infrastructure. The pilot is capped at 1,000 participants with 200 EVs currently enrolled as of this publication.

Project Goals

1. **Data Collection:** Evaluate how participants and EVs respond to different event times, lengths, and offered incentives in order to help guide better program design. Design metrics include incentive satisfaction, opt-in/opt-out metrics, and best time of day DR event dispatch for utility & customer benefits.
2. **OEM Added Value:** Demonstrate that OEMs can provide critical value by actively leading the marketing of customer recruitment and enrollment, thereby boosting program participation and cost-effectiveness for DTE. OEMs also brought the ability to communicate with vehicles at any location via telematics.
3. **Customer Engagement:** Help customers manage their charging habits and help the energy grid operate more efficiently. Participants always have control of their participation and can opt out of an event at any time.

Program Partners

- **Ford & General Motors (Chevrolet):** Vehicle OEMs.
- **EPRI:** Provider of the OpenADR dispatch portal for DTE.[13]
- **OpenADR:** Producer of two-way information exchange models and Smart Grid standardization.
- **Sumitomo:** Provider of IT operations/maintenance for OVGIP platform.

Managed Charging Approach

Since the program is ongoing as of this publication, DTE is still testing different weekdays and times to call DR events. During the duration of the pilot, from April to Dec. 2021, DTE is on track to call 30 DR events. Learning consists of processing M&V data after each event to determine cost effectiveness. The OEMs maintain multi-channel interfaces, such as in-vehicle and mobile apps, to engage with customers and give them event-override control when necessary.

Program Incentive Structure

Participants receive up to $100 in gift card incentives. $50 up-front for enrollment and $50 after remaining for the duration of the pilot. Benchmarking identified that participants are more likely to join with an up-front incentive and stay enrolled when there is a second incentive.

Program Successes

- **Successful Signaling:** Effectively communicates through OVGIP and the OEMs to curtail EV load during DR events.
- **Customer Enrollment:** Conduct targeted marketing through the OEM apps.

Program Challenges and Recommendations

- **Load Reduction Verification:** Initially, the program did not have enough baseline customer behavior data (e.g., when and how many vehicles are plugged in and what level of opt out will occur) to accurately estimate the expected load reduction prior to an event. Further data collection through the pilot will calibrate the load reduction estimates based on the number of participants and event parameters (i.e., time of day, type of event, length of event, etc.).
- **Customer Enrollment:** Challenges enrolling customers at the beginning of the program due to timing of OEM model changeovers and a few other technical integration items that were later corrected.

13 Ford, General Motors, BMW, Mercedes Benz, Honda, and Toyota are compatible with OVGIP.

Key Takeaways

- Using **OpenADR assists with communication** between the OVGIP system and the OEMs.
- **Demand Response events were successfully called using the OVGIP + OEM systems** and proved that telematics has value in DR programs.

Case Study—National Grid: ConnectedSolutions EV and PHEV Telematics Program

Summary of Program

In 2021, National Grid launched a managed charging program spanning smart-home devices that included residential customers with EVs from BMW, General Motors (Chevrolet), Ford, Tesla, and Honda into a Demand Response Program. EnergyHub provided a DERMS system to coordinate across the various OEMs. As of publication, over 100 customers were enrolled. National Grid aims to expand the program to include more OEMs and to introduce more flexible and dynamic managed charging components.

Project Goals

1. **For the utility:** Lower electricity use at peak times to reduce emissions and lower infrastructure costs. Stagger the charging load to prevent new peaks, system overload, and local congestion on the distribution grid. Promote the adoption of EVs as part of their decarbonization goals. Study the impact of EVs to lay the groundwork for large-scale adoption.
2. **For the customer:** Incentivize participation with OEM rebate incentives. Allow customers to play a role in their utility's decarbonization efforts.

Program Partners

- **BMW, General Motors (Chevrolet), Ford, Tesla, Honda:** Vehicle OEMs.
- **EnergyHub:** Provides the DERMS platform that integrates communication with the EV OEMs (except Tesla), through the OVGIP.

Managed Charging Approach

Program is designed to automatically signal the telematics systems in the vehicles to pause charging during peak events and automatically resume charging afterward. Per-event incentives are designed to ensure that charging is paused for at least 50% of the peak event.

Program Incentive Structure

Deployed enrollment and event-based incentives. Customers earned $25 for enrolling, $10-$20 per peak event per vehicle enrolled, and $20 for each year enrolled. Pay-for-performance model used to discourage customers opting out of events.

Program Successes

- **Customer Enrollment:** Greater than 20% enrollment rate of all eligible vehicles in the service area for some OEMs.
- **Multi-DER Approach:** A single platform to manage multiple classes of DER. Allows for more flexible load shaping.
- **New Apps:** Partnered with the OEMs to launch apps and web portals to assist with customer enrollment. The marketing strategy was successful in recruiting and communicating with EV owners in the area.
- **Scalability:** The platform is designed to allow National Grid to exceed basic demand response capabilities by providing additional grid services such as load shifting, load shaping, and voltage support. National Grid aims to make the program's load shaping more flexible and dynamic. Additionally, the platform will allow many more EV OEMS and EVSEs.

Program Challenges and Recommendations

- **Market Assessment:** Understand what EV models are able to participate and what size market share they have in order to estimate the number of enrollments.

Key Takeaways

- **Vehicle Telematics is a viable pathway for implementing a demand response program.** EV OEMs are open to partnering and working with utilities to achieve the managed charging goals.
- **Marketing through the OEMs can improve program enrollment** and is key to successfully recruiting applicable vehicle customers.

Case Study—Eversource Grid: Residential Connected Solutions Program

Summary of Program

In 2019, Eversource launched a new EV load management program as part of their integrated ConnectedSolutions program. The program uses a single DERMS platform, through its partner EnergyHub, to manage a portfolio of thermostats, batteries, and EVSEs. The EVSE portion of the program applies a bring-your-own-device (BYOD) model to residential customers using ChargePoint, Enel X, and SolarEdge devices. Through the program, Eversource has access to customer charging data and the ability to control EVSE charging during peak times. As of publication, the program had 602 residential EV customers enrolled.

Project Goals

1. **For the utility:** Stagger the charging load to prevent new peaks, system overload, and local congestion on the distribution grid. Promote the adoption of EVs as part of their decarbonization goals. Study the impact of EVs to lay the groundwork for large-scale adoption.
2. **For future program design:** Eversource aims to use the charging data to inform advanced load control strategies, such as managed overnight charging. Simultaneously, Eversource is testing customer engagement and retention strategies through incentive design.
3. **For the customer:** Make EVSEs more affordable and allow the customers to contribute to regional decarbonization efforts.

Program Partners

- **EnergyHub:** Provides the DERMS platform that integrates the different DER assets.
- **EVSE vendors:** ChargePoint, EnelX, SolarEdge

Managed Charging Approach

Eversource uses the EnergyHub DERMS system to pause charging during demand response events and create staggered charging loads. As a staggered charging program, it prevents moving the charging to a new system peak, prevents system overload, and eases local congestion on the distribution grid.

Program Incentive Structure

Through the end of 2021, customers can receive up to $300 either through a $300 rebate for newly purchased chargers or a combined incentive of $150 to enroll and $50 per year of load control for 3 years. The incentive structure was designed to be cost effective and sustainable over time, simple for customers to understand, and sufficient to incentivize the purchase of Level 2 chargers. Chose not to use a pay-for-performance model to simplify for customers.

Program Successes

- **New Technology Adoption:** 70% of all enrolled EVSEs were new purchases, driving adoption of networked Level 2 chargers.
- **Automated Enrollment Verification:** Enrolled EVSE owners seamlessly through enrollment portal.
- **Grid Services:** As enrollment grows, the managed charging program adds further grid value. Additional value is added by integrating this program into the existing DERMS system with other DER assets.

Program Challenges and Recommendations

- **Lower Than Predicted Peak Load Reduction:** Not all enrolled EVSEs are actively charging during the event window, so the average load shed across all EVSEs is low, even though the per device load shed is significant.

Key Takeaways

- Eversource is using this demand response program as a pathway to develop **dynamic load shaping.**
- **Networked managed charging can promote EVSE sales** and further demand for Level 2 chargers. BYOD model increases scope of targeted residential customers.
- Electric vehicle managed charging programs can successfully be **incorporated into the utility's integrated DER objectives** and can utilize the same DERMs platform as other DER assets.

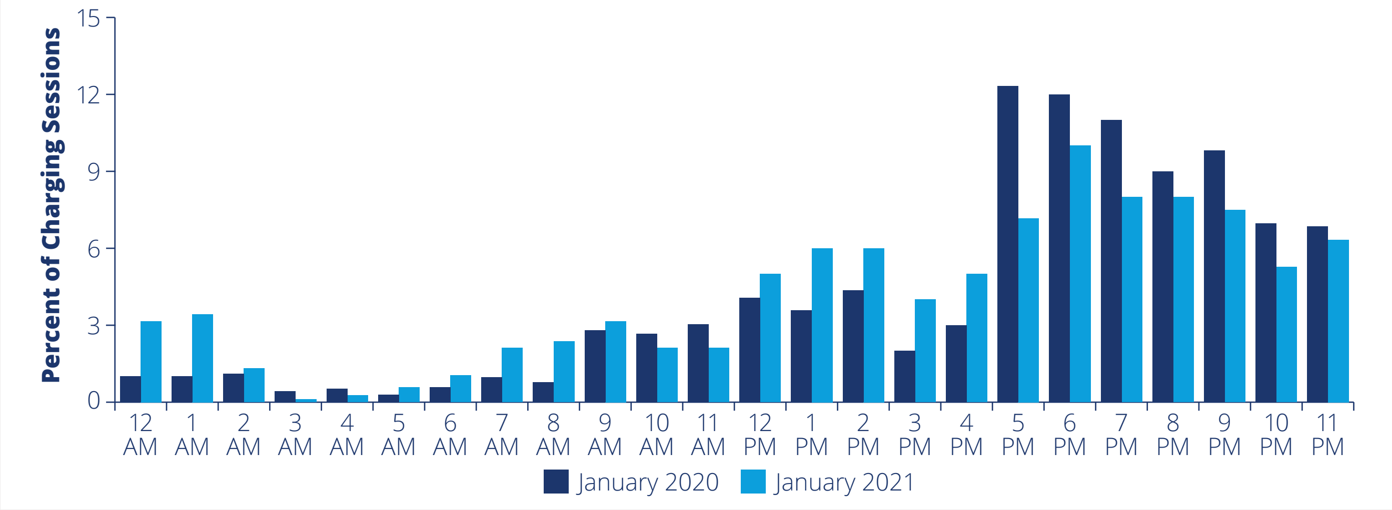
What Remote Work Could Mean for Managed EV Charging—Early Observations

What Remote Work Could Mean for Managed EV Charging—Early Observations

The COVID-19 pandemic has had a profound impact on the American way of life, including driving habits. With millions of people forced to shelter-in-place in early 2020, and millions more asked to work from home, Americans drove less (and for those with EVs, charged less). As the pandemic fades, Americans with white-collar jobs continue to largely work from home.

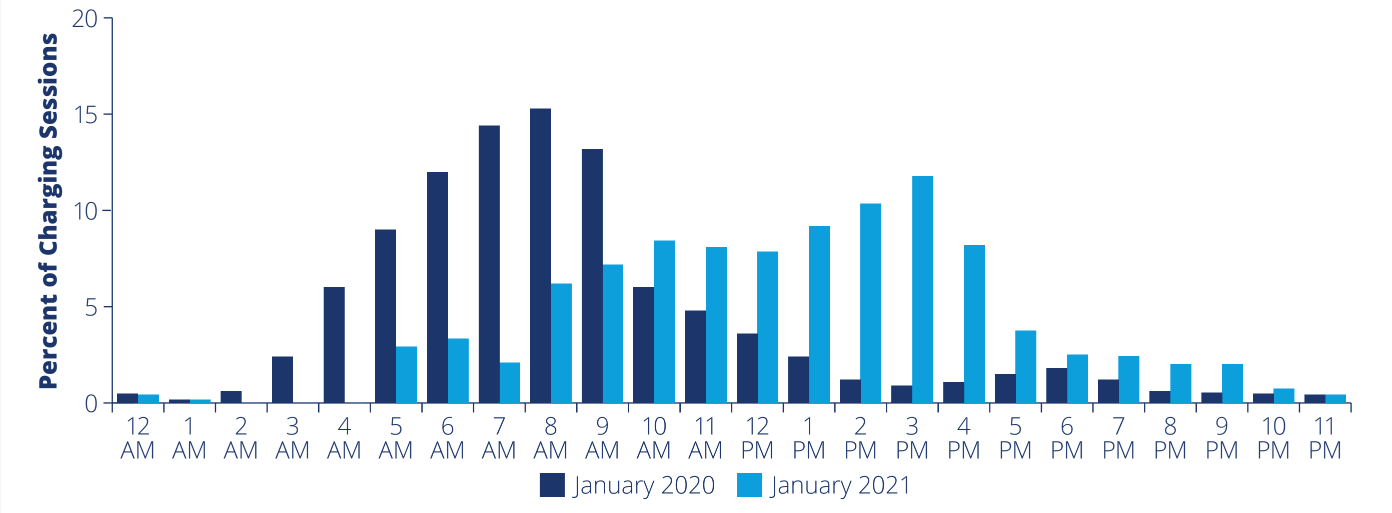
This fundamental shift in commuting and driving habits has also impacted EV charging patterns. According to data from more than 35,000 EV drivers on ev.energy's platform, plug-in

Figure 14. EV Plug-In Times of Residential Customers



Source: ev.energy, 2021

Figure 15. EV Unplug Times of Residential Customers



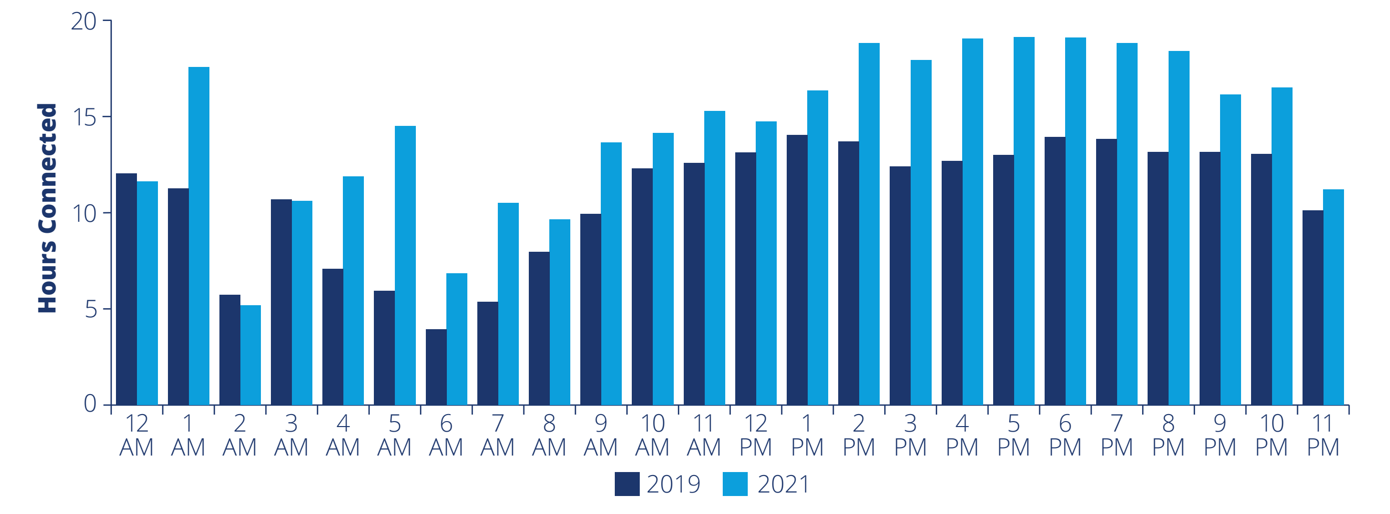
Source: ev.energy, 2021

times for residential customers changed from being largely clustered around the evening peak (5 pm - 9 pm) in January 2020 to being more evenly distributed throughout the afternoon, with the most common plug-in times continuing to be between 5 pm and 11 pm as of January 2021.

Unplug times have undergone a more significant shift, with unplugs shifting from their morning commute cluster of 6 am - 9 am in January 2020 to significantly later in the day. With many EV drivers working from home, the most common unplug time was 3 pm in January 2021, likely reflecting departures from the home office to pick children up from school.

SEPA also evaluated EV charging data from Omaha Public Power Department (OPPD) territory to explore these trends further. OPPD data showed similar trends with customers connecting over a wider range of times in the afternoon. Figure 17 shows the average time that a customer is connected to their charger based on the time of day that that charging session was initiated. The connected duration increased significantly between 2019

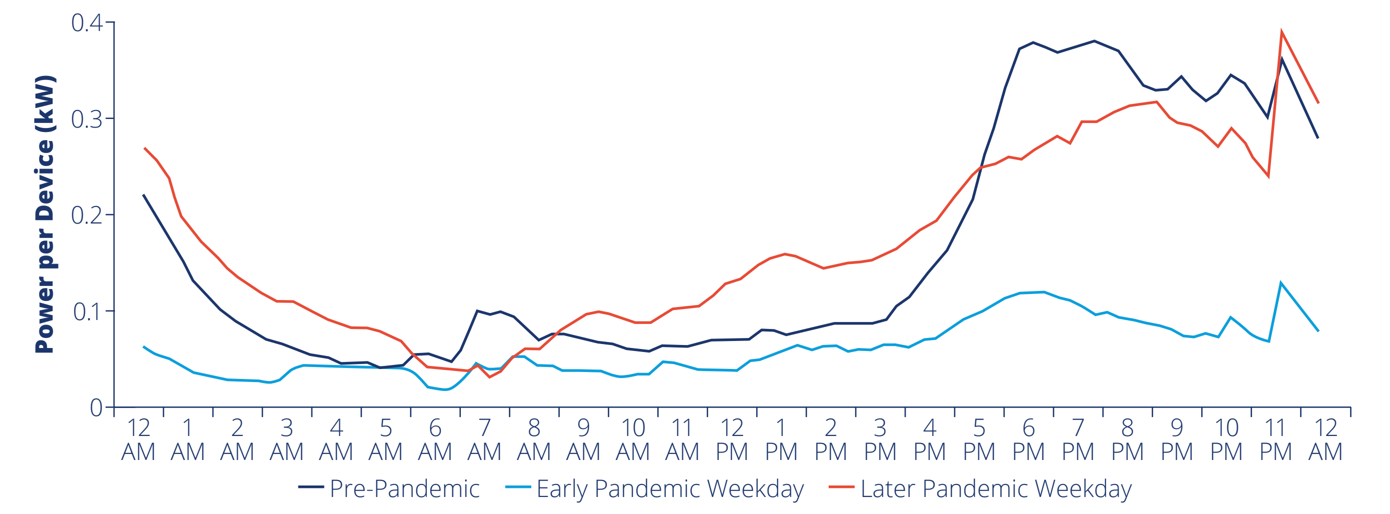
Figure 16. EV Charging Session Duration based on Session Initiation



Indicates total hours the vehicle was connected to the charger. Active charging time averaged between 2-4 hours.

Source: OPPD, 2021

Figure 17. Pandemic Impacts on EV Charging



Graph recreated from original, data points are approximated.

Source: EnergyHub, 2021

and 2021, with average connected duration increasing most for charge sessions that started in the afternoon and early evening.

Data provided by EnergyHub confirms a noticeable shift in when EVs are being charged. Pre-pandemic weekday charging was highly concentrated in the evening hours from 4pm to midnight while the 2021 (Later Pandemic) charging behavior was more evenly distributed in the day.

On the whole, the effect of the COVID-19 pandemic and work-from-home has resulted in a large increase in the average duration that a residential EV remains plugged in. Data from ev.energy showed an increase from an average of 12 hours in January 2020 to 20 hours in January 2021. Similarly, data from OPPD showed an increase in average duration from 12 to 17 hours between 2019 and 2021 (January-August).

According to data from OPPD and the ev.energy platform, the average duration of a residential charging session ranged between 2.5 and 3 hours. As a result, utilities have greater flexibility than ever to schedule customer charging within this extended plug-in window. Indeed, energy players such as Silicon Valley Clean Energy have harnessed this newfound flexibility to align EV charging schedules with renewable generation, while grid operators such as ERCOT have turned to aggregators like ev.energy to schedule EV charging away from emergency or demand-response events with even greater reliability due to flexibility on the customer's side.

Deep Dive Case Study—The Mobility House: Optimized Fleet Charging for Electric School Buses

Summary of Program

In partnership with the Stockton Unified School District (SUSD), The Mobility House (TMH) designed a charging strategy around the bus fleets and route schedules for the school district. SUSD has a large school bus fleet that serves 54 schools. The project is a part of the California Air Resources Board's (CARB) Clean Mobility in Schools Pilot Project. As part of the near-term electrification plan, SUSD installed 14 EVSEs in 2020, which consisted of ten Level 2 AC chargers rated at 16.8 kW and four Level 3 DCFC chargers. As part of the electrification strategy, TMH recommended which of the 27 buses and subsequent routes would be electrified in the near-term, and which in the future plans. The analysis included constraints involving SUSD's operations and budget plans. In 2021, an additional ten chargers were added to the project to support the planned growth of the battery electric buses (BEBs) fleet up to 24 BEBs. The initial project aimed to pair the EVSEs with a new solar PV + storage system, however, simulations demonstrated that it would be possible to effectively manage charging with software, and as a result there would be little financial value from the new storage system.

Project Goals

1. **Decarbonization:** Provide SUSD with a means of implementing part of its decarbonization plan. Switching to BEBs provides an immediate emissions reduction, with further potential through further RE adoption and on-site solar production.
2. **Prove Business Case for EVs:** Provide proof that a managed charging schedule provides reductions in costs from TOU and demand charges.

Program Partners

- **Center for Transportation & Environment (CTE):** CTE was the project lead and manager.
- **Sage Energy Consulting:** Developed roadmap to reach net-zero emissions.
- **Schneider Electric:** Executed the electrical and engineering plans.
- **Blue Bird:** Provider for BEBs.
- **PG&E:** Local utility with make-ready infrastructure and rebate programs.
- **California Air Resources Board:** Grant provider for program.

Managed Charging Approach

TMH used its proprietary Charging and Energy Management simulation algorithm to develop a recommended 15-minute charging schedule based on the existing routes and optimization of the charging costs based on PG&E's utility rate schedule. The new charging schedule aimed to shift SUSD from the default charging behavior of manually plugging the buses in and using a "first-in, first-out" approach. The default charging behavior leads to charging during expensive on-peak times, and can result in prohibitively expensive demand charges. TMH's new charging schedule was designed to save SUSD money by decreasing both TOU and demand-charge costs.

TMH's approach to managed charging emphasizes having the least amount of impact on the customer's operation schedule and doesn't require the customer to change their behavior. TMH's software design automatically adjusts the charging to when the vehicles are needed, and optimizes to achieve the lowest possible cost. Charging is based on site-specific data and any unknown or missing data was supplemented with market knowledge and TMH recommendations. This approach navigates the onsite electrical restrictions, provides the SUSD a view of potential cost savings, and calculates potential carbon reductions.

Program Incentive Structure

There were no event-based bonuses, recurring incentives, or penalties/fees to opt-out of the managed charging. The CARB grant covered most of the hardware and make-ready rebates with some coverage by PG&E rebates for the chargers and make-ready infrastructure. The program also uses PG&E's business EV tariffs.

Program Successes

- **Effective Cost Savings:** The managed charging strategy saved the district money that would have otherwise been spent on non-optimal TOU and demand charges. The district's total savings was simulated to be $31,406/yr for the 11 BEBs and $98,727/yr once the district deploys all 24 BEBs in the future.
- **CO_2 Reduction:** Replacing 11 of the existing diesel school buses with BEBs immediately reduces emissions by 183,000 kg CO_2/yr when fueling from the CA electricity grid.
- **Scalability:** The site was future proofed by laying the conduit for the 10 additional chargers that had not yet been funded at the start of the project. After funding, the additional chargers were easy to install without additional site work.
- **Quick Timeline:** The project was implemented smoothly within a year's timespan. Success was due to well-aligned incentives of all stakeholders, close and constructive collaboration of all stakeholders, and excellent project management.

Program Challenges and Recommendations

- **Plan Early:** Ensure that all stakeholders understand the project scope and are on the same page from the beginning of the project. Additionally, don't underestimate the amount of time it takes to receive and install charging infrastructure at the site.
- **Run Simulations Pre-Installation:** Simulations demonstrated that pairing a new storage system on this specific site did not add any financial value to the system. The financially optimal path for SUSD was to continue powering the building load, rather than the EVSE, from the existing PV system.
- **Ensure Interoperability:** Electrification of fleets requires a compatible ecosystem of vehicles, chargers, charge management software and other systems. It is important to think about interoperability from the beginning. This means selecting hardware and software that use non-proprietary communication protocols.
- **Funding Opportunities:** Each state has its own policies and rebates. Make sure you have done enough research to evaluate whether the project qualifies and see if grants from different sources can be stacked.
- **Partner Alignment:** Align expectations and timelines so that partners are on the same page. This is especially important with multiple stakeholders where excessive coordination is needed.
- **Staff Training:** Extremely important to train all drivers and staff on the local charging equipment. A common misconception with drivers is that each vehicle needs to be plugged in as soon as it returns in order to be fueled for the next drive. Educate drivers to ensure safety and reliability.

Key Takeaways

- Managed charging can **avoid expensive and timely grid upgrade costs** that often kill projects.
- **Using software-based managing services improves replicability and scalability beyond pilots.** Additional flexibility comes when using software built on open standards. Focusing on interoperability and open standards prevents having stranded assets as different technology adoptions occur in the future.
- **Future proof sites** to allow for technology additions such as V2G, and for further fleet expansions. As fleets electrify, sites need to be easily adjusted to accommodate. SUSD has been future-proofed to expedite converting the entire fleet to BEBs.

Case Study—Revel: Fleet Charging Optimization

Summary of Program

Revel, an electric mobility and infrastructure company, partnered with Ampcontrol to roll out a managed charging strategy at the Revel Superhub in Brooklyn, NY. The Superhub is the largest universal fast charging station in the Americas, with 25 75 kW chargers. The site is designed as dual-use for charging Revel's all electric rideshare fleet and for public 24/7 charging. The program charges Revel's fleet predominantly overnight during off-peak hours with Ampcontrol providing charging optimization to ensure the charging occurs in the most economical way. New York City has among the most expensive demand charges in the country, which leaves EV fleets vulnerable to expensive electricity bills.

Project Goals

1. **Reduce Electricity Costs:** By using Ampcontrol's optimization software, Revel aims to reduce the per kWh price of electricity for its fleet.
2. **Site Optimization:** Most locations capable of hosting a large fleet do not have the requisite utility service, and will need managed charging to maximize their grid connection.
3. **Vehicle Optimization:** Ensure that all of Revel's rideshare vehicles are charged by the time of their next shift while also reducing Revel's peak demand.

Program Partners:

- **EVGateway:** OCPP networking provider for Revel
- **Tritium:** The charger OEM
- **Ampcontrol.io:** Optimization software for fleet operation and charging

Managed Charging Approach

Using Ampcontrol's software system, the Revel fleet is charged overnight during off-peak hours and is optimized to ensure that all the vehicles are charged before their assigned shifts. Ampcontrol optimizes the EV load and scheduling to ensure the smoothest load curve. There are future plans to upgrade the software to allow for load shifting during demand response events while still guaranteeing all vehicles are shift ready. The software uses vehicle and charging station data, energy price data, EV battery information, and fleet timetables to set the charging schedule. Simulations showed that peak load could be reduced by up to 50% compared to the base case of non-managed charging.

The charging currently optimizes Revel's fleet of 50 Tesla Model Y vehicles. Revel plans to expand this model to new Superhubs across the city.

Program Incentive Structure

No direct incentive structure. Optimizes around existing utility rate tariffs and physical grid connection limitations.

Program Successes

- **Site Simulation:** Ampcontrol and Revel simulated the site early in the planning phase and were able to test different charging scenarios, including the number of chargers, AC/DC usage, and different vehicle schedules.
- **Dual-usage:** Revel designed the charging site to be accessible to the public. Ampcontrol's software automatically differentiates between external charging from the public and Revel's fleet vehicles. Differentiation allows the software to optimize the Revel vehicles instead of the public charging, and leaves the fast charging function open for public customers. The demand for daytime public charging is expected to be complementary to the overnight Revel rideshare charging.
- **Demand Response Future Proofed:** DR events in New York generally are called during a handful of days in the summer for 2- 4 hours per event. These periods represent a fraction of station uptime and present rationing opportunities. Ampcontrol can be optimized to ration during DR events and reduce both the speed and/or amount of charge per vehicle. DR windows are called at different times across the network, so each new Revel site will have a different DR optimization strategy. Sites will remain public during the DR windows and will rely on the integration of on-site energy storage to reduce impacts on customer charging experience.
- **Scalability:** By leveraging cloud-based software, Revel and Ampcontrol will be able to scale this optimization to future locations and expanded vehicle fleets. The software is designed to adapt to increasingly complex

requests such as managing multiple depots, mid-shift charging, and integrating different vehicle types. The software can be quickly updated to test new use cases without any hardware changes, and allows flexibility in their program design.

Program Challenges and Recommendations

- **Vehicle Differentiation:** Ensure that the optimization software can differentiate between fleet and non-fleet vehicles. Critical for ensuring the vehicle is under the correct charging schedule.
- **Data Mistakes:** The optimization software needs to allow for simple ways that the fleet managers can "overwrite" certain charging decisions, such as manually prioritizing certain vehicles or opting-out of a certain charging session. Some manual oversight is beneficial.

Key Takeaways

- **Dual-usage of charging sites** can be used effectively and promote more efficient usage of site locations.
- **Utilize software that is future-proofed** and allows for new market opportunities. Software services provide flexibility to adapt programs as needed for future growth.
- Site **simulation allows for cost-effective means of trialing** different types of site configurations and charging schedules.
- **Real-time optimization is possible** with all electric ride hailing fleets.

Strategically Planning for 'Preparatory Charging': Anticipating Extreme Weather and Public Safety Power Shut Offs

Each time a major storm system is identified, or a weather event is predicted, residents of the potentially affected area react in a familiar sequence: they hastily make a plan of action, purchase water and non-perishables (and maybe an asinine amount of toilet paper), and fill up their gas tanks. The sudden increase in demand for those resources causes strains and, if significant enough, local shortages. Just like ICE owners form long lines at gas stations, EV owners may plug in their vehicles to charge their vehicles as much as possible before the outage hits.

All of those vehicles suddenly plugging into the grid in anticipation of a predicted outage is what we call 'preparatory charging,' and can create problems if left unmanaged. Without a managed charging strategy, an uncontrolled spike in electricity demand could overwhelm grid infrastructure and cause damage, resulting in costly repairs or upgrades. Those EVs will also compete with critical facilities for electricity, which could compound further infrastructure failure and expanded outages.

Proactive managed charging is a solution to prevent unintended consequences from uncontrolled preparatory charging. Before a predicted outage, utilities have the opportunity to greenlight proactive managed charging, which will strategically direct customers across the service territory to begin charging their vehicle. This allows the utility to spread the charging requirements over a longer time window than would happen naturally. In many cases, a utility is aware of potential storm outages 24-48 hours in advance, which is more than enough time to smoothly ensure customers are fully charged.

Utilities will need regulatory permission to create proactive managed charging programs that incentivize passive or active managed charging in preparation for potential outages or evacuations. **Regulators may require new analysis methods to financially evaluate the budget allocations for this proactive managed charging strategy. Beyond typical cost-benefit analysis, these new analysis methods might consider the value of the following**:

- Customer choice in a vehicle and its energy source;
- Alleviating public fear of being stranded;
- Supporting the creation of a trusting customer-utility relationship;
- Building consumer confidence in electrification;
- Fortifying the energy system to build community resilience.

Customers will either need to respond quickly and accurately to utility charging instructions , or they will need to give the utility permission to take control of their vehicle's charging to optimize grid operations.

For example, PG&E is currently exploring proactive managed charging. Their proposed (as of September 2021) Resilient Charging program is designed to support EV owners in the event of an outage. The program plans to test a variety of methods to influence charging, and might be revised to offer incentives that determine the value of load control to customers. The program aims to increase the resiliency of customers that are EV owners and build confidence in vehicle electrification. PG&E will contract with a third party to manage the majority of the Resilient Charging program implementation. That third party will communicate with customers about a minimum of four test Public Safety Power Shutoffs (PSPS) events and actively manage vehicle charging so they are fully charged before an outage.

The Resilient Charging program, planned to commence in 2022 for one year, will enroll 8,000 EV drivers in High Fire Threat Districts and areas that will likely experience PSPS events. The participant pool will be diverse in their location within the service territory, demographics, vehicle, and charger type. PG&E also hopes to enroll customers that live in equity communities. In exchange for an enrollment incentive, the participants will be split into three groups to test different ways of structuring the program to determine the optimal program design. One group (the control) will not receive any charging reminders or be actively managed, another group will only receive charging reminders before PSPS events, and the final group will receive both charging reminders and have the charging of their vehicle actively managed prior to PSPS events. PG&E will regularly assess the effectiveness of the pilot, determine opportunities for process and customer outreach improvements, reflect on program challenges, and identify follow-on research studies.

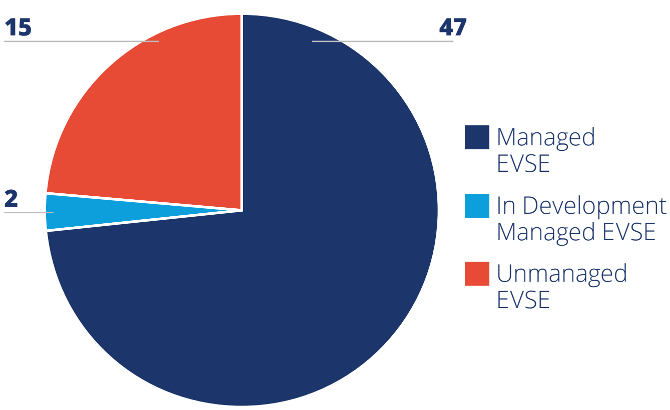
Proactive managed charging offers a solution to preparatory charging that may result from a predicted weather event, expected outage, or long holiday weekend. Solution providers, utilities, and regulators should begin the planning process for preemptive managed charging programs to proactively support the grid before problems have the chance to form in their service territory.

Chapter Four: Managed Charging Technology and Vendors

EVSE Vendor Landscape

The EVSE market has continued to develop since our 2019 report. The number of EVSE manufacturers with product offerings in the U.S. has remained largely the same, fluctuating slightly due to new vendors and several manufacturers exiting the market (especially Level 1 chargers). As shown in Figure 19, of the 64 identified EVSE manufacturers with product offerings in the U.S., 47 have at least one managed charging-capable product. Two manufacturers are in the process of developing their managed charging-capable offerings, which brings the total landscape to approximately 76% of EVSE vendors supporting managed charging. This is a notable increase since 2019, when only 65% of vendors had managed charging-capable offerings.

Figure 18. Vendors Offering Managed Charging EVSE in the US



N=64

Source: SEPA, 2021

EVSE Technology Classes

In large part, the decrease in non-managed charging-capable EVSEs is due to the discontinuation of many of the old Level 1 chargers and movement towards networked Level 2 EVSEs (Figure 20). Of the eight vendors offering Level 1 chargers, most of the applications differ from the mostly wallbox/standing device offerings in 2019. Of the eight Level 1 chargers, three are fully portable, one is embedded in an off-grid, solar array + EVSE product, two are combined Level 1/Level 2 devices, and only two vendors offer fully Level 1-only charging. Additionally, only two vendors with Level 1 chargers only offer that type of EVSE. Since 2019, vendors have continually trended towards Level 2 chargers; 55 of 64 vendors (86%) have at least one type of Level 2 product line (Figure 20).

The Level 2 market continues to offer the most products. Of note, 77% of vendors that offer DCFC EVSE have at least one Level 2 product offering. Conversely, only 44% of vendors that focus on Level 2 charging have DCFC products. As of this report, more vendors are invested in the Level 2 market with some trends of expansion into DCFC. Of the 64 total vendors, only seven entirely focus on DCFC and market primarily to medium- and heavy-duty vehicles and fleet owners.

Within the charger classes, there have also been technological developments such as the continued development of V2G, EVSE product design differentiation, and adoption of different business models. V2G has continued in its development, and 12% of the EVSE vendors either currently have V2G offerings or are in the process of developing their technology. V2G technology adoption is more common with vendors that have also

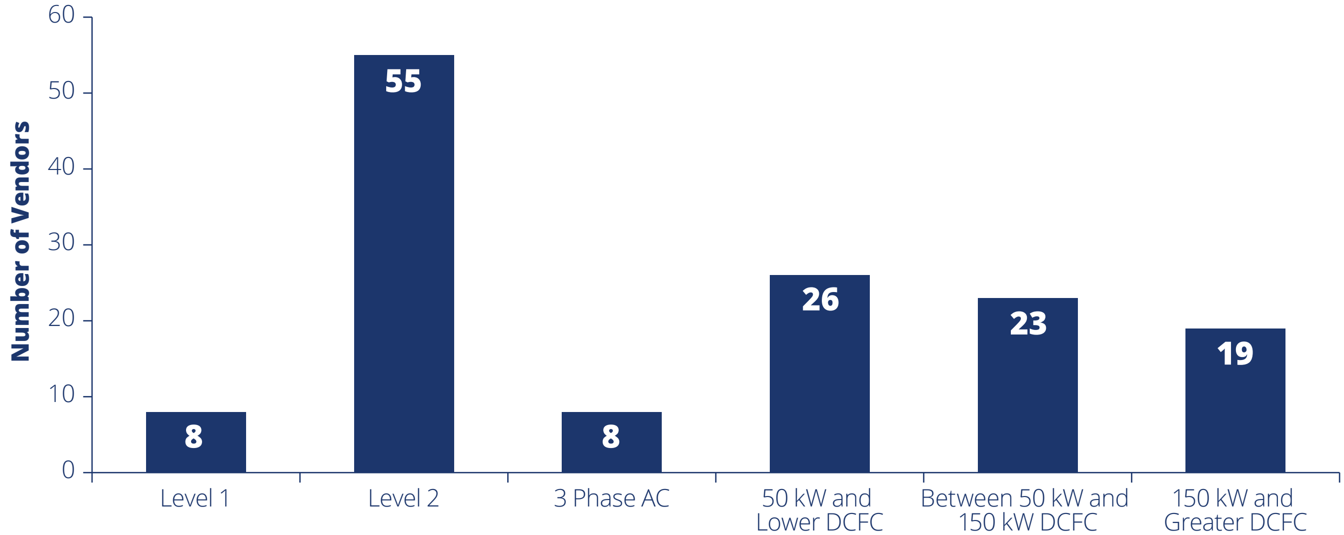
Table 3. Intersection of EVSE Classes

Level 1 Only Vendors	Level 2 & Level 1 Only	Level 2 & DCFC	DCFC Only
2	31	24	7

N=64

Source: SEPA, 2021

Figure 19. Vendor Product Offerings by Level



N=64.

Note: The 150 kW threshold is an arbitrary value and is not an industry standard.

Source: SEPA, 2021

expanded into DCFC and fleet management; five of the eight V2G vendors offer multiple classes of DCFC products, and one of seven vendors is developing a wireless Level 2 charging option. Some vendors are already differentiating their V2G offerings. EVolution (OATI) is calling its V2G technology "Vehicle-to-Everything (V2X)," where its V2X includes vehicle-to-business (V2B), vehicle-to-grid (V2G), and vehicle-to-home (V2H). WiTricity, the vendor developing wireless charging, is already marketing its product as V2G with the additional capability of charging mobile cars on roadways.

Other vendors have differentiated by adding storage and/or mobility to their products to offer increased resiliency for the end users. Freewire's DC Boost Charger is marketed as a semi-permanent charger that can grid connect during normal conditions, store energy in the integrated battery + management system that can increase peak shaving and load shifting, and be moved as needed for resiliency events. Signet Systems offers a similar DCFC system that includes power cabinets in the EVSE charger that can be charged during beneficial grid times. ChargePoint has addressed another aspect of resiliency through mission critical fleet monitoring. ChargePoint's Assure is an EV station and maintenance management program that provides 24/7 proactive monitoring and technical support, same-day dispatch, and 24-hour issue resolution to address the high uptime requirements of fleets.

Another minor product differentiation has occurred in the designs of the EVSE to accommodate more placements and usages. EVSE LLC advertises an overhead garage EVSE with adjustable technology to move the EVSE down to an ADA compliant height and AddEnergieTechnology designed a curbside specific Level 2 charger. Ebee Technologies and Panasonic are two companies that took a different design approach. Both offer modular kits for customers to design their own EVSEs for their specific end uses. Similarly, ChargePoint offers a customizable product through its ultra-fast DC charging platform that features a modular, scalable architecture that allows station owners to purchase what they need and scale as demand grows.

Furthermore, EVSE vendors are starting to adopt different types of business models that utilize the Charging-as-a-Service (CaaS) model. Blink offers a variety of product and business model services, three of which allow Blink some long-term ownership over the EV chargers. SemaConnect offers a similar CaaS model where SemaConnect maintains ownership of the EVSE and handles the maintenance and user billing for a fixed monthly subscription. Other vendors like ChargePoint offer variations of the "as-a-service" model. ChargePoint offers "ChargePoint-as-a-Service" (CPaaS), which allows site hosts to have full operational control of the charging stations and all of the associated software and services for an annual fee. Appendix B contains a detailed list of the known EVSE vendors and their equipment offerings.

EVSE Messaging Protocols

As more EVSE vendors include networking capabilities in their products, there has been a clear trend to include at least one open protocol to improve interoperability. In 2019, 66% of EVSEs with networking capability utilized OCPP protocols.[14] Today, 40 vendors utilize OCPP, representing 81% of the total networking vendor pool and 97% of EVSE vendors using open, non-proprietary protocols (Table 4). Of the 40 vendors that use OCPP, 53% use only OCPP and 47% use OCPP with at least one other open protocol. Outside of the proprietary protocols, only one vendor did not use OCPP as one of its open protocols; instead relying on a combination of OpenADR + ISO/IEC 15118. It is important to note that sharing data from a charge point network and enabling load management events does not require OCPP. Other ways to enable these functionalities include utilizing APIs (Application Programming Interfaces) or other protocols (such as OpenADR) with DERMS providers.

When vendors use two or more protocols, OCPP is most typically paired with either ISO/IEC 15118 or Open ADR; seven vendors use OCPP + ISO/IEC 15118 and six use OCPP + OpenADR.[15] Since 2019, both ISO/IEC 15118 and OpenADR have maintained about the same adoption rate. Both were used by eight vendors in 2019 and both have about the same usage rate in conjunction with OCPP.

Table 4. Adoption of Open Protocols by EVSE Manufacturers

OCPP	ISO/IEC 15118	OpenADR	API	Proprietary
40	12	9	4	7

Note: Many EVSE utilize more than one messaging protocol.

N= 64.

Note: Protocols that were not publicly available were considered proprietary.

Source: SEPA, 2021

Network Service Provider Landscape

Network Service Providers (NSPs) are software-based, technology platform vendors that provide interfaces between charging stations, their operators, and EV drivers. At the time of publication, SEPA identified 43 Network Service Providers, a significant increase from the 28 identified in 2019. NSPs offer networking services that can be characterized as one of three different types: local EV networks, DERMS control and monitoring platforms, and regional/nationwide charging networks. Of the 43 vendors, 30 provided localized networks, 16 provided nationwide customer charging networks, and 11 provided a DERMS platform. Many NSPs offer more than one type of networking service, and within the networking archetypes, NSPs vary in their types of business models. Similar to the EVSE vendors, Charging-as-a-Service has become a more common business model, with 16% of NSPs having a CaaS offering.

Many NSPs with localized software solutions market to Charge Point Operators (CPOs), such as fleet owners, and/or utility providers that are developing a managed charging program or seeking better data on their EVSE equipment. These local networks can provide CPOs and utilities remote access to the EVSE to optimize station utilization, access and analyze the charging data, and conduct load management. Additional functionalities for CPOs include setting access controls and driver pricing, especially for EVSE open to public usage. Local EV networks can be on-site installations that turn non-networked chargers into self-contained, smart systems, or can be larger networks within a service area. Some NSPs like Liberty Plugins and PowerFlex market to customers who want entirely self-contained systems that are non-cloud based, while other NSPs like Kitu Systems and The Mobility House offer cloud-based solutions that can scale as fleets increase in size (See Appendix C for more NSPs). NSPs with cloud-based networks can aggregate the discontinuous EVSE to use in demand response events and as virtual power plants (VPP) in regional markets. For example, Enel X has been using the EVSEs connected to its JuiceNet platform to act as part of its VPPs that Enel X bids into the California Independent

14 OCPP is a communication protocol used between a charge point (i.e., charging station hardware) and an EV charging network (i.e., management system) used for operating & managing charge points.

15 Using OpenADR with OCPP. This paper outlines how to integrate EVs into the electricity grid using the industry standards OpenADR and OCPP.

System Operator's (CAISO) wholesale and day-ahead markets and in resiliency events. During peak events, these VPPs can be used to decrease load and participate in peak shaving.

DERMS systems go beyond localized EVSE networks and monitor, control, and schedule EV charging based on local distribution grid conditions, market signals, and system peak conditions. DERMS systems are geared for utility and grid operators rather than private fleet managers. Many of the existing DERMS vendors for utility EV managed charging programs use a local NSP network. As discussed in the Eversource and National Grid case studies in Chapter 4, the programs utilize both the ChargePoint Network and the EnergyHub's Mercury DERMS system to manage the EV charging. Not all DERMS providers can use any type of localized NSP platform, and many DERMS providers have specific partnerships with other NSPs. DERMS systems provide additional functionality for utilities by providing a platform that incorporates additional distributed energy resources such as solar, energy storage, smart thermostats, etc.

Nationwide network platforms are utilized by EV drivers and provide maps of existing nearby charging stations, along with information like EVSE type, charging price, device status, directions, user feedback, and charging method. NSPs with nationwide network platforms are called eMobility Providers, and they market their platforms to CPOs to provide value for the charging equipment and market to EV drivers to utilize the EVSEs. Approximately 81% of the NSPs with nationwide networks also have localized charging network solutions, showing a trend of NSPs marketing dual usage to CPOs: a local managed charging network and streamlined customer usage of the EVSE. Nationwide NSPs have also begun to partner with fleet managers to more effectively connect CPOs and other fleet managers to a broader customer base. ChargePoint has partnered with the automotive fleet manager company Element Fleet Management Corp and the financial technology provider WEX to create a consolidated billing system for charging and fueling across client fleets.

Some NSPs have expanded beyond creating their own nationwide networks to facilitate the integration of different networks. Plug & Charge is one such initiative to increase interoperability by allowing customers from one network to be connected to a larger, interconnected network using protocols like ISO/IEC 15118 and Plug & Charge protocols. Hubject is an NSP that has partnered with nationwide NSPs like Electrify America to facilitate this integration. Other NSPs, like The Mobility House and Greenlots also use these open protocols for the Plug & Charge functionality. ZEF Energy is an NSP with a network within a network, where ZEF Energy is powered by Greenlots and provides a network for the Minnesota-North Dakota region. Peer-to-peer roaming is another version of network interconnectedness, where vendors like ChargePoint advocate for peer-to-peer roaming agreements to reduce driver costs and accessibility to EVSE. Amp up is another nationwide NSP that has partnerships with 14 other NSPs and allows customers to use these other networks on its mobile app.

Managed Charging NSPs

Of the total number of NSPs, 93% are managed charging capable. 100% of NSPs that offer localized and/or DERMS solutions are managed charging capable. The non-managed charging networks mainly occur with the nationwide, roaming customer networks solutions. In contrast, in 2019 only 79% of the NSPs were managed charging capable, which shows a significant increase in emphasis on developing managed charging.

Given the number of NSPs in the market, it can be challenging to interface with the various networks, especially for utilities with their own networks and proprietary systems. The usage of APIs and open protocols like OpenADR and OCPP allow for more effective integration of these networks into utility systems, especially for ADMS and DERMS systems that would control EV charging through the NSP networks. As with the EVSE vendors, OCPP is the most common protocol among the NSP vendors, with 53% of the NSPs using some version of OCPP. Since 2019, more vendors have adopted OCPP 2.0, which supports ISO/IEC 15188 functionality and provides further interoperability capabilities. Vendors using OCPP have increased from 14 to 23, showing a significant increase in the usage of this protocol.

Most typically, vendors use two or more open protocols, with the most popular combinations including either OCPP + Open ADR or OCPP + API protocols. Many of the top NSP vendors advocate for using both OCPP and either OpenADR or API protocols. DERMS vendors using open protocols often use OpenADR and API to enhance interoperability and improve utility integration. Smarter Grid Solutions, Itron, and Energyhub are DERMS providers that use OpenADR to allow for integration of EVs into DR programs. Both OpenADR and API protocols have increased since 2019; OpenADR increased from 11 to 17 vendors and API increased from 6 to 15 vendors. OpenADR has increased in popularity in part due to its usage among DERMS providers. With the layering capabilities of these communication protocols, more vendors have begun to use multiple open protocols along with their proprietary protocols to enhance interoperability and improve integration with existing systems.

Table 5. Adoption of Open Protocols by Network Service Providers					
OCPP	**ISO/IEC 15118**	**OpenADR**	**API**	**Proprietary**	**IEEE 2030.5**
23	7	17	15	10	4

Note: Many NSPs utilize more than one messaging protocol. Protocols that were not publicly available were considered proprietary.

N= 43.

Source: SEPA, 2021

An Introduction to Vehicle Telematics

Telematics encompases the integrated use of telecommuniations and vehicle informatics to collect, track, and communicate a wide range of information relating to an individual vehicle or fleet of vehicles. As vehicles become more sophisticated and more connected, and managed charging programs expand beyond the residential segment, telematics is playing a new role in the managed charging ecosystem for both fleets and private vehicles. Telematics for commercial fleet management and optimization has matured over the years and is changing the way commercial fleets manage for reliability, efficiency, refueling or recharging, and customer service standards. Telematics serves an additional function for electric fleets by enabling fleet managers to remotely track and automatically optimize battery state of charge, battery charging, and route optimization in real time.

Traditionally telematics is closely associated with commercial fleet management, however, it is gaining popularity for new personal vehicle models. This is evidenced by a marked increase in OEMs that offer in-vehicle telematics either as a standard or add-on feature for personal vehicles, or as a service for commercial fleets. While telematics offer many features beyond the scope of managed charging—and in fact is marketed primarily for those features—telematics can provide specific vehicle data relevant to a residential managed charging program. Information such as driving efficiency and its impact on range, battery state of charge and battery health, and vehicle charging history by location can all be used to inform utility managed charging programs. Common examples of personal vehicle telematics include GM's Onstar program, BMW's ConnectedDrive program, or Ford's Sync integrated communications system.

In the context of managed EV charging, onboard telematics and vehicle-based communication have benefits and limitations when compared to networked chargers.

Benefits of Vehicle Telematics

- Delivers high quality vehicle data regardless of vehicle location (state of charge, kWh and kW delivered during a charging session, customer plug-in/unplug time, etc.)
- Enables multi-location managed charging (start/stop or throttling)
- Allows for communication with charging stations in advance and during charge sessions
- Delivers social equity benefits by offering a lower-cost avenue for customer participation (vs. a networked L2 charger) as well as by enabling managed charging for renters and residents of multi-unit dwellings who may not have a dedicated charger or parking space
- Provides an additional marketing outreach channel from OEMs to customers

Limitations of Vehicle Telematics

- As a relatively new technology, some older vehicle models lack telematics platforms and therefore cannot participate in managed charging programs that rely only on telematics for communication and control
- No standard approach exists for what type of data is collected, the naming nomenclature for the data collected, and how that data is shared (e.g., the battery state of charge can be shown as SoC, KWh remaining, miles remaining etc.).
- Telematics often take the form of GSM-based cellular connectivity that relies on existing cellular networks for communication over a broad geographical area. In some cases this can limit controllability in areas of low cell service (e.g., parking garages, rural areas, etc.).

It is becoming more apparent that networked chargers and vehicle telematics are complementary technologies that together create significant opportunities to improve and expand the value that managed charging brings to customers and the grid.

How Telematics and Networked EVSEs Can Be Complementary

Increasingly, utilities are offering both vehicle telematics and networked EVSEs as options for customers interested in enrolling in their managed charging programs. The benefits of doing so include:

- Maximum load coverage and customer eligibility
- Equity of access to managed EV charging programs
- Increased accuracy of scheduling and charging when both vehicle telematics and a networked EVSE are used together

Including both vehicle telematics and networked EVSEs in managed charging programs maximizes the number of devices a utility can connect to. While rebate-subsidized EVSEs have historically been a common technology for managed charging programs, many customers are already offered a non-networked L2 charging cable with the purchase of their vehicle, and therefore do not require or see additional value in a networked device. Moreover, there are significant income barriers in installing a networked EVSE, including installation costs ranging from $680-$2,000 (source: ICCT) as well as permission from the landlord if the customer is a renter (commercial or residential). As a result, customer uptake of networked L2 chargers has been limited and utilities have responded by including vehicles with on-board telematics as eligible devices. While this has dramatically increased customer eligibility, the coverage offered by vehicle telematics can be restricted by OEM limitations: for example, Nissan Leaf models prior to 2018 were not manufactured with telematics, and models from 2019 & beyond do not offer telematics in the base trim.

Telematics and networked EVSEs can equally be leveraged to ensure equity of access to EV charging programs from low-and middle-income customers. For example, Southern California Edison offers rebates for second-hand EVs, which tend to be older and lower-priced models that lack vehicle telematics. But through its ChargeReady Home Installation rebate, customers receive a $500 rebate towards a networked L2 charger that provides the utility with load control regardless of the vehicle's telematic capabilities. Similarly, California Community Choice providers Silicon Valley Clean Energy and MCE are both offering networked L2 *and* L1 charging options to ensure equitable access to their GridShift and MCE Sync programs, respectively, including for residential customers living in multi-unit dwellings.

When connecting to "both ends of the cable," managed EV charging platforms can deliver a highly accurate and precise managed charging session. While vehicle telematics can provide up-to-date readings of the vehicle's battery level to inform a managed-charging algorithm, networked EVSEs offer precise control to turn charging on/off and throttle power in line with a utility's requirements. For example, hardware-agnostic managed charging provider ev.energy can use either vehicle telematics or a networked EVSE to deliver demand-response and temporarily interrupt a customer's charging session, while leveraging battery level readings from the vehicle to ensure the customer's car is still fully charged by the time they specify.

Chapter Five: Program Recommendations

While the rate of EV adoption remains uncertain, there is growing consensus across the transportation and electricity ecosystems that high levels of EV penetration in light-, medium-, and heavy-duty segments are both necessary and inevitable. As society navigates the transition to a low carbon economy and electric vehicles evolve from niche to mainstream, utilities, customers, and vendors will all need to adapt. The approaches to managed charging presented in this report and the examples of how utilities are designing, implementing, and evolving their managed charging programs provide the industry with guidance on how to minimize the challenges and maximize the benefits that electric vehicles offer to utilities and customers alike.

In the following section we offer key recommendations for designing, implementing, and adapting managed charging programs. These recommendations are based on utility trends, utility interviews, a review of the vendor landscape, and a set of seven case studies that explore various approaches to managed charging of different customer and vehicle segments.

Program Design

Plan for programs to evolve to meet system needs. When designing a managed charging program for any customer or vehicle segment, the utility must plan for the evolution of the program from the early stages that may be a pilot or capped program to the long-term time horizon when a large portion of customers will be engaged. Considering the near-term and long-term time horizon must also include an assessment of how grid impacts will change as EV penetration increases. For example, a utility may begin with a passive TOU program that allows the utility and customers to gain experience with managed charging. As EV penetration increases, the program may evolve to an event-based DR program, then as customers get more comfortable and the utility implements more communication and control, the program can transition to a continuous managed charging, and perhaps eventually to a fully integrated DERMS system.

Design programs to be feasible at scale. Each component of a managed charging program must be designed to work when the program is available to all customers. Data collection and control must be automated, incentives must be sized in a way that is financially feasible when implemented at scale, and programs will need to be aligned or integrated with other DER applications. Program design considers factors such as the level of reliability and accuracy of available vehicle and charging device data, as well as the degree of complexity (e.g., number of vehicles, scale of time).

Dedicate resources to ensure alignment and coordination with other funding sources and related programs. As local, state, and federal governments continue to adopt policies that enable or promote decarbonizing the economy, utilities and other stakeholders need to be aware of programs that have overlapping goals or funding sources. Identify funding sources that support low carbon transportation, and design programs to be complementary.

Structure programs such that the default behavior benefits both the customer and the grid. Programs that are 'Opt-out' achieve greater levels of managed charging than those that are 'Opt-in'. Designing programs that allow customers to 'Opt-out' of managed charging rather than 'Opt-in' reduces cognitive burden and enables increased participation. For example, a program that requires a participant to agree to participation every time their charge session will be managed requires a greater level of engagement compared to a program where the management happens automatically unless the driver indicates they want to opt out for that day. Programs should aim for a 'set it and forget it' customer experience where customers trust that they will have the level of charge required for their daily driving needs and will only consider opting out if they are planning to use their vehicle in a way that differs from their typical daily pattern.

When possible, implement managed charging programs to allow participation via OEM telematics and networked chargers. Design programs with backwards compatibility in mind to minimize excluding older vehicles. Adopting a hardware-agnostic approach will maximize customer eligibility and enrollment figures, delivering a larger amount of MW for the utility to control.

Program Rollout and Implementation

Include customer education in the marketing and recruitment phases of the project, and provide technical education after enrollment. Residential and commercial customers will be navigating a transition to a new technology with a steep learning curve. Providing easily accessible guidance that addresses common issues and questions creates a better customer experience and strengthens the customers perception that the utility is a key partner in this transition. For OEMs—integrations via APIs is critical to marketing, enrollment, visualization, and load control.

Develop solutions that are compatible with relevant regulations and utility capabilities and continue to track market and technology advancements to ensure the programs evolve alongside the market.

Leverage dealerships, in-app messaging, and traditional marketing to educate and inform customers that are not currently EV owners. An accessible customer interface, regular customer engagement via in-app messaging and compelling incentives are all critical to maximize customer retention and the reliability of load-shifting or load-reduction delivered by the program. Include non-EV owners in the education and outreach after initial program recruiting and marketing is completed. Eventually, all vehicle owning customers will become EV owners, so including them in awareness campaigns will streamline the recruitment process when they purchase an EV.

Program Evolution

Take a holistic view of multi-DER strategy and streamline operations by bringing the management of all DERs onto one platform. Adopting a single platform is not always simple with legacy utility systems, and utilities will have to consider how EVs fit into their overall DER portfolio.

Allow utilities flexibility in creating programs so they can learn more about customer incentives, behavior, and load flexibility and adapt programs accordingly. Regulators may need to continue encouraging utility laggards to pilot managed EV charging programs ahead of more widespread EV adoption before the need for managed charging becomes more pressing.

Continue to support utility pilots for emerging technologies and to test different market mechanisms. Many TOU and DR programs develop first in a piloting stage and then receive additional funding to scale the program.

Glossary

Active Managed Charging: This form of managed charging, also known as direct load control, supersedes customer charging behavior and imposes utility preferences on charger functionality. Charging is controlled by communication signals sent from a utility or aggregator to a vehicle or charger. Active managed charging can be event based, where load is controlled during a limited number of events in a given time period. Active managed charging can also be continuous, which enables more constant control that is responsive to grid conditions on a more granular scale.

Aggregator: An aggregator is a third party intermediary linking electric vehicles to grid operators. Increasingly, aggregators are stepping into a role of facilitating interconnections to entities that provide electricity service. Broadly, aggregators serve two roles: downstream, they expand the size of charging networks that electric vehicle (EV) customers can access seamlessly, facilitating back-office transactions and billing across networks; upstream, they aggregate a number of EVs and Charging Station Operators (CSO) to provide useful grid services to Distribution Network Operators (DNO) and Transmission System Operators (TSO).

Bulk system: The bulk system refers to the entirety of the infrastructure used for the generation and transmission of energy.

Charging Session: A charging session is the amount of time that transpires beginning when an EV driver plugs a charger into their vehicle and ending when they unplug the charger from the vehicle. In the context of managed charging, a charging session serves as the opportunity for throttling to take place.

Charging Station: The physical site where the Electric Vehicle Supply Equipment (EVSE) (also known as the charger) or inductive charging equipment is located. A charging station typically includes parking, one or more chargers, and any necessary "make-ready equipment" (i.e., conduit, wiring to the electrical panel, etc.) to connect the chargers to the electricity grid, and can include ancillary equipment such as a payment kiosk, battery storage, or onsite generation.

Charger: A layperson's term for the on-board or off-board device that interconnects the EV battery with the electricity grid and manages the flow of electrons to recharge the battery. Also known as Electric Vehicle Supply Equipment (EVSE).

Continuous Managed Charging: This managed charging method, also known as dynamic managed charging, adjusts the EV load according to real-time or near real-time grid conditions. Continuous managed charging adjusts EV charging schedules in response to wholesale energy prices, renewable generation, grid constraints, and other utility signals while adhering to driver preferences.

Demand Response (DR): Demand response is a load management method that is used during periods of peak demand in order to relieve grid stress. As part of a demand response effort that occurs during a charging session, the charger could be throttled to reduce energy consumption temporarily and return to full charging capacity once grid stress is relieved.

Electric Vehicle Supply Equipment (EVSE): The equipment that interconnects the AC electricity grid at a site to the EV. It can be Level 1, Level 2, or Direct Current Fast Chargers (DCFC) charging. Also known as a charger.

Electric Vehicle Service Provider (EVSP): The EVSP is responsible for all aspects of vehicle charging operations, from infrastructure and hardware, to functionality and software. Utilities will need to coordinate with the ESVP to conduct managed charging according to utility preferences.

Incentive Stacking: Incentive stacking refers to the strategy used by utilities in the development of their managed charging programs to motivate customers to charge their vehicles in a way that optimizes the grid.

Interoperability: The ability of devices, systems, or software provided by one vendor or service provider to exchange and make use of information, including payment information, between devices, systems, or software provided by a different vendor or service provider.

Managed charging (V1G, controlled charging, intelligent charging, adaptive charging, or smart charging): Central or customer control of EV charging to provide vehicle grid integration (VGI) offerings, including wholesale market services. Includes ramping up and ramping down of charging for individual EVs or multiple EVs whether the control is done at the EVSE, the EV, the EV management system, the parking lot EV energy management system or the building management system, or elsewhere.

Multi-layer Optimization: This managed charging approach optimizes charging according to bulk system and distribution circuit constraints while meeting driver preferences. The benefit of this approach is that it optimizes grid performance at each level and will be effective in service territories with high EV penetration.

Network Service Provider (NSP): The NSP provides services related to chargers, such as data communications, billing, maintenance, reservations, and other non-grid information. The NSP sends the grid commands or messages to the EV or EVSE (e.g., rates information or grid information based on energy, capacity, or ancillary services markets; this is sometimes called an electricity grid network services provider). The NSP may send non-grid commands (e.g., reservations, billing, maintenance checks). The NSP may receive data or grid commands from other entities, as well as send data back to other entities.

Networked EVSE: These devices are connected to the Internet via a cable or wireless technology and can communicate with the computer system that manages a charging network or other software systems, such as a utility demand response management system (DRMS) or system that provides charging data to EV drivers on smartphones. This connection to a network allows EVSE owners or site hosts to manage who can access EVSE and how much it costs drivers to charge.

Non-networked EVSE: These devices are not connected to the internet and provide basic charging functionality without remote connections capabilities. For example, most Level 1 EVSE are designed to simply charge a vehicle; they are not networked and do not have additional software features that track energy use, process payment for a charging session, or determine which drivers are authorized to use the EVSE. Secondary systems that provide these features can be installed to supplement non-networked EVSE.

Original Equipment Manufacturer (OEM): The original equipment manufacturer, or OEM, creates the parts that are used by other companies to build a final product. In the context of this paper, that final product is an electric vehicle.

Open Standards: Generally denotes a data format, communications protocol, payment protocol, or other technical interface developed in an open and transparent process by a non-profit party that allows any entity to contribute to its development and can be used royalty-free.

Open Charge Point Protocol (OCPP): OCPP is an open-source communication protocol for EV charging stations (EVSE), network solution providers (NSPs), and Distributed Energy Resource Management providers (DERMS).

Passive Managed Charging: This charging method, also known as behavioral load control, relies on customer behavior to affect charging patterns. Price signals are often utilized in passive managed charging programs to influence customer charging behavior, but ultimately, the customer remains in control of the vehicle charging.

Platform: The base hardware and software upon which software applications run.

Preparatory Charging: This term refers to a collective EV driver reaction to an expected outage in the near future, usually as a result of extreme weather. After realizing an outage may be imminent, EV drivers will plug in their vehicles and commence charging, just as ICE drivers would fill up their gas tanks to prepare for a predicted extreme weather event. The impact of preparatory charging will increase grid stress, which will be magnified depending on the level of EV penetration.

Proactive Managed Charging: To prevent any unintended consequences of uncontrolled preparatory charging, utilities can use proactive managed charging as a tool before a predicted outage. Proactive managed charging ensures all EV customers reach the vehicle charge level they want while balancing load across the grid to prevent infrastructure damage or an even more severe outage.

Proprietary Protocol: A protocol that is owned and used by a single organization or individual company.

Protocol: Set of rules and requirements that specify the business process and data interactions between communicating entities, devices, or systems. Most protocols are voluntary in the sense that they are offered for adoption by people or industry without being mandated in law. Some protocols become mandatory when they are adopted by regulators as legal requirements. A standard method of exchanging data that is used between two communicating layers.

Price Signal: A price signal is used to influence customer charging behavior according to what would benefit the grid. At times of high grid stress, a higher rate will be used to motivate customers to halt charging in order to reduce electricity demand. At times of high renewable generation, a lower rate will be used to encourage customers to begin charging to take advantage of low-cost, excess generation.

Standard: An agreed upon method or approach of implementing a technology that is developed in an open and transparent process by a neutral, non-profit party. Standards can apply to many types of equipment (e.g., charging connectors, charging equipment, batteries, communications, signage), data formats, communications protocols, technical or business processes (e.g., measurement, charging access), cybersecurity requirements, and so on. Most standards are voluntary in the sense that they are offered for adoption by people or industry without being mandated in law. Some standards become mandatory when they are adopted by regulators as legal requirements.

Standardization: Process where a standard achieves a dominant position in the market due to public acceptance, market forces, or a regulatory mandate.

Telematics: In the context of EV charging, including managed charging, telematics refers to the communication of data between a data center (or "cloud") and an EV, including sending control commands and retrieving charging session data.

Third-party Optimization: When the charging schedule of a single vehicle, or fleet of vehicles, is optimized on behalf of the driver or fleet manager by a third party that is not a utility. Typically the third-party is a solution provider that offers proprietary optimization software that determines the best approach to vehicle charging given a defined set of constraints and optimization metrics such as cost, carbon, vehicle duty cycle, or other metrics.

Time-of-Use EV only: A Time-of-Use (TOU) rate reflects the wholesale cost of energy at different times of day; an on-peak TOU rate is more expensive and is in effect when demand is at its peak, and an off-peak TOU rate is less expensive and is in effect when demand is lower. A Time-of-Use EV only rate is a TOU rate that only applies to EV charging; customers that are eligible for this time of rate will be billed separately for their energy usage associated with their charging station and will often need to install a second, separate meter.

Time-of-Use Whole home: A Time-of-Use Whole home rate is a TOU rate that applies to the energy consumption of the entire house, including that associated with an EV charging station.

Unmanaged Charging: Describes the charging behavior of EV drivers when left completely uninfluenced by incentives of any kind. Unmanaged charging typically occurs when it is most convenient for the driver to plug in their vehicle, whether they are parked in a public parking lot, arrive at work, or return home.

Use Case: Defines a problem or need that can be resolved with one or more solutions (technical and/or non-technical) and describes the solutions. The use case is a characterization of a list of actions or event steps, typically defining the interactions, describing the value provided and identifying the cost.

Vehicle Grid Integration (VGI): VGI includes any action taken via a grid-connected electric vehicle and/or electric vehicle supply equipment, whether directly through resource dispatching or indirectly through rate design, to alter the time, magnitude, or location at which grid-connected electric vehicles charge or discharge, in a manner that optimizes plug-in electric vehicle charging and provides value to the customer and the grid. Examples of such actions include, but are not limited to, reducing charging expenses, increasing electric grid asset utilization, avoiding distribution or transmission infrastructure upgrades, integrating renewable energy, offering resiliency and backup power, and offering reliability and wholesale energy services. VGI spans a wide range of use-cases, actors, assets, and technologies. The consensus in industry is that VGI includes both V1G (managed charging) and V2G (vehicle to grid) solutions.

Vehicle to Grid (V2G): V2G assumes a bidirectional energy transfer capability and not just a discharging of the battery. Energy from the EV battery is converted to an AC current which flows from the EV back to the electricity grid or to a facility circuit which is connected to the electricity grid, even if there is no net export or power from the facility. Other applications include Vehicle to Home (V2H), Vehicle to Building (V2B), or Vehicle to Load (V2L).

Appendix A: Utility-Run Managed Charging Programs by Program Type, 2019-2021

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021

Utility Name, State	Utility Type	Program Name	Short Description	Program Incentives	Project Partners
Program Type: Direct Load Control via the Charging Device					
Austin Energy, Texas	Muni	Home Charging Rebate	The maximum rebate amount is $1,200 for Wi-Fi enabled & $900 non-Wi-Fi ; Austin Energy may, at any time during your commitment period, replace your charging station with an Austin Energy-owned charging station located in your home and on your side of the meter. Austin Energy may install and operate Austin Energy owned data monitoring or charge management devices in your home and on your side of the meter.	Rebate	
Barron Electric Cooperative, Wisconsin	Co-op	Electric Vehicle Charging Station & Miscellaneous	Barron Electric Cooperative will give a free Siemens 30-A Level 2 VersiCharge electric vehicle charger to members who purchase an electric vehicle and meet the requirements listed below. Must be on load control as defined by cooperative	Rebate	
Belmont Municipal Light Department, Massachusetts	Muni	Charging a t Home	HELPS Connected Homes Program leverages the technology of smart appliances and devices into cost savings for the light department and its customers. Customers agree to allow Connected Homes to make brief, limited adjustments to their devices during times of peak electric demand and are rewarded with a quarterly incentive, applied as a bill credit. $10/ month incentive for enrolling their JuiceNet and Chargepoint chargers. Belmont Light also offers a $250 rebate for WiFi-enabled Level 2 charging equipment	Demand Response & Rebate	
Consumers Energy, Michigan	IOU	PowerMIFleet	PowerMIFleet is a program designed to help fleet owners and operators reduce operating costs, eliminate emissions, and simplify vehicle maintenance by transitioning to electric vehicles. We're here to connect your organization with the planning resources, expert guidance and financial incentives to easily and cost-effectively transition to an electric fleet. PowerMIFleet is part of our commitment to help drive savings for your wallet and the environment, while keeping the grid operating efficiently and sustainably through clean energy transportation.	Rebate	

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021					
Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Direct Load Control via the Charging Device					
Consumers Energy, Michigan	IOU	PowerMIDrive™: Home Charger Rebates	$500 Rebate from Consumers of install an approved Wi-Fi connected Level 2 charger at home. Applicants must agree to participate in Consumer's Residential Time of Use Rate, authorize Consumers Energy to enable demand response capability, and authorize Level 2 charger's network provider to share electric consumption data with Consumers Energy	TOU-wholehome & Rebate & Demand Response	
Consumers Energy, Michigan	IOU	PowerMIDrive™: Public Charger Rebates	Up to $5,000 rebate. You can qualify for a Public Level 2 Rebate if you plan to install at least one Public Level 2 Charging Station from PowerMIDrive's approved list at your business for public and customer use, at your workplace for employee use, or for your tenants if you own an apartment complex or condominium with more than four units (Multi-Dwelling Unit). Must authorize Level 2 charging station's network provider to share electric consumption data with Consumers Energy and authorize Consumers Energy to enable demand response capability.	Rebate & Demand Response	
Consumers Energy, Michigan	IOU	PowerMIDrive™: DCFC Charger Rebates	Up to $70,000 Rebate. To qualify for a rebate, you must: Be a Consumers Energy electric business customer and Install at least one approved charger at your business. Must authorize Level 2 charging station's network provider to share electric consumption data with Consumers Energy and authorize Consumers Energy to enable demand response capability.	Rebate & Demand Response	
Dominion Energy, Virginia	IOU	EV Charger Rewards	Get a rebate of $125 when you purchase a new qualified charger and register it with the manufacturer. By accepting the rebate, you agree to be enrolled in the demand response* portion of the program. Charger registration must be made on or after March 1, 2021 with demand response events to begin no sooner than July 31, 2021. You may opt-out of any demand response event if you choose to do so via your charger or its associated app. Additionally, you will receive $40 after your anniversary date (after you have participated in the program for one year). If you remain enrolled, you will receive $40 after each anniversary.	Rebate & Demand Response	
Duke Energy Florida, Florida	IOU	Park & Plug Program	Duke Energy Florida will own and operate 530 EV charging stations at site host locations within their service territory between 2019-2022. In addition to collecting vehicle charging data, hosts must also allow Duke to conduct demand response events for the purpose of understanding and evaluating charging stations as a DR resource. The equipment will be aggregated through the NovaCHARGE network.	Demand Response & Rebate	NovaCHARGE

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021					
Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Direct Load Control via the Charging Device					
Eversource	IOU	Connected Solutions	The EVSE portion of the program applies a bring-your-own-device (BYOD) model to residential customers using ChargePoint, Enel X, and SolarEdge devices. Through the program Eversource has access to customer charging data and the ability to control EVSE charging during peak times.	Rebate & Program Participation Reward	Energy Hub,
Green Mountain Power (GMP), Vermont	IOU	eCharger	GMP provides a free at-home Level 2 charger to new EV customers. These chargers collectively represent one of the largest residential managed charging programs in the country with 300 customers enrolled in the program as of February 2019.	Rebate	ChargePoint, FLO
Green Mountain Power (GMP), Vermont	IOU	Rate 72	GMP partners with you and manages the charging for you during peaks. We alert you to energy peaks (about 5-7 per month, they last a few hours and usually start around 5 pm or 6 pm). By not charging during peaks, you will save money. You can opt out, and still charge during a peak, and you will pay more. Off peak charging is $0.133/kWh, which on average is like paying $1.03 per gallon. If you charge during a peak, it is $0.68/kWh.	Demand Response	
Hawaiian Electric Company (HECO), Hawaii	IOU	Electrification of Transportation: Strategic Roadmap	HECO's strategic roadmap for EVs, includes much work focused on "smart" or managed charging, including for workplace, multi-unit dwellings, and electric buses. Specifically related to e-buses, they plan to offer a bus battery service agreement to partially offset the cost premium over diesel buses. The program will include a pilot demand response program, and explorer V2G, as well as second-life battery use for stationary storage.	Demand Response	
Holy Cross Energy, Colorado	Co-op	Distribution Felxibility Program Provisions	In exchange for receiving an electric vehicle charger (EVSE) at no cost the Consumer also agrees to enroll in HCE's Distribution Flexibility (DF) Tariff—with the following terms and conditions being supplemental EVSE specific program rules. The Consumer agrees to allow HCE full operational control of the EVSE. HCE may delay or initiate the use of EVSE during times of peak demand.	Rebate & Demand Response	

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021					
Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Direct Load Control via the Charging Device					
Lincoln Electric System, Nebraska	Muni	LES Electric Vehicle Study	In 2018, LES launched a new EV study focused on our customers' charging behaviors and the impact on our local grid. LES provided participants an easy-to-install module that records when and where customers charge, when and how far they travel, and the energy consumed while both traveling and recharging. FleetCarma, a leader in studying electric vehicle fleets, is helping facilitate the study by providing the data collection platform and anonymizing the data for customer privacy. For 2021, LES added a demand response pilot to the study scope, incentivizing participants to avoid charging during peak system demand periods in both the winter and summer seasons.	Demand Response	FleetCarma
Marin Clean Energy (MCE), California	Muni	MCE Workplace and Multifamily Property Charging Station Program	The rebate program provides rebates from $1,610-$2,500 per port for the hardware and installation costs for workplaces and multifamily properties (including market rate and low income) within MCE's service area. Rebates are only eligible for MCE approved EVSE vendors which include networked and managed-charging capable equipment. Further, MCE provides 50% or 100% renewable energy for the charging infrastructure.	Rebate	Pacific Gas & Electric and multiple vendors
Massachusetts Municipal Wholesale Electric Company, Massachusetts	Muni	Scheduled Charging Program	This program provides customers with a $300 rebate for a ChargePoint L2 charger. As part of the rebate, customers are automatically enrolled in scheduled charging program that aligns with the utility's (e.g., Sterling) TOU rate. It also requires the customer to enroll in an emergency scheduling program to reduce energy consumption during peak hours.	Rebate & Demand Response & TOU-wholehome	Multiple utilities, including Sterling Municipal Light Department (Sterling), ChargePoint
National Grid, Massachusetts	IOU	EV Market Development Program	National Grid is preparing for future integration of EVs into its electric distribution system by implementing a research plan "that will use detailed utilization and transaction data from participating charging site hosts to evaluate the electric system impacts of charging stations." These charging stations—approximately 700 Level 2 and 80 DCFC stations—are being installed through National Grid's Electric Vehicle Market Development Program that funds the installation of the electrical infrastructure to the station stub and rebates toward the stations ("make ready"). The research plan will consider potential demand response approaches that "could be conducted via charging stations or via direct communication to vehicles, and will evaluate other technology integration approaches for high-capacity Direct Current Fast Charging stations," according to the application.	Rebate & Demand Response	Multiple vendors

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021

Utility Name, State	Utility Type	Program Name	Short Description	Program Incentives	Project Partners
Program Type: Direct Load Control via the Charging Device					
Pacific Gas & Electric (PG&E), California	IOU	EV Charge Network - Load Management Plan	PG&E is in the process of implementing a three-year $130 million program to install 7,500 Level 2 electric vehicle (EV) chargers at multi-unit dwelling and workplaces. The chargers will be installed throughout PG&E's service territory between 2018 and 2020. EV Charge Network program participants who choose to implement their own pricing (Custom Pricing), such as free charging or a flat fee, must participate in the EV Charge Network Load Management Plan. The Load Management Plan utilizes a PG&E Demand Response (DR) pilot program, and as a part of this program participants will be asked to shift the amount of EV charging at their site on certain occasions (called "events") to support the grid.	Demand Response & Rebate	
Pacific Power, Oregon	IOU	Electric Vehicle Charging Station Grant Program	As part of the funding criteria for this infrastructure grant program, Pacific Power provides additional scoring points if the project can be integrated into a future DR and VGI networked program.	Demand Response	
Platte River Power Authority, Colorado	Power Authority	Smart Electric Vehicle Charging Study	EV drivers in Northern Colorado can receive a $200 instant rebate on a JuiceBox smart charging station (250 target) that is managed-charging capable. Customers can program the charger for time-of-day rates and will be enrolled in a demand response program.	Demand Response & TOU-wholehome & Rebate	eMotorWerks
Portland General Electric (PGE), Oregon	IOU	Home EV Charging Rebates	A pilot program that provides up to a $500 rebate for residential customers who own or lease an electric vehicle to install a charger at home. Income-eligible customers could qualify for up to a $1,000 rebate. The new rebate pilot program also rewards customers who allow PGE to shift their EV home charger's energy use away from high demand times, when prices are high, or renewable resources are less available. This helps manage the grid and provides participants with a $25 reward at the end of each season. First 5,000 customers will get the rebate.	Rebate & Demand Response	

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021					
Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Direct Load Control via the Charging Device					
Portland General Electric (PGE), Oregon	IOU	PGE Electric School Bus Fund	PGE is working to assist two-to-five school districts and/or school bus fleet operators in its service territory with the acquisition of approximately four electric buses and the installation of demand response-enabled charging infrastructure. 2021: If your application is selected, PGE will provide: The incremental cost of electric school buses (the difference in cost between the traditional bus and the electric bus), up to $500,000 per application; For reference, the incremental cost is approximately $200,000 for a Type A electric school bus, and $250,000 for a Type C or D electric school bus. Funding for the electric bus charger of your choosing and all associated installation costs; Funding for bus driver and technician training; Technical assistance to school districts throughout the process, including site assessments, guidance on charger and bus selection, and monthly check-in calls and Optionally, PGE can manage the design, permitting, procurement, and construction process if recipients decide to not hire a contractor.	Demand Response	
Portland General Electric (PGE), Oregon	IOU	PGE Workplace Smart Charging Pilot	As of 2017, PGE installed 69 workplace charging spots among 18 locations and 20 chargers are DR-enabled.	Demand Response & Rebate	
Snohomish County PUD, Washington	Muni	FlexEnergy	Flextime- Customers with and without smart technology can save money by using energy when demand is low (Chargepoint charger). These pilots will employ a time-of-day rate design. FlexPeak- Customers with and without smart technology earn incentives for lowering their bill by reducing energy usage in response to PUD requests on select days and times (Juicebox charger). FlexResponse- Customers earn incentives for allowing smart devices in their homes to reduce energy consumption when alerted by the PUD. (JuiceBox Charger)	Demand Response	
Sonoma Clean Power (SCE), California	Muni	Drive EV + Grid Savvy	In exchange for a $5 monthly bill credit, choice of three subsidized EVSE, and an EVSE activation rebate, customers are enrolled in Sonoma's "GridSavvy" demand response (DR) program. The JuiceNet-enabled EVSE can be scheduled to charge during off-peak TOU hours as well as participate in DR events. The customer always has the ability to override DR events via the JuiceNet app and dashboard.	Demand Response & TOU-wholehome & Rebate	eMotorWerks

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021					
Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Direct Load Control via the Charging Device					
Southern California Edison (SCE), California	IOU	Charge Ready Program	As part of the full-scale program, SCE provides L1 and L2 charging equipment from approved vendors that can provide DR services for workplace, fleet, multi-unit dwellings, and destination centers (e.g., hotels, sports venues). The program covers all electric infrastructure costs and a rebate to offset some or all of the equipment and installation. To participate in the program, customers must agree to participate in DR events. Commercial requirement to also participate in the TOU pricing.	Demand Response & Rebate	Multiple vendors
Xcel Energy, Minnesota	IOU	EV Service Pilot	Xcel Minnesota's managed charging pilot project is available for 100 residential customers. Xcel provides turn-key EVSE, installation, and operation and maintenance for a single monthly fee, paying for the charger up front or monthly. Load monitoring and data management are included in the service package and participants are automatically enrolled in the EV electric pricing plan, which uses the charger for billing purposes. Customers can choose between an eMotorWerks JuiceBox Pro 40 or a ChargePoint Home Level 2 residential charger and data is collected through the customer's Wi-Fi.	TOU-EV meter & Rebate	ChargePoint, eMotorWerks
Program Type: Direct Load Control via Telematics					
DTE Energy, Michigan	IOU	OVGIP PEV DR Pilot	DTE Energy will be working with automakers to test the capabilities of EPRI's OVGIP program with their DR and DSM programs. Including potential energy reduction (kW); Testing results from different time of events (11 am - 3 pm event, and 3 pm -7 pm events); PEV user behavior in response to different incentives; Override (Opt in / Opt out) approach by PEV user; and Deliverability of event (ensure communication signals functioned properly) The pilot program started in 2018, and is expected to extend through 2021. The target of PEV users enrolled in the program is capped at 1,000 participants. Based on the verified benefits (i.e., peak load reduction), the Company will evaluate if an expansion to a fully developed program with significantly more customer engagement makes sense from a DR perspective.	Demand Response	EPRI
DTE Energy, Michigan	IOU	DTE Smart Charge	The DTE Smart Charge program rewards electric vehicle (EV) drivers for temporarily pausing or starting their vehicle's charging when it's most beneficial to the energy grid. All you have to do is plug in — your automaker and DTE Energy will do the rest. Plus, you can get up to $100 for joining and remaining in the program. The program duration is from January 2021 through December 2021.	Demand Response	Ford & Chevrolet

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021					
Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Direct Load Control via Telematics					
MCE Clean Energy (California)	Muni	MCE Sync	MCE Sync takes a hardware-agnostic approach using both vehicle telematics and networked EVSEs to automatically optimize customers' EV charging when they are plugged in at home. Using a mobile app, MCE Sync customers enter a ready-by time and have their charging times optimized to off-peak, grid-friendly hours. On top of automatic time-of-use savings, customers can earn up to $10 per month in bill credits for participating in Grid Resiliency events.	Off-peak TOU, Demand Response bill credits	ev.energy
National Grid, Massachusetts	IOU	EV and PHEV Program	Enroll Your Vehicle to Make the Grid More Sustainable. Earn $25 for enrolling in the program and an additional $10-20 per peak event for each vehicle you enroll. If you do not participate in any peak events, you will still earn $20 for each year you are enrolled. After enrolling your qualified EV (Electric Vehicle) or PHEV (Plug-in Hybrid Electric Vehicle), National Grid will automatically send a signal to pause charging during peak events, and automatically resume charging afterward. You will earn incentives each time your charging is paused for at least 50% of a peak event. Pausing a level 2 charging session will earn you $20 and pausing a level 1 charging session will earn you $10.	Demand Response	BMW, Chevrolet, Ford, Honda
Pacific Gas & Electric (PG&E), California	IOU	BMW iChargeForward	In the first phase of the pilot, partners focused on three goals: (1) test aggregation via an automaker coordinating grid-services; (2) test technical feasibility and performance of EV charging curtailment plus second-life EV batteries for grid services; (3) test customer willingness to participate in EV load management. BMW enrolled 96 i3 drivers and utilized proprietary aggregation software to delay charging via cellular (GSM-based) telematics. While the program was designed to minimize customer mobility interruptions, it also provided customers with an opt-out feature. Results from the first phase showed that the vehicle pool contributed 20% of the target kW reduction on average. Also, more than 90% of surveyed participants were satisfied and indicated that they were likely to recommend the program to friends and family. In the second phase, the program pilot expanded participating vehicles to more than 350 and focused on the customer experience. The pilot aimed to test EV charging optimization, based on: (1) maximizing renewable energy intake while managing customer bill; (2) accounting for both residential and away-from-home charging; (3) Offering load-curtailment and load- increase grid services. The pilot will continue into through 2019 and final results will be published later in 2019.	Simple Off-Peak	BMW

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021					
Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Direct Load Control via Telematics					
Silicon Valley Clean Energy, California	Muni	GridShift	GridShift syncs to your electricity rate and automatically charges your vehicle during off-peak hours. GridShift aligns your EV's charging with renewable generation on the California grid. GridShift tracks your EV energy consumption, costs, and associated CO2 savings for all of your charging at home and on the go.	Demand Response & Off-Peak	
Xcel Energy, Colorado	IOU	Charging Perks Pilot	Xcel Energy is proposing to partner with several automakers to reach EV owners through connected car systems. Each participating automaker will work with Xcel Energy and our customers to schedule overnight charging to meet customer driving needs, while charging the vehicle at the best times for the power grid. The Charging Perks pilot proposes to offer EV owners a $100 sign-up incentive, plus a $50 to $100 bill credit at the end of the study's first year, depending on what kind of home charging station they use. By using technology already inside EVs, Xcel Energy will better understand when, where and how drivers charge their electric vehicles and how to make charging easy for the customer and beneficial for the grid. Pilot is designed to have 500 EVs on residential rate and 100 on a TOU rate. Daily optimization for vehicle charging through the on-board telematics.	Program Participation Reward	Vehicle OEMs
Program Type: Behavioral Load Control					
Alabama Power, Alabama	IOU	Rate Rider PEV Plug-In Electric Vehicle	Residential TOU: The Customer's metered kWhs during the EV CHARGING PERIOD billed in accordance with the applicable rate schedule will be discounted by: 1.7155¢ per kWh Commerical TOU: Applicable for service in which charging the batteries of electric vehicles is necessary for non residential customer use. The load will be separately metered from all other electrical load and used for the exclusive purpose of charging electric vehicle batteries. Service shall not be resold or shared with others.	TOU-wholehome for EV drivers & Commerical TOU- EV meter	ev.energy
Alameda Municipal Power, California	Muni	Time-of Use (TOU) Rate for EV Owners	Alameda Municipal Power (AMP) launched an optional time-of-use (TOU) rate plan for electric vehicle (EV) owners on July 1, 2021. EV customers who opt in to enroll in this optional rate will be charged two different prices depending on when they use electricity. From 5-9 p.m. on weekdays (non-holidays), they will pay 50 cents/ kilowatt-hour. For all other hours on weekdays, the rate will be 13.2 cents/ kilowatt-hour. For all hours of the day on weekends and holidays, the rate will be 13.2 cents per kilowatt-hour. The TOU plan is not separately metered.	TOU-wholehome for EV drivers	

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021					
Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Behavioral Load Control					
Alaska Electric Light & Power Co.	Muni	Electric Vehicle Rate (Residential & Commerical)	AELP offers a Peak/Off-Peak plan for residential and commerical customers with electric vehicles	TOU-EV meter	
American Electric Power (AEP), Ohio	IOU	AEP Ohio EV Charging Incentive Program	In April 2018, the Public Utilities Commission of Ohio approved a $10 million rebate program to support the installation of 375 charging stations in AEP Ohio service territory. The incentive program allows commercial site hosts to select pre-approved hardware and networks that are managed-charging capable. Rebates are available to government and non-government owned properties, workplace charging, multi-housing unit buildings and low-income neighborhoods. Rebates apply toward the chargers and make-ready infrastructure, with amounts varying based on the types of station, the type of owner, and the public's ability to access the station.	Rebate	
Anaheim Public Utilities, California	Muni	Personal Use EV Charger Rebates	Anaheim Public Utilities is offering rebates to customers (both residential/domestic and business/non-domestic) who install Level 2 (240-Volt) plug-in Electric Vehicle (EV) Chargers. Under this program, Anaheim will reimburse customers for out-of-pocket expenses per EV charger, and the charging facility may be used for personal or business purposes without being made available to the public. Up to $400 per any Level 2 EV charger for customers NOT participating in one of the Utilities networked Time of Use (TOU) programs of EV Rate programs. Up to $1,000 per networked charger and the customer must also sign up for one of the Utilities networked TOU programs or EV Rate programs	TOU-wholehome & TOU-EV meter & Rebate	
Austin Energy, Texas	Muni	EV360 Time-of-Use Rate Pilot Program	EV360 is a fixed, time-of-use rate that includes unlimited charging at any public Plug-In Everywhere™ station and unlimited off-peak charging at home for $30 a month. Off-peak hours are from 7 pm - 2 pm on weekdays, and anytime on weekends. Eligible residential customers install a separate residential meter circuit attached to an L2 charger.	TOU-EV meter	Austin Energy's GreenChoice Program
Avista Utilities, Oregon/ Washington	IOU	Avista Residential Electric Vehicle Charging Equipment Program	Avista will pay for the Level 2 charger, direct installation costs, and 50% of the premise wiring costs, up to $1,000. Customers are responsible for the remainder of the premise wiring costs. Customers are asked to provide feedback through periodic surveys and to program vehicles to charge during off peak hours whenever possible.	Simple Off-Peak & Rebate	

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021					
Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Behavioral Load Control					
Azusa Light & Water, California	Muni	EV Off-Peak Charging Discount & Rebate Program	Applicable to residential customers owning or leasing electric vehicles and receiving electric service from Azusa Light & Water under Schedule D, Schedule WHISH, and Schedule RL. For qualifying residential customers, the price for electricity consumed during the hours of 10 pm and 6 am in excess of 50 kWh, shall be discounted by 5 cents per kWh from the "all excess kWh" contained in their respective rate schedule. The amount of discounted electricity shall not exceed 500 kWh per billing period. Additionally, EV customers who install an ENERGY STAR Level 2 EV charger in their residence are eligible for $150 rebate.	TOU-wholehome for EV drivers & Rebate	
Baltimore Gas & Electric (BGE), Maryland	IOU	Vehicle Charging Time of Use Rate	BGE now offers a special time of use rate for electric vehicle (EV) charging. This new customer pricing plan provides the benefit of reduced electric bills to customers who charge their EV during off-peak hours. If you drive 15,000 miles per year, you could save approximately $120 per year by charging your electric vehicle during off-peak hours on the Vehicle Charging Time of Use Rate instead of the Standard Schedule R rate.	TOU-wholehome for EV drivers	
Baltimore Gas & Electric (BGE), Maryland	IOU	Residential Charger Rebate	Through BGE's EVsmart Program, you may be eligible for a $300 rebate when you install a qualified Level 2 charger for your home. Any BGE customer who lives in a single-family home (either attached or detached) with secure home Wi-Fi (hotspots not sufficient) is eligible to participate. Customers must agree to share charging data with BGE. Rebates are limited and are available while supplies last.	Rebate-info collection	
Concord Municipal Light Plant	Muni	EV Miles Program	Participants must program their electric vehicle or home smart charger to start charging after 10 pm and end charging by 12 noon, Monday through Friday. Charging is open 24 hours a day on weekends. Participants agree to release their electric meter or electric vehicle charger data, where available, for the purposes of the program. Participants will provide a photograph or screenshot showing their car's charging schedule. Drivers of all-electric vehicles will receive a $10 monthly credit; drivers of plug-in hybrid vehicles will receive $5 monthly.	Simple Off-Peak	
Consolidated Edison (ConEdison), New York	IOU	SmartCharge New York	Using gamification, this program incentives customers to reduce charging during on-peak periods of time. Customers are financially rewarded—up to $500 a year—for participating in the program.	Program Participation Reward	FleetCarma, ChargePoint

Smart Electric Power Alliance

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021					
Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Behavioral Load Control					
Duke Energy Florida, Florida	IOU	ChargeFL	In Florida, Duke Energy launched an electric vehicle (EV) study with FleetCarma called Charge Florida. The three-year study will provide insight into what impact residential EV charging has on the grid. It will monitor when people charge, how much energy they use and overall charging behaviors to gain valuable perspective.	Program Participation Reward	FleetCarma
Green Mountain Power (GMP), Vermont	IOU	Rate 74	You control your charging! Has regular, set, peak and off-peak hours, and you choose when to charge and how to save. If you charge during peak hours (Monday-Friday 1-9 pm) the rate is $0.168/kWh. If you charge off peak (all other times) it is $0.128/kWh, which is on average like paying $1.00 per gallon.	TOU- wholehome for EV drivers	
Hawaiian Electric Company (HECO), Hawaii	IOU	eBus Make-Ready Infrastructure Pilot Project	The PUC approval clears the way for Hawaiian Electric to install "make-ready" infrastructure that will support up to 20 electric bus charging ports at five to 10 qualifying customer sites over three years on the three islands. The company will use the pilot to inform the design of a potential full-scale program. Hawaiian Electric will pay for and manage construction of equipment and wiring up to and beyond the fleet operator's meter to the point where the chargers would be installed. The customers' responsibilities will include installing and maintaining the charging station(s), the cost of the electricity used, and procuring the electric buses. Hawaiian Electric is in the process of ramping up the program and expects to begin accepting applications from prospective participants by January 2022.	Rebate & TOU-EV meter	
Heber Light & Power, Utah	Muni	EV Charger Rebate Application	Level 2 charger and installation rebate up to $500 per home for residential single-family homes. As part of the program, the customer will provide charger utilization data upon request	Rebate- info collection	
MiddleBorough Gas and Electric Department	Muni	SmartCharge New England-MGED	MGED has joined the SmartCharge New England program. This helps us support EV drivers in our community and reward customers who charge electric vehicles in the MGED service area during off-peak hours. MGED customers who own or lease an electric vehicle, whether Battery-Electric or a Plug-in Hybrid, and charge their EV within the MGED service area can earn monthly cash rewards. The first 20 participants will also receive a $50 early sign up bonus reward.	Simple Off-peak	FleetCarma

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Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Behavioral Load Control					
Mississippi Power, Mississippi	IOU	SmartCharge Mississippi	This one-year profiling study will set out to better understand how EVs are driving and charging in Mississippi. Participating EV drivers will receive a telematics device, which is easy-to-install and collects charging data directly from the vehicle. This anonymized data, which includes where and when EVs charge, will be analyzed to better understand how EVs impact their existing infrastructure and provide insights for future offers for EV customers. Enrolled participants will receive $25 for joining the program, $5 a month for continuing to participate and $25 for completing the full year. Participants will also get access to a data rich portal that provides information about their EV, such as driving efficiency, battery health, GHG emissions and more.	Program Participation Reward	FleetCarma
National Grid, New York	IOU	Voluntary time-of-use rate	Upstate NY customers can reduce your costs with the voluntary time-of-use rate (SC-1 VTOU) by charging your electric vehicle during the off-peak hours of 11 pm to 7 am. Most EVs can be easily programmed to charge during these hours using an onboard timer, mobile app, outlet timer, or EV charging station.	TOU-wholehome	
National Grid, Rhode Island	IOU	SmartCharge Rhode Island	The initiative allows National Grid to study the charging behaviors of EV drivers across the Ocean State. SmartCharge participants earn $50 annually for signing up, activating a monitoring device in their vehicle and charging their vehicle within National Grid's service territory. Going a step farther, the planning designers decided to offer some participants additional motivation for charging their vehicles at off-peak times—from 9 pm until 1 am—to study whether incentives would sway drivers' charging behavior. The group was presented with prices of $0.06 per kWh from June to August and $0.04 per kWh for the remainder of the year. After a year of study, all participants (roughly 300) were offered the additional off-peak charging incentives. It's now been two years since this pilot launched and there's good news to report. Seventy percent of EV drivers have shifted their behavior and are now charging during off-peak hours.	Simple Off-peak & Program Participation Reward	FleetCarma

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021					
Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Behavioral Load Control					
NV Energy, Nevada	IOU	Electric Vehicle TOU	NV Energy offers special Electric Vehicle Time-of-Use rates that allows customers to pay a discounted rate if they charge the vehicle during the utility's electric vehicle charging period (late night to the early morning hours of the day). . Rates are even lower during late-night and early morning hours (during the electric vehicle charging period). The discounted rate applies to all of the energy used at a home or apartment during that period of time, not just electricity used to charge an electric vehicle.	TOU-wholehome for EV drivers & Commerical TOU-EV meter	
Pacific Gas & Electric (PG&E), California	IOU	EV Charging Rates	Home Charging EV2-A (non-tiered, TOU): This rate plan works for customers who have an electric vehicle (EV) and/or battery storage and can charge during off-peak hours of 12 a.m. to 3 p.m., in addition to shifting other household energy usage to off-peak hours. EV-B (non-tiered, TOU): Customers who want to track their EV charging separate from their home energy consumption with a dedicated meter. If you can reduce your usage from 7 a.m. to 11 p.m. on weekdays, and 3 p.m. to 7 p.m. on weekends and holidays, this rate plan may be best for you. Dual meters: one for your household and one for electric vehicle charging.	TOU-wholehome & TOU-EV meter	
Pasadena Water and Power, California	Muni	Smart Charger	Electric cars can be conveniently charged in garages or driveways while they're parked overnight using existing outlets. Installing a charging station at home will charge the vehicle even faster. Customers can receive a $600 rebate when they install a qualifying "Wi-Fi enabled" EV charger, or a $200 rebate when they install a standard (Non Wi-Fi) EV charger in their home. From our EV survey, the program is serving around 2000 EVs through smart chargers.	Rebate	
Pepco Holdings Inc. (Pepco), DC	IOU	Whole House Time of Use rate	Pepco now offers District of Columbia electric vehicle (EV) drivers the Whole House TOU* electric rate. This new electric rate option is designed to help you manage your energy costs by letting you save on your electric bill when charging your vehicle during offpeak hours, when electricity prices are lower than peak hours.	TOU-wholehome	

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Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Behavioral Load Control					
Pepco Holdings Inc. (Pepco), Maryland	IOU	Residential Charger Rebate	Through Pepco's EVsmart Program, you may be eligible for a $300 rebate when you install a qualified Level 2 smart charger for your home. Upgrading to a Level 2 smart charger allows you to charge your electric vehicle faster and may include an optional Wi-Fi app to control your settings and save money. Any Pepco customer who lives in a single-family home (either attached or detached) with secure home Wi-Fi (hotspots not sufficient) is eligible to participate. Customers must agree to share charging data with Pepco.	Rebate & Simple Off-Peak	Chargepoint, Enel X, Siemens, and Telsa compatible chargers
Public Service Enterprise Group (PSE&G), New Jersey	IOU	Electric Vehicle Charging Program	PSE&G's Clean Energy Future—Electric Vehicle (EV) Program received approval to invest $166 million to build out New Jersey's EV charging infrastructure, which will have customer and societal benefits. It will also put New Jersey on track to become a front-runner in transportation electrification. The EV program is designed to support the deployment of EV chargers across a wide range of customers and sectors including Residential, Mixed-Use and Public DC Fast Charging. This program offsets the cost of make ready infrastructure needed to operate EV chargers. Customers are responsible for the cost of the EV charging unit. Make ready infrastructure is defined as the work on the utility side of the meter, known as pole to meter (PTM) and on the customer side of the meter, known as behind the meter (BTM).	Off-peak & Rebate	
Salt River Project, Arizona	Muni	SmartCharge Arizona	This three year study will provide insight in to the charging behavior of the EV drivers in the area. This program will also include a customer controlled load shifting program, called SmartCharge Rewards® which is designed to promote EV charging during times that are beneficial to the grid while also reducing the cost of charging for their EV customers.	Program Participation Reward	FleetCarma
Salt River Project, Arizona	Muni	Electric Vehicle Price Plan	The Electric Vehicle (EV) Price Plan works like the Time-of-Use Price Plan, but it's designed to help EV owners save. The biggest difference is that, with this plan, customers can lower energy costs by charging their vehicle during super off-peak hours, between 11 p.m. and 5 a.m.	TOU-wholehome	
San Diego Gas & Electric (SDG&E), California	IOU	Power Your Drive	San Diego Gas & Electric's day-ahead, price-varying EV rate reflects circuit and system conditions and the changing price of energy throughout the day. Through a user-friendly phone app, EV drivers can save money by setting vehicle charging times to low-priced hours of the day.	Dynamic TOU	ChargePoint, Greenlots, Siemens

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021					
Utility Name, State	**Utility Type**	**Program Name**	**Short Description**	**Program Incentives**	**Project Partners**
Program Type: Behavioral Load Control					
Silicon Valley Clean Energy, California	Muni	EV-A, EV-B, EV2A	Residential TOU rates, SVCE specific rates that are cheaper than the PG&E rates	TOU-wholehome for EV drivers	
Snohomish County PUD, Washington	Muni	SmartCharge Snohomish PUD	FleetCarma is pleased to announce the launch of SmartCharge Snohomish PUD, a new two-year electric vehicle (EV) pilot program in partnership with Snohomish PUD. This 100 vehicle profiling study will set out to better understand how EVs are driving and charging in Snohomish County and Camano Island.	Program Participation Reward	FleetCarma
Southern California Edison (SCE), California	IOU	TOU-D-Prime	Get more value for your Electric Vehicle (EV) and other clean energy tech with TOU-D-PRIME. If you charge your EV at home when rates are lowest—between 8 a.m. and 4 p.m.—it's roughly equivalent to a gas-powered driver paying less than $2 for a gallon of gasoline. This Time-Of-Use (TOU) rate plan has the same periods as TOU-D-4-9 pm, but features lower peak rates, a higher fixed daily basic charge compared to other TOU rates, and no baseline credit.	TOU-wholehome	
Tacoma Power, Washington	Muni	SmartCharge Tacoma	Tacoma Power intends to collect charging information for Electric Vehicles (EV) and Plug-In Hybrid Electric Vehicles (PHEV) in the Tacoma Power service territory. Tacoma Power will send you payments at three different points during the study. The first payment is $50 after you complete the entrance survey and we confirm the C2 device is connected. The second payment of $200 occurs after the first year of participation, i.e., leaving the C2 device clipped in your EV's OBD port to provide EV data for this study. Lastly, the third payment of $250 occurs after the second year of participation and completion of a final survey.	Program Participation Reward	FleetCarma
Tucson Electric Power, Arizona	IOU	Smart EV Charging Program	Workplace rebate: $4,5000/port up to 75% of project cost, MUD rebate: $6,000/port up to 85% of project cost. DCFC all sites: $24,000/port up to 75% of project cost. Customers must purchase and install a minimum of two (but up to six) Level 2 or DC-fast charging ports at their location. Projects that involve the installation of six or more ports will be evaluated on an individual basis and incentives may vary. Customers must sign a Site Host Agreement with a three-year term. Customers must be on one of TEP's Time-of-Use pricing plans.	TOU-wholehome for EV drivers & Rebates	

Table 6. Utility-Run Managed Charging Programs by Program Type, 2019-2021

Utility Name, State	Utility Type	Program Name	Short Description	Program Incentives	Project Partners
Program Type: Behavioral Load Control					
Wallingford Electric Division, Connecticut	Muni	SmartCharge New England	WED is looking for customers with all-electric or plug-in hybrid vehicles to voluntarily enroll in this Program and allow FleetCarma to remotely record when their cars are charged. This data will help WED devise strategies to address the expected growth in electric vehicle charging. WED is offering this program at no cost to 25-qualified customers who are willing to make the 2-year commitment.	None	FleetCarma
Xcel Energy, Minnesota	IOU	EV Charging Subscription Pilot	A new, two-year pilot program in Minnesota makes it easier and more affordable to own and charge an electric vehicle. Pilot participants will get a new Level 2 charger installed hassle-free, and unlimited charging on nights (9 p.m. to 9 a.m.) and weekends. Flat monthly subscription prices range from about $33 a month to about $44 a month, depending on whether the customer rents the charging equipment or purchases it upfront. They will only pay that amount each month, regardless of how much they charge their vehicle overnight. The pilot program is open to 150 Xcel Energy customers.	Simple Off-peak & Rebate	BMW, Ford, General Motors, and Honda

Source: SEPA, 2021

Appendix B: EV Supply Equipment Manufacturers with Managed Charging-Capabilities

Table 7. EV Supply Equipment Manufacturers with Managed Charging Capabilities

EVSE Manufacturer	Level 1	Level 2	DCFC	V2G	Energy Star	EVSE Products (Level & Type)	Proprietary/ External Platforms	Application/ Messaging Protocols	Network Communication Interfaces
EVSE Manufacturers with Managed Charging Capable Devices									
ABB		■	■	■	■	Terra AC wallbox (3 kW to 22 kW, Type 1 & 2), Terra DC wallbox (11 to 24 kW, CCS 1 & CHAdeMo), Terra DCFC chargers (50-350 kW, CCS 1 & CHAdeMo) eBus, Depot and Fleet chargers (50-450 kW)	ABB Ability Connected Services; EV Connect; Optimax	OCPP and OCPP enabled protocols; OpenADR via OCPP; D/R API, Custom APIs, ISO/IEC 15118	Cellular (GSM/3G/4G), Ethernet, Bluetooth, Wi-Fi, RFID
AddEnergie Technologies		■	■		■	Flo (Level 2 residential, SAE J1172); SmartTWO (Level 2 + curbside version, SAE J1772); CoRe+ (workplaces, car fleets, & multi-residential, SAE J1772); SmartDC Fast Charger (SAE CCS 1 & CHAdeMO Combo)	AddEnergie's Cloud-based control system (CSNMS & PowerLimiting)	Proprietary	Wi-Fi (IEEE 802.15.4), Cellular (3G), ZigBee (IEEE 802.15.4 meshed network), RFID, HomePlug
Advanced Charging Technologies		■				Quantum (2-24 kW, Industrial Material Handling Equipment), Quantum GSE (6-12. 10-24 kW), Airport Ground Support Equipment) Quantum Outdoor (6-12, 10-24 kW, Commerical Outdoor Material Handling Equipment)	ACTIntelligent	Proprietary	Wi-Fi, PLC optional, CHARGlink (ACT smart accessory)

Table 7. EV Supply Equipment Manufacturers with Managed Charging Capabilities

EVSE Manufacturer	Level 1	Level 2	DCFC	V2G	Energy Star	EVSE Products (Level & Type)	Proprietary/ External Platforms	Application/ Messaging Protocols	Network Communication Interfaces
EVSE Manufacturers with Managed Charging Capable Devices									
Andromeda Power		■	■			ORCA Inceptive (Transportable Charger V2V & V2B for CHAdeMO/ CCS); ORCA Mobile (Portable DCFC CHAdeMO/ CCS); ORCA Air (SAE or CHAdeMo); ORCA Air Secure (DCFC for CHAdeMO/CCS); ORCA Rescue (back-up charger)	InCISIVE ORCA-NET Power Cloud platform	OpenADR 2.0b, OCPP 1.6, Open Smart Charging Protocol (OSCP), ORCA-VEN proprietary	Wi-Fi (IEEE 802.11g), Cellular (3G/4G), Ethernet, MODBUS/ IP
Blink		■	■		■	Level 2 (HQ 100 & 150, IQ200, SAE J1772), DCFC (50 kW, 75 kW, 175 kW, CHAdeMo & CCS1), Mobile Emergency Charger	Blink Network	OpenADR 2.0b, Blink OCPP, OCPP 1.6J	Wi-Fi (IEEE 802.11g), Cellular (4G LTE)
BTC Power		■	■		■	Level 2 Residential and Commercial EV Charging Station DC Fast Charger (CHAdeMO & SAE combo)	BTCP Network	OCPP 1.5/1.6, ISO 15118:2014	Ethernet, Cellular (4G), RFID, Wi-Fi (2.4 GHz, 802.11 b/g/n)
Chargepoint		■	■		■	CT4000 Commercial (includes CT4011, CT4021, CT4023, CT4025, CT4027, CT4011, CT4013), ChargePoint Express 250 and Express Plus (DC), CPF25, CPF50 Express 100 (DC), Express 200 (DC), CT 2025, CT2021, CT2023, CT2000 (includes CT2001, CT2002, CT2003), CT2100 Family (includes CT2101, CT2102, CT2103), CT500	ChargePoint Network	OCPP v1.6 + extensions, ChargePoint Web Services APIs	2.4/5GHz Wi-Fi (802.11 a/b/g/n residential),3G GSM, 3G CDMA Cellular (commercial), commerical GPRS, 4G LTE through ChargePoint Gateway CPGWx
Circontrol		■	■			WallBox eNext Series (Level 2, SAE J1772/Type 1), Raption Series DCFC (CHAdeMO)	CirCarLife Dynamic Load Management	OCPP 1.5 and 1.6J, OCPP 2.0 HW Ready	4G/3G/GPRS/ GSM, RFID Reader, 2.4 GHz WiFi(IEEE 802.11 b/g/n), Bluetooth v 4.2 + BLE, Ethernet
Delta Electronics, Inc		■	■			AC Max, Mini Plu, Mini (Level 2, SAE J1172); DC Wallbox, City Charger, Ultra Fast Charger, UFC 200 Ultra Fast Charger (DCFC, CCS2 & CHAdeMO)	WLAN	ISO 15118, OCPP 1.5S/1.6J	Ethernet, Cellular 3G/4G, RFID (ISO/ IEC 14443)

Table 7. EV Supply Equipment Manufacturers with Managed Charging Capabilities									
EVSE Manufacturer	**Level 1**	**Level 2**	**DCFC**	**V2G**	**Energy Star**	**EVSE Products (Level & Type)**	**Proprietary/ External Platforms**	**Application/ Messaging Protocols**	**Network Communication Interfaces**
EVSE Manufacturers with Managed Charging Capable Devices									
Eaton Corporation		■				XChargIn: Series A, X, M, S (all Level 2, Type 1 & Type 2)	XComfort Home Controller, xChargIn Peak Control	OCPP	LAN, WAN, GSM 3G, RFID
Ebee Technologies		■				Chargespot Berlin (Level 2, configurable to all ports)	Grid Chargespot, CC612 Charge Controller	ISO/IEC 15118, OCPP 1.5 / 1.6, OICP 2.0 (roaming)	2G (GSM, GPRS, EDGE), 3G (UMTS) & 4G (LTE), Ethernet, LAN, WLAN, RFID, Mobile App, SMS
Efacec		■	■			QC 60/90/120 (CCS, SAE AC Type 2, and CHAdeMO), QCBus (40/90/150 kW, CCS), HV 350 G2 (350 kW), PC G3	EVCore	ISO 15118, OCPP 1.5 or proprietary, IEC 61851	Wireless 3G (GSM or CDMA), LAN, Wi-Fi
electrifyHome		■			■	Homestation (Level 2, SAE J1772)	Electrify America app	Proprietary	Wifi (WLAN w/ 2.4GHz b/g/n w/ WPA2)
Emporia		■				Smart Energy Home (SAE J1772)	Smart Home Energy Management System	Proprietary	2.4 GHz Wi-Fi (802.11 b/g/n)
EnelX		■	■		■	JuiceBox 40 (Level 2 EVSE; SAE J1772), JuiceBox Pro (commerical, CHadeMo & CCS), JuicePump, JuicePump (150 kW)	JuiceNet	OpenADR 2.0b, OCPP 1.6J	Wifi (802.11 b/g/n 2.4 GHz), 4G/LTE, Gigabit Ethernet, RFID (ISO 14443A/B)
EV Box		■	■		■	Type 1 (SAE J1772) or Type 2 (EN/IEC 62196-2) plug 1; EVB-BSHW-25FtS; EVB-BSHP; EVB-BSHP-25FtsD	EV Connect; Greenlots	OCPP 1.5S/1.6S/ 1.6J	WiFi 2.4/5 GHz (IEEE 802.11 a/b/g, IEEE 802.11 d/e/i/h), Bluetooth 4.0, 4G LTE, 3G, GSM, RFID
Evercharge		■			■	EverCharge (SAE J1772/ Telsa)	SmartPower	OpenADR; ISO 15118	Smart Power Network
EVgo		■	■			Level 2 AC Charging: 32 Amp & 80 Amp; DCFC: 50 kW, 100 kW, 180 kW, 200/350 kW	EVgo Platform	OCPP	Not available
EVoCHARGE		■			■	EVSE/iEVSE/iEVSE Plus (Level 2, SAE J1772)	Optional RFID Access Control with Network Capability	OCPP 1.5, 1.6	4G LTE, RFID, Wifi

Table 7. EV Supply Equipment Manufacturers with Managed Charging Capabilities

EVSE Manufacturer	Level 1	Level 2	DCFC	V2G	Energy Star	EVSE Products (Level & Type)	Proprietary/ External Platforms	Application/ Messaging Protocols	Network Communication Interfaces
EVSE Manufacturers with Managed Charging Capable Devices									
EVolution (OATI)		■	■	■		Acclerated (Level 2, SAE J1772); Express (DCFC Level 3,); Rapid (), Bi-directional	EVolution Software	OCPP 1.5, 1.6	4G Ethernet, Ethernet
EVSE LLC (Control Module Ind.)	■	■				ChargeWorks 3703 (Level 1 and Level 2, SAE J1772); 3722 Garage Overhead Charger (Level 2, SAE J1772); 3704 AutoCoil (Level 2, SAE J1772)	Greenlots SKY Smart Charging platform	OCPP	Ethernet, Cellular, radio, Wi-Fi, LAN/ igBee, RFID
FLO		■			■	FLO Home X5 (Level 2, SAE J1772) , FLO Home G5 (Level 2, SAE J1772)	Power-line Communication	OCPP 1.6j, OpenADR 2.0b, RESTful API	PLC Adapter (HomePlug AV 500 network)
Freewire Technologies		■				Mobi, Mobi Gen, and DC Boost Charger (CCS1 & CHAdeMo)	FreeWire AMP platform	OCPP 1.6J	4G LTE, Ethernet, RFID (ISO 14443A/B), Wi-Fi
Grizzl-e		■				Grizzl-E Smart & Classic (Level 2, SAE J1772), Grizzl-E Mini (portable Level 2)	Any OCPP1.6 app	OCPP 1.6	Wi-Fi
Heliox DC Chargers			■			Rapid CS 50 kw all-in-one, Rapid CS 150 kW Modular, Flex 180 kW (SAE J1772), Ultra-fast 600 kW, Mobile DC 40 kW	Charge Point Platform	ISO 15118, OCPP 1.6/2.0/ ChargeSight API	LAN, 4G modem & LTE / 3G UMTS/ 2G GPRS
IES			■			KeyWatt wall/station (22 kW AC/24 kW DC; Combo 1/2, CHAdeMo, AC Type 2); Station/eBus 50 kW Keywatt (Combo 1/2, CHAdeMo), KeyWatt Trolley & Cube (mobile)	PLC GreenPhy	OCPP 1.6, ISO/IEC 15118	3G/4G, LAN/ TCP-IP, RFID, Ethernet
Ingeteam		■	■			Fushion Wall/Street (configurable all types), Rapid 50 DC & Rapid ST 200/400 DC (CHAdeMo, CCS Type 2)	INGEREV Web Manager/ Smart DLM 2.0	OCPP, ISO 15118	3G/ 4G, Ethernet, Wi-Fi, RFID, Modbus TCP
IoTecha (collaboration w/ECS)		■		■		LIVA Level 2 charger	IoT.ON™ Cloud Services	ISO/IEC 15118 OCPP 1.6	2.4GHz Wi-Fi (802.11 b/g/n), Bluetooth, Ethernet, Cellular LTE
Juice Bar LLC		■			■	Juice Bar Gen 3: 32A, 40A, 48A, & 80A (SAE J1772 Type 1)	External (Greenlots, EV Gateway)	OCPP 1.6J	Ethernet, Cellular (3G), LAN, RFID

Table 7. EV Supply Equipment Manufacturers with Managed Charging Capabilities

EVSE Manufacturer	Level 1	Level 2	DCFC	V2G	Energy Star	EVSE Products (Level & Type)	Proprietary/ External Platforms	Application/ Messaging Protocols	Network Communication Interfaces
EVSE Manufacturers with Managed Charging Capable Devices									
Leviton		■			■	Evr-Green 4000 (SAE J1772, Level 2); Evr-Green Level 2 series w/ portable mini (SAE J1772, non-networked)	External ChargePoint platform	OCPP 1.6	2.4 GHz Wi-Fi (IEEE 802.11 b/g/n), 4G-LTE, RFID (ISO 15692/1443)
Lite-On Clean Energy Technology, Corp		■			■	Lite-On Smart Charger (SAE J1772) , Lite-On Intelligent (SAE J1772) Portable Charging Cordset	External ChargeLab OCPP platform	OCPP	WiFi, RFID
Noodoe EV		■	■			AC Level II (SAE J1772); H1100 (SAE J1772); Exceed DC DC60 P (60 kW DCFC, CCS1 & CHAdeMO)	Noodoe EV OS Web portal	OCPP 1.6 JSON	Ethernet, RFID (ISO/ IEC 1443A/B), 4G, Wi-Fi
NovaCHARGE		■				NovaCharger 7000 & 8000 (SAE J1772)	In-band communications, any OCPP network	OCPP 1.6J, OpenADR	Wi-Fi (802.11 b/g/n), 4G-LTE, RFID ISO14443)
Nuuve		■	■	■		Nuvve Powerports: Single and 3-phase AC (19.2 kW/80Amp & 99 kW/480V) and Uni&Bidirection DC (60 kW or 125 kW)	Nuvve GIVes™	Not available	2.4 GHz Wifi, 3G/LTE, 4G/60Hz, Ethernal RJ 45
Phihong		■	■			DW30 (30 kW DCFC), DS60 (60 kW DCFC), DS90 (90 kW DCFC), DS120 (120 kW DCFC), DS150 (150 kW DCFC), DS180 (180 kW DCFC), DM30 (Movable DC Charger) [CCS & CHAdeMO]; AX Series (Level 2, SAE J1772)	Human Interface (HMI)	OCPP 1.6 JSON, upgradeable to 2.0, ISO 15118	Wi-Fi, Ethernet, 4G Cellular, RFID (ISO 14443A/B), LAN
Plugless Power		■				Not available	Not available	Not available	Not available
Proterra			■			Proterra 1.5 MW Charging Station, Commerical & Industrial Series (60, 90, 120, 150, 180 kW) [CCS1 industrial]	Proterra APEX Connected Vehicle Intelligence System	OCPP 1.6	4G Cellular, Modbus TCP via fiber optic, Wi-Fi, Ethernet
Rhombus			■	■		RES-D2-CS 20 DC, RES-D3-CS 20, RES-DCVC60-480, RES-DCVC125-480, [uni- and bi-directional, CCS1 SAE J1772]	VectorStat	OCPP 1.6J, ISO 15118-2	Cellular (4G/LTE), Wi-Fi, Ethernet

Table 7. EV Supply Equipment Manufacturers with Managed Charging Capabilities

EVSE Manufacturer	Level 1	Level 2	DCFC	V2G	Energy Star	EVSE Products (Level & Type)	Proprietary/ External Platforms	Application/ Messaging Protocols	Network Communication Interfaces
EVSE Manufacturers with Managed Charging Capable Devices									
Schneider Electric		■	■			EVlink Smart Wallbox, & Parking (Level 2, SAE J1772); DCFC (CHAdeMo/ CCS Type 2/ AC Type 2	EVlink Energy Management	OCPP 1.6	Ethernet, 3G/4G modem
SemaConnect		■			■	Series 5 (Personal, SAE J1772), Series 6 (Smart EV Station, SAE J1772), Series 7 (Fleets Level 2, SAE J1772), Series 8 (Retail, SAE J1772)	SemaConnect Network platform (partners w/ PlugShare, EVgo, & Chargehub)	OCPP, OpenADR 2.0b	4G LTE(CDMA and GSM/GPRS), RFID (ISO 1443)
SETEC Power Co.		■	■	■		AC (7 kW, 11 kW, 22 kW, 43 kW wall/standing chargers), DCFC (20 kW Wallbox, 60-300 kW, 110-200 kW, 30-100 kW/ CHAdeMo & CCS 1/2), Mobile DC Chargers (10 kW-60 kW), Vehicle to Home (3 & 6 kW systems)	Not available	OCPP 1.5/1.6	Power-Line-Communication, RFID (ISO 1443A/B), Wi-Fi, 4G, GSM
Siemens		■	■			VersiCharge AC series (Level 2, J1772) VersiCharge Ultra series (DCFC 50 & 175, CCS1 & CHAdeMo) SICHARGE UC (Heavy-duty 150-600 kW, CCS)	Siemens Network connections for control backend & smart building integration, Integration with OCPP 1.6 compliant platforms through direct connection, ev.energy	OCPP 1.5/1.6J & upgradable to OCPP 2.0.1, Proprietary Siemens	Wi-Fi (IEEE 802.11 b/g/n), Ethernet, WLAN, Cellular (3G/4G LTE), Modbus TCP/IP, Modbus RS-485, WCDMA, RFID (local Whitelist, MiFare)
Signet Systems, Inc.			■	■		SHFC25K (25 kW, CCS 1/2 & CHAdeMO), SHFC50K (50 kW, CCS 1/2 & CHAdeMO), HFC 150K (150 kW, CCS 1/2 & CHAdeMo), DC 350K (350 kW, CCS 1/2 & CHAdeMO)	Websockets	OCPP 1.6 JSON	RFID(ISO 1443A); LTE/GSM; Apple & Android Pay
Smartenit	■	■				SmartElek L1/L2 (SAE J1772)	Smartenit Cloud Services & ElekNet IoT; optimal DER management w/ Smart Meter, Gateway, or Cloud	OCPP 1.6J	Zigbee 3.0, 2.4 G Wi-Fi, BLE, optional LoRA & LTE-M1/ NBIoT

Table 7. EV Supply Equipment Manufacturers with Managed Charging Capabilities									
EVSE Manufacturer	**Level 1**	**Level 2**	**DCFC**	**V2G**	**Energy Star**	**EVSE Products (Level & Type)**	**Proprietary/ External Platforms**	**Application/ Messaging Protocols**	**Network Communication Interfaces**
EVSE Manufacturers with Managed Charging Capable Devices									
Tellus Power		■	■		■	US UL AC Charger (Dual Port Level 2, SAE J1772TM), DCFC (30, 60, 120, 160, 180, 240, and 300 kW, CCS1 or CHAdeMO)	evGateway (Proprietary platform)	OpenADR 2.0, OCPP 1.6J	LAN(hardwired CAT-5), Wi-Fi, Ethernet, Cellular (4G), RFID (Multi-standard, ISO/IEC 1442A/B), Credit Card Reader
Tritium PTY LTD			■			RT50 (50 kW DCFC, CCS 1/2 and CHAdeMO), RTM 50/75 kW (50 or 75 kW DCFC, RT175-S (175 kW DCFC, CCS and CHAdeMO), PK 350 (350 kW DCFC, CCS 2 and CHAdeMO)	OCPP networks	OCPP 1.6J	Cellular (3G/4G), Ethernet, RFID (ISO/ IEC 14443A/B)
Valent Power		■	■			Quick-e L2 Charger (SAE J1772), Quick-e DCFC (25-50 kW, CCS 1/2 & CHAdeMO)	Any OCPP network	OCPP	Wi-Fi (802.11 b/g/n), Bluetooth (v4.2BR/EDR & BLe), RFID (ISO14443A/ MIFARE), WLN (LTE-M1), GSM/ CDMA modem, Base-T Ethernet
Volta		■	■			L2(Level 2, SAE J1772); DC Fast (CCS + CHAdeMO)	Not available	Not available	Not available
WiTricity		■		■		Wireless Charger	Not available	Not available	Not available
EVSE Manufacturers without Managed Charging Capable Devices									
Beam	■					EV ARC 2020 (SAE J1772)	Not applicable	Not applicable	Not applicable
Bosch		■				Level 2 Charger: EV800, EV400, & EV 810	Not applicable	Not applicable	Not applicable
BougeRV		■				Level 2 EVSE (SAE J1772);	Not applicable	Not applicable	Not applicable
ClipperCreek	■	■			■	CS-100 (Level 2) (SAE J1772)HCS-40, HCS-20; ACS-15 & ACS-20(Level 1, SAE J1772, PCS-15 (SAE J1772), AmazingE Fast Level 2 (SAE J1772)	Not available	Not available	Not available
Delphi	■					IC-CPD (Level 1)	Not applicable	Not applicable	Not applicable

Table 7. EV Supply Equipment Manufacturers with Managed Charging Capabilities									
EVSE Manufacturer	**Level 1**	**Level 2**	**DCFC**	**V2G**	**Energy Star**	**EVSE Products (Level & Type)**	**Proprietary/ External Platforms**	**Application/ Messaging Protocols**	**Network Communication Interfaces**
EVSE Manufacturers without Managed Charging Capable Devices									
EV Express			■			EV Express Models 25 kW, 50 kW, 150 kW, Ultra Fast 350 kW (CHAdeMO & SAE CCS)	CCMS	N/A	N/A
Konnectronix	■	■				L1 & L2 PowerPost EVSE (SAE J1772)	No applicable	No applicable	No applicable
Lefanev		■				Lefanew Level 2, Level 2 Intelligent, & Portable Level 2 (SAE J1772)	Not available	Not available	Not available
Mopar		■			■	Mopar plug-in charger (Level 2, SAE J1772)	Not applicable	Not applicable	Not applicable
MUSTART		■				MUSTART (Level 2, SAE J1772)	Not applicable	Not applicable	Not applicable
ShorePower Technologies	■	■				Shorepower EVSE (Level 1 or Level 2 optional, SAE J1772)	Not applicable	Not applicable	Wi-Fi, Cellular, Ethernet, RFID
Sun Country Highway		■			■	AmazingE (Level 2, SAE J1772, portable), EV Series (Level 2 single & dual port, SAE J1772), SCH Series (EVs & commerical fleets, Level 2, SAE J1772), Plug-in Series (Level 2, non-hardwired, SAE J1772)	Not applicable	Not applicable	Not applicable
Tesla Motors	■	■				Wall Connector (Level 2, Telsa), Mobile Connector (SAE J1772 adapter, Level 1/2 optional)	Not applicable	Not applicable	2.5 GHz Wi-Fi (802.11 b/g/n)
Wattzilla (LiquidSky Technologies)		■			■	WattZilla Uno/Duo (single & dual port Level 2, SAE J1772), WattZilla Gorilla(3-phase, 105 kW AC EVSE), Quadzilla (4 ports, SAE J1772), Black Mamba (portable Level 2), WaltZilla (Level 2, In-the-Wall charger, SAE J1772)	Not applicable	Not applicable	Not applicable
Webasto (formerly Aerovironment)		■			■	TurboCord (portable for 120V/240 V); TurboDX (Level 2)	Not available	Not available	Not available

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Appendix C: Network Service Providers with Managed Charging-Capabilities

Table 8. Network Service Providers with Managed Charging Capabilities			
Network Service Provider	**Platform(s) (Devices)**	**Application/ Messaging Protocols**	**Network Communication Interfaces**
Network Service Providers with Managed Charging Capabilities			
Amp Up	Amp Up	OCPP	Cellular
Amply Power	OMEGA Charge Management System	Not available	Not available
AutoGrid	AutoGrid DERMS	OpenADR, SCADA, SEP2.0	AMI, 4G, Internet, Private Networks
ChargePoint	ChargePoint Network	OCPP v1.6 + extensions, ChargePoint Web Services APIs	Wi-Fi , Cellular
Connectivity Solutions Plus	INSYS Powerline GP	ISO/IEC 15118	Ethernet
Driivz	Driivz platform, SmartChain Energy Manager	OCPP 1.5, 1.6 and 2.0, OpenADR 2.0, and ISO/IEC 15118	Wi-Fi, Cellular
Electrify America	EV Connect, Greenlots, SemaConnect	OCPP, ISO/IEC 15118	Wi-Fi, Cellular
Enbala	The Enbala Engine	Open API, OpenADR	Not available
Enel X	JuiceNet platform	OCPP, OpenADR, other API-based systems	Wi-Fi, Ethernet, Cellular
EnergyHub	Mercury DERMS (EVSE and OEM partners)	OpenADR 2.0, IEEE 2030.5, other API-based systems	Wi-Fi, Ethernet, Cellular
EV Connect	EV Cloud platform	OCPP 1.6 & OCPI, OpenADR 2.0, other API-based systems	Wi-Fi, Cellular
ev.energy	ev.energy platform	OCPP, OpenADR, other API-based systems	Wi-Fi, Cellular
evGateway	Vendor Agnostic	OCPP 1.6J/ upgradable to 2.0, Open ADR2.0b	Cellular (CDMa, GMS) Wi-Fi, LAN, Ethernet
EVgo (NRG Energy)	EVgo Network; EV Optima smart charging platform	OCPP	Cellular
FleetCarma	SmartCharge Rewards Platform, (OBD-II C2 device) and SmartCharge Manager (multi-device)	Not available	Cellular
Freewire	Amp Software	API repository	4G LTE, Ethernet
Greenlots	SKY Smart Charging platform	OCPP and OpenADR 2.0b	Wi-Fi, Cellular
Hitachi Energy	ABB Ability DERMS	Not available	Not available

Table 8. Network Service Providers with Managed Charging Capabilities			
Network Service Provider	**Platform(s) (Devices)**	**Application/ Messaging Protocols**	**Network Communication Interfaces**
Network Service Providers with Managed Charging Capabilities			
IoTecha	IoTecha's Intelligent Power Platform (IoT.ON)	ISO/IEC 15118	HomePlug GreenPHY +V2G Analyzer w/ Ethernet
Itron	IntelliSource	OpenADR	Not available
Kitu Systems	Kitu Convoy Electric Vehicle Service Platform (EVSP)	OCPP optional, SEP 2.0 (IEEE 2030.5-2018), OpenADR 2.0 VEN, RESTful API,	Zigbee, Cellular
Koben Systems Inc. (KSI)	myEVroute network	OCPP	Not available
Liberty Plugins	HYDRA-R Multi-Charger Control System	OpenADR 2.0, OCPP 1.5	Cellular, Ethernet
Mobility House	TMH ChargePilot	OCPP 1.6/ 2.0, ISO/IEC 15118, ChargePilot REST API, OpenADR	Smart Charger Controller via LAN or LTE router, Modbus TCP/IP
MOEV	MOEV AI	Proprietary	Proprietary
NoodoeEV	NooDoe EV OS	OpenADR 2.0b	Not available
NovaCHARGE	ChargeUp Network	OCPP, OCPI, OpenADR, proprietary API	Not available
Nuvve	GIVe Platform	REST API	Wireless, Ethernet
OATI	webSmartEnergy	Not available	Not available
Opconnect	OpConnect Network	OCPP	Cellular, Ethernet, Bluetooth
OSII	Monarch Platform	Not available	Not available
PowerFlex	PowerFlex Adaptive Load Management Platform	OCPP 1.6	Cellular, Ethernet, Zigbee
PXiSE	PXiSE Active Control Technology (ACT)	2030.5, SEP2.0	Not available
Saascharge	EV Charging Platform	OCPP, OCPI, API Interfaces, ISO 15118	Wi-Fi, M2M
Schneider Electric	EVlink™	OCPP	Ethernet, LAN, Cellular 3G/3G
SemaConnect	SemaConnect Network, partnerships with PlugShare & ChargeHub	OCPP, OCPI, OpenADR	Wi-Fi, Cellular (4G LTE)
Siemens	Siemens Network	OCPP 1.5/1.6J & upgradable to OCPP 2.0.1, Proprietary Siemens	Wi-Fi, Cellular, Ethernet, Modbus
Smarter Grid Solutions	Cirrus Flex	REST API, OpenADR, SunSpec, 2030.5, OCCP, DNP3, Modbus	Not available
Virtual Peaker	Not available	Not available	Not available
ZEF Energy	ZEFNet	OCPP 1.6, OpenADR 2.0b, Partner API	Cellular, Wi-Fi

Table 8. Network Service Providers with Managed Charging Capabilities

Network Service Provider	Platform(s) (Devices)	Application/ Messaging Protocols	Network Communication Interfaces
Network Service Providers without Managed Charging Capabilities			
Hubject	Charge eRoaming Platform; Hubject Plug&Charge Network	ISO/IEC 15118	Not available
PlugShare	PlugShare Network	PlugShare Station API	Not available
Volta Charging	Not available	Not available	Not available

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