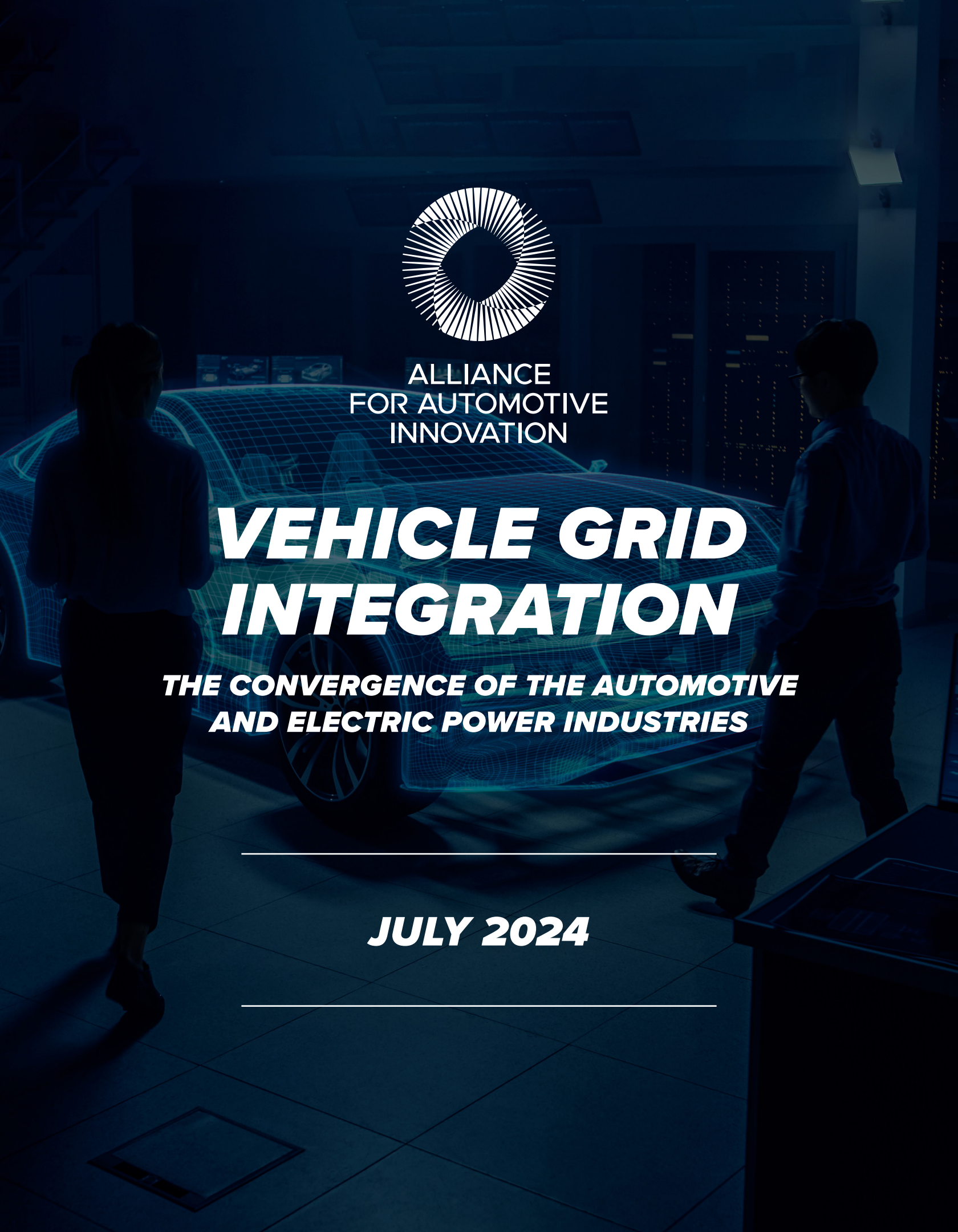


ALLIANCE
FOR AUTOMOTIVE
INNOVATION

VEHICLE GRID INTEGRATION

THE CONVERGENCE OF THE AUTOMOTIVE AND ELECTRIC POWER INDUSTRIES

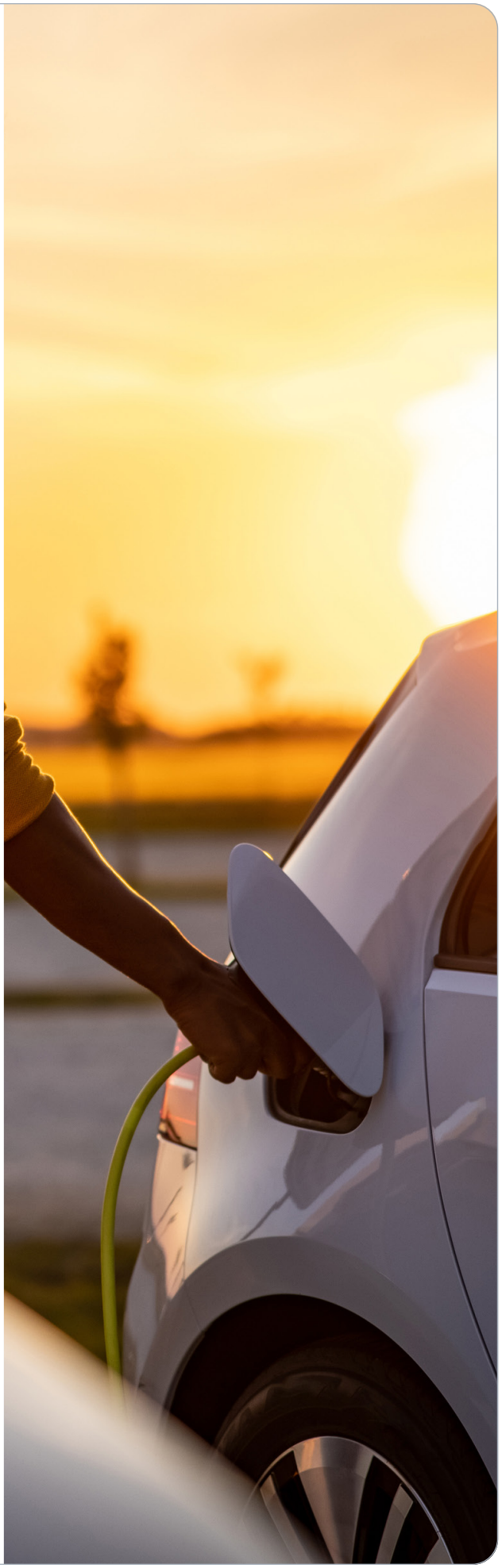
JULY 2024

SUMMARY

The automotive and electric power industries are converging. Born in the late 1800s, the industry traveled separate paths and grew to vast scale by the end of the 20th century. Utilities bought cars and trucks to support their operations, and the auto industry purchased electricity to light offices and power factories. Today, automakers and their customers increasingly see electric utilities as the enabler of reliable and affordable mobility. In the 21st century, transportation electrification will be a significant driver of electric utilities' load growth.

The Alliance for Automotive Innovation (Auto Innovators) is committed to making electrified transportation a success for all EV drivers and for all utility customers. For EV drivers, success means no compromise mobility, enabled by convenient, reliable, and affordable charging that is coupled with opportunities to save on charging costs through EV-enabled grid services. For utility customers, success means that utilities serve EV charging load in a cost-effective manner that delivers economic and environmental benefits to all utility customers, supports utilities' efforts to modernize their systems, and takes advantage of technological advancements in the latest generation of EVs to enhance grid reliability and resilience.

To reach this future, our industries must successfully navigate the intersection of EVs and the grid. This White Paper focus on both economic and technological aspects of vehicle-grid integration (VGI). It highlights recent research and regulatory actions, identifies lessons learned and best practices from demonstrations and pilots, and recommends policies to achieve this win-win outcome. The intended audience is utilities, their regulators and governing boards, policymakers, and the broader community of transportation electrification stakeholders.



Rates and managed charging are the keys to capturing the benefits of EVs

EV rates and driver-centered managed charging programs are the keys to realizing the potential economic and environmental benefits of EV charging.

Well-designed residential tariffs and programs deliver cost-based incentives to use the grid efficiently, share savings with participating EV drivers, and do not compromise their mobility.

Getting Commercial and Industrial (C&I) rates right is also essential to attract investment to electrify fleets and build out the public high-power charging network needed for future light-, medium-, and heavy-duty fleets.

RECOMMENDATIONS

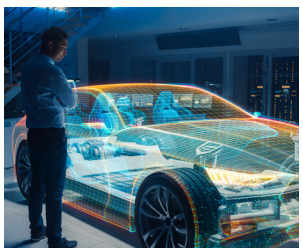
- *Utilities and regulators should adopt optional Commercial and Industrial EV rates that ensure commercial viability of fleet electrification and DCFC stations in the early stages of operation and in lightly trafficked areas, while fully recovering costs and preserving incentives for innovation.*
- *Utilities should make Time of Use (TOU) rates universally available to all EV drivers, and structure programs to ensure that suitable enabling technologies, such as smart charging, are available to all participants.*
- *Utilities should make both Whole-house and EV-only time varying rates available to their customers.*
- *Utilities should develop dynamic EV charging rates and include EVs in Demand Response (DR) Programs. These opportunities should be available to all EV drivers on an opt-in basis.*
- *EV Tariff and DR program rules should permit revenue stacking for multiple types of grid services that are mutually exclusive.*
- *Early-acting utilities should promptly scale up successful pilots to full-scale programs and pro-actively market them to maximize participation.*
- *Utilities in more nascent stages should build on the experience of early actors and draw on lessons learned to avoid repetitive pilots and to accelerate availability of mass market programs open to all EV drivers.*
- *Utilities should partner with OEMs to develop and implement marketing, education, and outreach to EV drivers about opportunities to provide valuable grid services and lower their electricity bills by participating in EV rates and DR programs.*

Technology and Standards

Innovation is rapidly transforming the ways EVs interact with the grid. Telematics capabilities in vehicles enable remote charge management as well as delivery of vehicle data that could be used for billing purposes. New standards and policies can help accelerate the use of telematics for these purposes.

EVs with bidirectional charging capabilities (V2X), such as the Ford F-150 Lightning and the Chevrolet Silverado RST pickup trucks, can power a home during an outage, or provide clean, quiet electricity at a campground or job site.

Fully commercializing bidirectional charging requires pricing, managed charging programs, and policies that support a sound business case for automakers to invest in it and install it on vehicles. Technical standards also ensure the safety of consumers and utility personnel, protect customers' privacy, and support cybersecurity efforts.



RECOMMENDATIONS

- *EV rates and DR programs should include options for EV drivers to participate by leveraging vehicle telematics to manage EV charging energy use. Utilities and regulators should draw upon the experiences of utilities across the country that have piloted telematics-based charge management for a variety of rates and programs.*
- *Utilities should move expeditiously to validate the accuracy of telematics data for calculating billing determinants, and demonstrations and pilots should be designed to support robust analysis that can be extrapolated to other utilities' service territories.*
- *Utilities and regulators involved in developing mobile submetering standards should coordinate to avoid duplicated effort and hasten development of a single approach that can be adopted nationwide.*
- *Utilities, Regional Transmission Operators, and regulators should adopt programs and policies that compensate EV drivers for exporting power to the grid.*
- *Utilities and their regulators should coordinate with other agencies to align incentives for drivers that provide other services to the public.*
- *Utilities and their regulators should adopt streamlined interconnection rules with and informed by learnings from other jurisdictions.*
- *Utilities and their regulators should build off successful V2X pilots and demonstrations and incorporate the efforts of the DOE's Vehicle to Everything Initiative to ensure that their efforts advance the electricity and auto industries' understanding of and ability to benefit from bidirectional charging.*
- *Utilities and their regulators should disseminate best practices, findings on benefits and value streams, and lessons learned about how to overcome barriers to V2X deployment.*

ALLIANCE FOR AUTOMOTIVE INNOVATION

INTRODUCTION

The automotive and electric power industries are converging. Born in the late 1800s, the industries traveled separate paths and grew to vast scale by the end of the 20th century. Utilities bought cars and trucks to support their operations, and the auto industry purchased electricity to light offices and power factories. Today, automakers and their customers increasingly see electric utilities as an enabler of reliable and affordable mobility. In the 21st century, transportation electrification will be a significant contributor to electric utilities' load growth. However, with proper planning and coordination, transportation electrification can be an asset to the grid.

The future of mobility is electric. Since 2017, automakers and their battery partners have committed to invest over $125 billion in the U.S. to electrify vehicles.[1] There are currently 113 electric vehicle (EV) models for sale at U.S. dealerships,[2] and that number is expected to exceed 150 in the next couple of years.[3] EV options exist in every class of light-duty vehicle, including pickup trucks, SUVs, and minivans. Electrified medium- and heavy-duty trucks, buses and off-road vehicles are also available, with more models coming soon.[4]

Figure 1: EV Market Share[5]

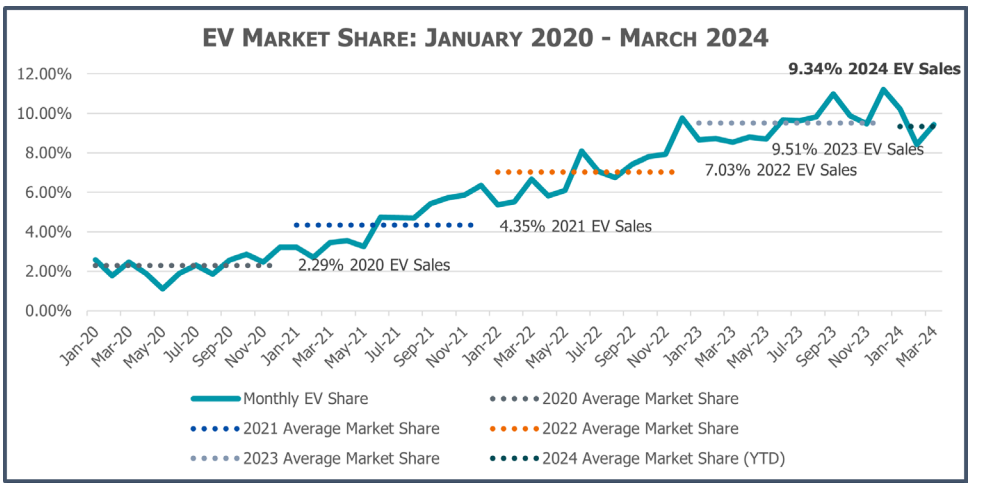
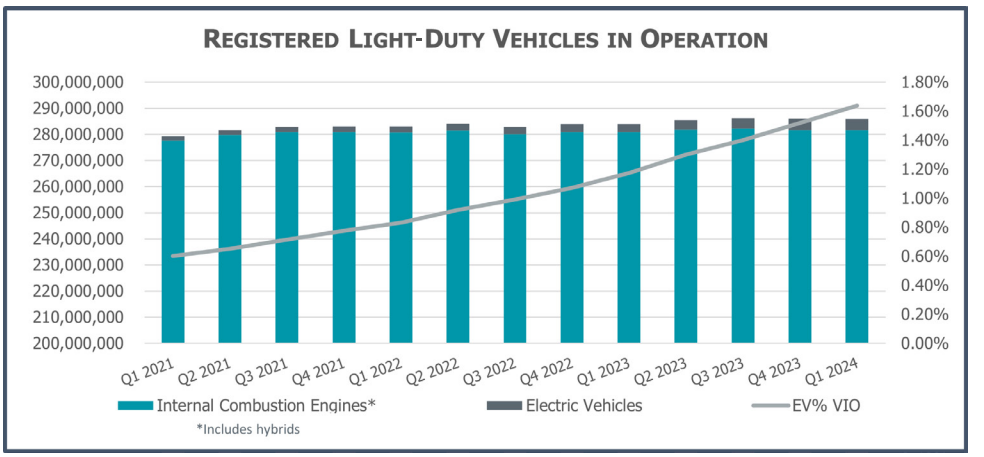


Figure 2: Registered Light-Duty Vehicles in Operation[6]



[1] https://www.autosinnovate.org/posts/communications/the-future-is-electric-infographic.pdf
[2] https://www.autosinnovate.org/posts/papers-reports/get-connected-q4-2023
[3] (2022) EVs, PHEVomes hitting U.S. dealerships through 2026 | Automotive News. Available at: https://www.autonewsh.com/future-product/evs-phevs-hitting-us-dealerships-through-2026 (Accessed: 10 June 2024).
[4] https://californiahvip.org/vehiclecatalog/
[5] https://www.autosinnovate.org/posts/papers-reports/get-connected-q1-2024. Note: EV market share includes hydrogen fuel cell electric vehicles, which do not depend on electricity from the grid
[6] https://www.autosinnovate.org/posts/papers-reports/get-connected-q1-2024. Note: EV market share includes hydrogen fuel cell electric vehicles, which do not depend on electricity from the grid.

ALLIANCE FOR AUTOMOTIVE INNOVATION

INTRODUCTION

Recent advancements in battery technology have enabled the latest EVs to offer 200-300 miles of range, some upwards of 400 miles. Some new EVs have bidirectional charging capabilities, which means that they can also discharge electricity to the grid, power a home during an outage, or provide clean and quiet electricity at a campground or job site.

The latest generation of EVs are also smart and connected. The systems of sensors, microprocessors, and communications capabilities commonly available on today's vehicles can enable an inexpensive means to manage charging. Once standards and policies are in place, the ability to send and receive data through a vehicle's telematics system could also provide a low-cost way to separately meter EV charging load.

These capabilities enable EV drivers to provide a variety of grid services that can improve reliability and resiliency, support integration of renewable energy, and lower the average cost of service—putting downward pressure on rates for all utility customers. The emissions reductions and consumer savings, including the total cost of ownership, are even greater when utilities successfully implement rates and programs that harness the flexibility of EV charging load at home or work.[7]

The Alliance for Automotive Innovation (Auto Innovators)[8] is committed to making electrified transportation a success for *all* EV drivers and for *all* utility customers. For EV drivers, success means *no compromise mobility*, enabled by convenient, reliable, and affordable charging that is coupled with opportunities to save on charging costs through EV-enabled grid services. For utility customers, success means that utilities serve EV charging load in a cost-effective manner that delivers economic and environmental benefits to all utility customers, supports utilities' efforts to modernize their systems, and takes advantage of technological advancements in the latest generation of EVs to enhance grid reliability and resilience.

To reach this future, our industries must successfully navigate the intersection of EVs and the grid. This white paper focuses on both economic and technological aspects of vehicle-grid integration (VGI). It highlights recent research and regulatory actions, identifies lessons learned and best practices from demonstrations and pilots, and recommends policies to achieve a variety of benefits. The intended audience is utilities, their regulators[9] and governing boards, policymakers, and the broader community of transportation electrification stakeholders.

The paper begins by discussing Commercial and Industrial (C&I) tariffs, considering how alternatives to conventional rate designs can support growth of the nascent DC Fast Charging (DCFC) industry and encourage fleet electrification, while recovering the cost of serving these loads. Next, it examines residential rates and managed charging programs, and outlines approaches that can reduce drivers' cost to charge their EVs and put downward pressure on the utilities' overall cost of service by providing incentives to charge when energy is less costly, or the local distribution grid is uncongested. It then considers ways to advance two technologies that offer tremendous potential to capture more savings and deliver additional grid services—vehicle telematics and bidirectional charging.

[7] The U.S. Department of Energy indicates that 80% of EV charging is done at home due to the convenience and low cost of residential charging (https://www.nrel.gov/docs/fy21osti/78540.pdf)
[8] From the manufacturers producing most vehicles sold in the U.S. to autonomous vehicle innovators to equipment suppliers, battery producers and semiconductor makers – Alliance for Automotive Innovation represents the full auto industry, a sector supporting 10 million American jobs and five percent of the economy. Active in Washington, D.C. and all 50 states, the association is committed to a cleaner, safer and smarter personal transportation future. www.autosinnovate.org.
[9] Throughout this paper we will use "Regulators" as shorthand for the many different types of bodies that oversee the nation's electricity suppliers.

ALLIANCE FOR AUTOMOTIVE INNOVATION

TARIFF DESIGN

Utility rate design can significantly impact the business case for fleet electrification and deployment of charging infrastructure, especially high-powered charging. In their first few years of operation, DCFC stations in high traffic areas may have "spikey" loads, with short bursts of high demand interspersed with idle intervals. While load is likely to level out as station utilization grows over time, this pattern may persist at less-traveled locations. Loads for fleets in the early stages of electrification may display similar patterns. In both cases, the demand charges commonly included in traditional C&I tariffs can account for a much larger portion of the customer's bill than energy charges, averaging out to a very high cost per kWh.[10] For fleet operators, this translates into an unfavorable Total Cost of Ownership (TCO) for EVs compared to conventional vehicles. For electric vehicle service providers (EVSPs), this means choosing between passing these costs on to their customers through high per-kWh prices for charging sessions, which creates uneconomical conditions at low traffic stations, or simply not operating in high-cost/low-traffic areas. These outcomes discourage EV adoption and can cause "charging deserts."

Several utilities have already developed alternative C&I tariff designs to tackle this problem.[11] In many other states, regulators and utilities are addressing this issue in response to the Infrastructure Investment and Jobs Act's requirement for them to consider tariff reforms that promote electrification.[12]

Table 1 provides several examples, including temporary demand charge holidays, preserving only the non-coincident demand charge, offsetting the demand charge with declining short-term subsidies, and replacing the demand charge with a kW-based subscription fee that gradually ratchets up as charging load grows at a site. Auto Innovators does not favor any one of these options over the others, but instead encourages utilities and regulators to look to these examples as potential templates for alternative C&I EV rates.

» **RECOMMENDATION**: *Utilities and regulators should adopt optional Commercial and Industrial (C&I) EV rates that ensure commercial viability of fleet electrification and DCFC stations in the early stages of operations and in lightly trafficked areas, while fully recovering costs and preserving incentives for innovation.*

Table 1: Examples of Alternatives to Conventional Commercial & Industrial Rates

Rate Design	Description	Utility	State
Fully Volumetric	Distribution charges recovered on a kWh basis, no demand charge	DTE	MI
Coincident Demand Charge	Based upon coincident, instead of more common, non-coincident demand	Versant	ME
Demand Charge Discount	Demand charge rebate 50% first two years, 25% next two years	PSE&G	NJ
Demand Charge Limiter	10 year declining demand charge limiter credit	Ameren	IL
Demand Charge Holiday	Demand charges waived for a specified period	SCE	CA
EV TOU + Subscription Rate	Demand charge holiday + monthly subscription charge	SDG&E	CA
EV TOU + Declining Block Rate	DCFCX - Declining block tiered structure with TOU	Tuscon Electric Power	AZ
EV TOU + Demand Charge Reduction	EV Rate "Business Electric Vehicle Charging Service"	Evergy Kansas	KS
EV TOU + Demand Charge Reduction + CPP	Demand charge reduction and critical peak pricing	Xcel CO	CO
Real Time Rate	Real time day ahead rate (available to all commercial customers)	Georgia Power	GA

Automated Load Management (ALM), the practice of balancing vehicle energy needs with site energy control and grid needs, can help improve the transportation electrification business case for fleets. In certain cases, ALM can reduce the capital costs associated with charging infrastructure installations and utility upgrades as well as the ongoing operational costs associated with charging the vehicles. As fleets' operating hours and flexibility vary widely, participating in ALM should be strictly voluntary.

[10] Fitzgerald, Garrett, and Chris Nelder. DCFC Rate Design Study. Rocky Mountain Institute, 2019 (Rev. Feb. 2020). Available at: http://www.rmi.org/insight/DCFC-rate-designstudy
[11] Fitzgerald, op. cit. and Ryan, N., et. al., Best Practices for Sustainable Commercial EV Rates and PURPA 111(d) Implementation, National Association of Regulatory Utility Commissioners Regulatory Training Initiative, Dec. 2022. Available at https://pubs.naruc.org/pub/55C47758-1866-DAAC-99FB-FFA9E6574C2B
[12] Infrastructure Investment and Jobs Act of 2021, Public Law 117-58, Section 40431, https://www.congress.gov/117/plaws/publ58/PLAW-117publ58.pdf.

ALLIANCE FOR AUTOMOTIVE INNOVATION

RESIDENTIAL EV RATES AND MANAGED CHARGING

Most EV drivers only need to charge their car for a few hours per day; if they can, they usually charge at home.[13] To maximize the economic and environmental benefits of electrifying personal transportation, utilities must focus on availability, awareness, and accessibility of EV rates and managed charging programs. Utilities should make available a variety of optional EV rates and programs. Effective marketing, education and outreach are crucial to ensure that EV drivers are aware of these opportunities and appreciate the potential bill savings. EV drivers also need inexpensive, hassle-free ways to access the cost savings afforded by these rates and programs.

A variety of EV rates and managed charging programs should be available to all drivers

All EV drivers should have the opportunity to leverage their charging flexibility to provide grid services and receive compensation. Flexibility can be monetized via targeted EV rates or Demand Response (DR) programs. Participation can be enabled with a variety of technologies, and control can be implemented by the customer directly or remotely by the utility, automaker, or a third-party aggregator.

Table 2: Examples of Residential EV Rates and Managed Charging Programs

State	Tariff/ Program Type	Example	Metering Method(s)
WHOLE HOUSE RATES			
MI	2-3 period TOU -- Whole House	DTE Time of Day Plan (D1.2) https://www.dteenergy.com/us/en/residential/service-request/pe v/pev-res-rate-plans.html	Existing Meter
MI	Critical Peak Pricing w/ TOU	DTE Dynamic Peak Pricing Plan (D1.8) https://www.dteenergy.com/us/en/residential/service-request/pe v/pev-res-rate-plans.html	Existing Meter
EV ONLY RATES (WITH SUBTRACTIVE BILLING)			
MI	2-3 period TOU -- EV Only	DTE EV Rate (D1.9) - requires separate utility meter https://www.dteenergy.com/us/en/residential/service-request/pe v/electric-pricing.html	2nd Utility Meter
MD	2-3 period TOU -- EV Only	BG&E EVSmart (Uses networked L2 or telematics) https://www.bge.com/SmartEnergy/InnovationTechnology/Pages/EVTOURa te.aspx	Networked L2 Charger or Vehicle Telematics
CA	Dynamic Time Varying Rate	SCE Dynamic Rate Pilot https://www.dret-ca.com/dynamic-rate-pilot/	Exisitng Meter
CA	Dynamic Time Varying Rate with Location Adder	SDG&E Power Your Drive https://www.sdge.com/residential/electric-vehicles/power-your-drive/power-your-drive-ev	2nd Utility Meter
MA	Demand Response: Off-Peak Charging Rebate custmer receives a payment for NOT charging during peak hours	National Grid Charge Smart MA https://www.nationalgridus.com/Charge-Smart-MA	Networked L2 Charger or Vehicle Telematics
NC	Subscription Rate: Unlimited charging up to a cap for a flat monthly fee with DR events	Duke EV Complete Home Charging Plan Pilot Program https://www.ford.com/grid/duke	Vehicle Telematics

Time-of-use (TOU) rates are a foundational option. They are easy to understand, allow drivers to save money by shifting when they charge their EVs, and deliver a threshold level of benefits to the grid. Pilots have shown that EV drivers respond to TOU rates, especially when they have access to enabling technology.[14,15]

Technology can enable either “passive” or “active” charge management. With passive management, the customer adjusts the timing of charging in response to a price signal, perhaps using a timer built into the vehicle or charger. With active management, a third-party (i.e., utility, automaker, or aggregator) determines when charging occurs, usually subject to constraints and parameters set by the driver. Smart phone apps provided by automakers, utilities, and third parties increasingly offer drivers active charge management, making it easy for them to maximize bill savings without risking the possibility of an incomplete charge. Active charge management also helps minimize the risk of “timer peaks,” which can occur when a population of EVs simultaneously start charging at the beginning of the off-peak or super off-peak period.

» **RECOMMENDATION**: *Utilities should make optional TOU rates universally available to all EV drivers and structure programs to ensure that suitable enabling technologies, such as timers and smartphone apps, are available to all participants.*

[13] Blair, Brittany, G. Fitzgerald and C. Dougherty, *The State of Managed Charging in 2021*, Smart Electric Power Alliance, Nov. 2021, p. 8
[14] Smart Electric Power Alliance, *Residential Electric Vehicle Rates that Work*, Nov. 2019.
[15] Cook, Jonathan, C. Churchwell and S. George, *Final Evaluation of San Diego Gas & Electric’s Plug-in Electric Vehicle Pricing and Technology Study*, Nexant, Inc., Feb. 20, 2014.

ALLIANCE FOR AUTOMOTIVE INNOVATION

RESIDENTIAL EV RATES AND MANAGED CHARGING

Whether the rate or program applies only to an EV's charging load or to the entire load at the driver's home is a critical distinction. Separating out an EV's energy use on a driver's utility bill spotlights the savings that come from shifting charging. Since the public's perception of EVs and charging behavior are still in the formative stages, highlighting these benefits will be crucial in the near term. Available evidence suggests that TOU rates that apply only to the vehicle (EV-only) are more effective in shifting load than whole-house TOU rates.[16] As discussed below, the main barrier to widespread enrollment in EV-only rates is the cost and inconvenience of separately metering EV charging load for billing purposes.

» **RECOMMENDATION**: *Utilities should make both whole-house and EV-only TOU rates available to their customers.*

Over time, utilities can introduce more complex options that yield additional grid benefits and offer higher compensation for participating EV drivers. More sophisticated time varying rates and DR programs create value by shifting charging in response to day-to-day (and even hour-to-hour) fluctuations in electricity market and grid conditions.[17] These rates and programs are usually implemented via remote "active" charging. Utilities have piloted a variety of optional rates including day ahead, locational Real Time Pricing, Peak Time Rebates, and event-based DR programs.[18,19] Drivers participating in DR programs usually have the ability to opt-out of events. These rates and programs are not for everyone: they should be open to all EV drivers, but participation should be voluntary, and drivers should be allowed to opt-out of events.

» **RECOMMENDATION**: *Utilities should develop dynamic EV charging rates and include EVs in Demand Response (DR) programs. These opportunities should be available to all EV drivers on an opt-in basis.*

Some EV drivers may be able to provide multiple types of grid services that are mutually exclusive. Allowing these drivers to "stack" revenues can enhance the value proposition of EV ownership and augment savings in the utility's cost of service. For example, a driver taking service on an EV-only TOU rate could provide additional value and further lower their monthly electricity bill by also participating in a DR program that rewards them for not charging during periods when the local distribution grid is most stressed.[20] However, EV drivers may not be able to deliver and receive compensation for these services if overly restrictive tariff or program rules prohibit dual participation.

» **RECOMMENDATION**: *EV tariff and DR program rules should permit revenue stacking for multiple types of grid services that are mutually exclusive.*

[16] Compliance Filing of Southern California Edison Company (U 338-E), San Diego Gas & Electric Company (U 902 E), And Pacific Gas and Electric Company (U 93 E) Pursuant to Ordering Paragraph 2 of Decision 16-06-011, filed with the California Public Utilities Commission Docket No. R18-12-006, April 1, 2022.
[17] For examples see Energy + Environmental Economics, *Rate Designs Harnessing Vehicle Grid Integration Technology: Novel Rate Designs for Aggregator Enabled Smart Charging*, May 2021.
[18] Blair (2021), op. cit.
[19] Opinion Dynamics, *PG&E Electric Vehicle Automated Demand Response Study Report*, CALMAC Study ID PGE0469.01, Feb. 2022.
[20] This example assumes that peak load on the local distribution grid does not coincide with the systemwide peak, which would presumably be the basis for setting TOU periods.

ALLIANCE FOR AUTOMOTIVE INNOVATION

RESIDENTIAL EV RATES AND MANAGED CHARGING

Finally, promptly transitioning successful pilots to mass market programs is crucial to achieving cost-effective VGI as EV adoption accelerates. In one survey, most EV drivers reported that they are willing to participate in EV rates and/or managed charging programs.[21] Yet, only about 25% of residential customers had access to time varying EV rates as of 2019, and about a third of the available rates were still pilot programs. Most residential managed charging programs are classified as pilots, with enrollment capped at a few hundred or thousand EV drivers.[22] New York is an important exception: in 2020, the New York Public Service Commission (PSC) ordered the state's utilities to scale up successful pilots and recently issued an order approving their proposed mass market programs.[23] Outside of New York, the majority of EV drivers have little or no opportunity to receive compensation for shifting charging to low-cost hours and ratepayers lose out on the associated cost savings. The opportunity to shape consumers' expectations and behavior around charging is also lost at this early stage of EV adoption.

» **RECOMMENDATION**: *Early-acting utilities should promptly scale up successful pilots to full-scale programs and proactively market them to maximize participation.*

» **RECOMMENDATION**: *Utilities in more nascent stages should build on the experience of early actors and draw on lessons learned to avoid repetitive pilots and to accelerate availability of mass market programs open to all EV drivers.*

Effective marketing programs are needed to make drivers aware of opportunities

EV drivers must be aware of opportunities to save money though EV rates and DR programs to benefit from them. Even in states with the highest EV adoption, awareness is currently low. For example, a survey of Northern California EV owners found that only 24% of EV drivers and just 30% of drivers with networked Level 2 chargers were aware of DR programs or of their benefits.[24] A survey of utilities found that availability of a marketing budget, free enrollment (e.g. no 2nd meter), and having multiple utility and non-utility marketing channels can boost enrollment.[25] As trusted mobility providers, automakers can help market VGI rates and programs to their customers.[26]

» **RECOMMENDATION**: *Utilities should partner with automakers to develop and implement marketing, education, and outreach to EV drivers about opportunities to provide valuable grid services and lower their electricity bills by participating in EV rates and DR programs.*

EV drivers also need low-cost, hassle-free ways to access EV-only rates and DR programs

To participate in an EV-only tariff or DR program, drivers must be able to separate their charging load from their overall electricity use. A recent survey of Investor-Owned Utility's (IOU) EV rates found that about half of the residential EV tariffs identified required some form of dedicated metering for the vehicle.[27] Until very recently, the only authorized way to isolate EV charging load was by installing and, in some cases, purchasing a second revenue grade meter dedicated to the vehicle. This is both expensive and inconvenient, deterring drivers from opting in to EV only rates.[28] In 2022, the California Public Utility Commission approved a submetering protocol that permits data from qualifying networked Level 2 chargers to be used for billing purposes.[29] Although an improvement on the status quo, this approach still requires drivers to install a costly charger that many find unnecessary to meet their needs. The following section outlines steps to overcome this barrier.

[21] SEPA (2019), pp. 18-20 and 22-23; Opinion Dynamics (2022) pp. 25 ff.
[22] Opinion Dynamics (2022), pp. 69-74.
[23] State of New York Public Service Commission, Order Approving Managed Charging Programs with Modifications," Case 18-E-0138, July 14, 2022.
[24] Opinion Dynamics, pp 54-56.
[25] SEPA (2019) p.26-28.
[26] SEPA (2023), *Managed Charging Programs: Maximizing Customer Satisfaction and Grid Benefits.*
[27] P. Cappers, et. al., April 2023, *A Snapshot of Rate Designs Among U.S. Investor-Owned Utilities*, available at https://eta-publications.lbl.gov/sites/default/files/ev_rate_snapshot_report-final-20230424.pdf.
[28] SEPA (2019), pp. 16 and 28-29.
[29] See "Decision Adopting Plug-In Electric Vehicle Submetering Protocol and Electric Vehicle Supply Equipment Communication Protocols" (D.22-08-024), available at: https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-decision-makes-california-first-state-in-the-nation-to-allow-submetering-of-electric-vehicles.

ALLIANCE FOR AUTOMOTIVE INNOVATION

VEHICLE TELEMATICS

Innovation is rapidly transforming the ways EVs interact with the grid. Telematics capabilities in vehicles enable remote charge management as well as delivery of vehicle data that could be used for billing purposes. New standards and policies can help accelerate the use of telematics for these purposes.

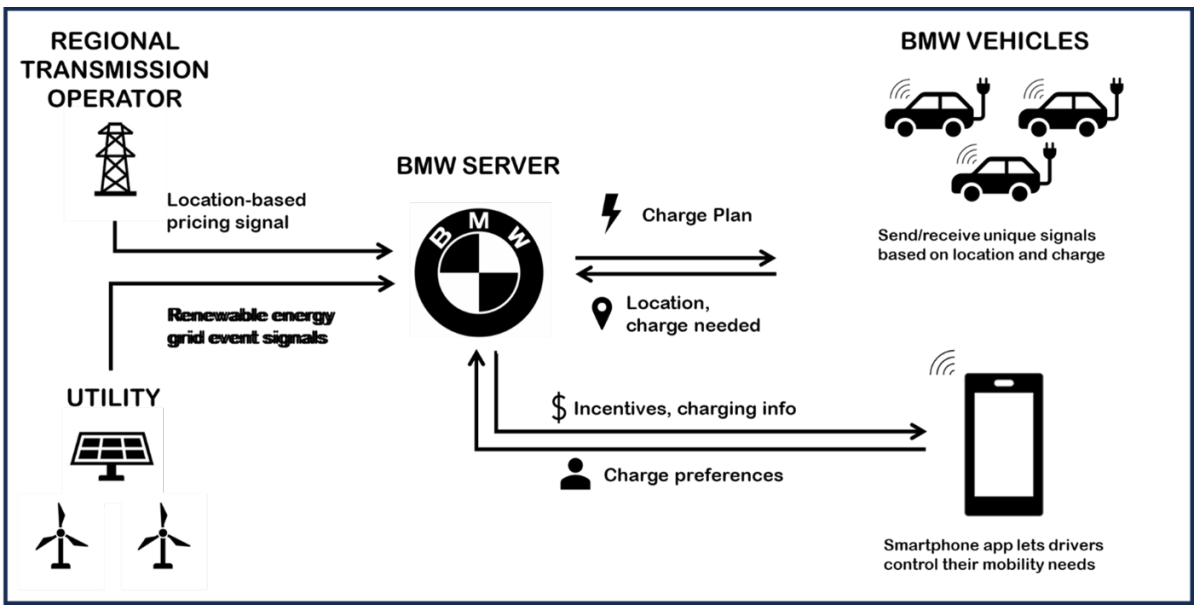
Using telematics data enhances the value proposition of managed charging

The term telematics refers to the integrated use of two technologies—telecommunications and informatics (or computing). Today, most new light-duty vehicles are equipped with a host of sensors and microprocessors, Wi-Fi, and - in some cases - GPS capability. Like stationary chargers, telematics-based systems can monitor the rate of charge (kW) and total energy dispensed (kWh) in a charging session. For over 25 years, automakers have used telematics systems to offer optional features such as navigation, remote diagnostics, and roadside assistance. Examples include GM's OnStar®, Ford's SYNC®, and BMW's ConnectedDrive® systems.

Telematics systems are already ubiquitous in commercial fleets, which combine them with enterprise fleet management systems to optimize operations, monitor vehicles' health and ensure timely maintenance. As they electrify their fleets, operators are also using telematics data to manage charging to lower their electricity bills and provide grid services, optimize use and deployment of charging infrastructure, and defer the need for on-site electrical and grid upgrades.

Telematics-based managed charging programs integrate vehicle and utility data to optimize the timing of charging, thereby enhancing the value of an EV as a grid resource. Utility rate tariffs and program guidelines inform charging schedules set via a smart phone app that does not require a Wi-Fi network connection. By factoring the state of charge into the optimization algorithm, telematics-based managed charging systems can determine how long it will take to replenish the battery and therefore how much latitude there is to modulate charging to shift load and provide grid services. Figure 3 shows how these data are used to develop a charge plan in BMW's ChargeForward Program (discussed further below).

Figure 3: Information Flows in BMW's ChargeForward Program[30]



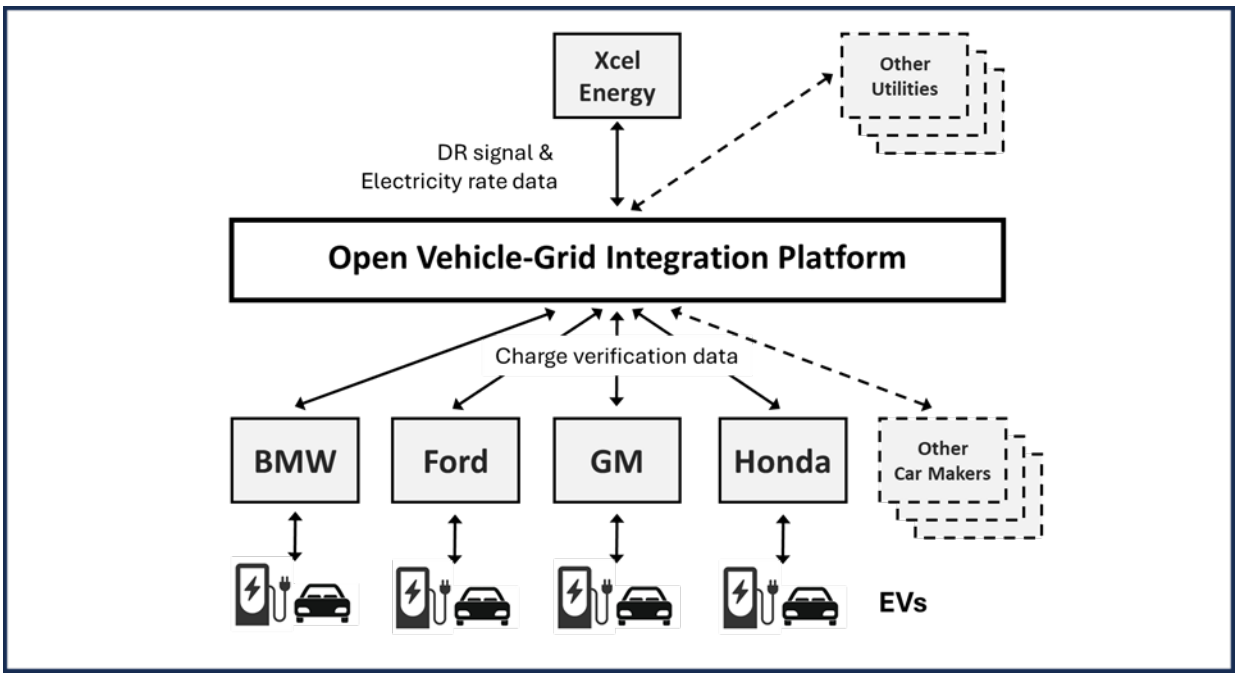
[30] Source: https://www.bmwchargeforward.com/assets/BMW-ChargeForward-Report-667376fa.pdf

VEHICLE TELEMATICS

Managed charging aggregators are essential partners

Automakers are exploring go-to-market approaches with utilities to efficiently utilize vehicle telematics for VGI pilots and programs. To facilitate vehicle-to-utility communications, aggregators must be employed to bridge the gap of communication between utilities and vehicles from different automakers. These software platforms solve the "many-to-many" problem, making it possible for multiple automakers' vehicles to exchange data with an individual utility, for a single automaker's vehicle to communicate with multiple utilities, or both. One approach to aggregation is the Open Vehicle-Grid Integration Platform (OVGIP). Developed by a consortium of automakers, OVGIP supports management and monitoring of vehicle charging using telematics data (Figure 4). In addition to OVGIP, companies like WeaveGrid and EnergyHub also support the management and monitoring of vehicle charging, and have partnered with automakers like Toyota, Hyundai and KIA.

Figure 4: Open Vehicle-Grid Integration Platform System Architecture[31]



Aggregators,[32] whether third-parties or operated by the automakers themselves, should be included in program development, especially with respect to compensation design. Aggregators should be seen as strong allies, given their ability to enable customer enrollment. This is especially true for bidirectional vehicle programs because business models for bidirectional charging are still in the early stages of development. As discussed in the next section, it is imperative to include strong earning opportunities for aggregators to develop enabling solutions and an attractive value proposition for customers to encourage their enrollment. Today, many customers are unable to participate in programs, such as the Pacific Gas and Electric (PG&E) V2X Pilot, without an aggregator.[33] In the future, programs without proper consideration for the aggregators' roles will likely be passed over in favor of those that are well-designed.

[31] Source: https://sumitomoelectric.com/press/2021/12/prs111
[32] An aggregator can be a company that works with utilities on the behalf of a group of automakers.
[33] https://www.pge.com/en/clean-energy/electric-vehicles/getting-started-with-electric-vehicles/vehicle-to-everything-v2x-pilot-programs.html#tabs-b0ada91e14-item-0334db-

ALLIANCE FOR AUTOMOTIVE INNOVATION

VEHICLE TELEMATICS

VGI pilots are demonstrating the value of telematics-based managed charging

Utilities across the country have conducted pilots of various managed charging programs that use telematics data and systems. Xcel Energy, Duke Energy, and several other utilities are piloting programs that employ the OVGIP. In California, BMW and PG&E's ChargeForward pilot demonstrated the use of telematics to schedule vehicle charging sessions to support grid reliability and prioritize charging with renewable energy.[34] Drivers specify their charging preferences (e.g., least cost, lowest emissions) and planned departure time in a smartphone app, and the system schedules charging. In select territories across the U.S., Toyota has partnered with WeaveGrid and EnergyHub to enable real-time data and grid services for utilities by utilizing relevant software platforms for actionable load management.[35,36]

In some of these pilots and programs, telematics data flowing from the EV to the utility through automaker servers, and/or the OVGIP platform, are also used to meter the EVs' electricity use, eliminating the need for a costly second utility meter. Several utilities, including National Grid,[37] ConEd,[38] and DTE,[39] are already using telematics-based systems to implement incentive programs to encourage drivers to charge outside of peak hours and verify eligibility for incentive payments. The next step is to develop the rules, standards, and policies to use more granular telematics data to measure billing determinants.

- **RECOMMENDATION**: *EV rates and DR programs should include options for EV drivers to participate by leveraging vehicle telematics to manage EV charging energy use. Utilities and regulators should draw upon the experiences of utilities across the country that have piloted telematics-based charge management to implement a variety of rates and programs.*
- **RECOMMENDATION**: *Utilities should move expeditiously to validate the accuracy of telematics data for calculating billing determinants, and demonstrations and pilots should be designed to support robust analysis that can be extrapolated to other utilities' service territories.*
- **RECOMMENDATION**: *Utilities and regulators involved in developing mobile submetering standards should coordinate development of mobile submetering standards to avoid duplicative efforts and hasten development of a single approach that can be adopted nationwide.*

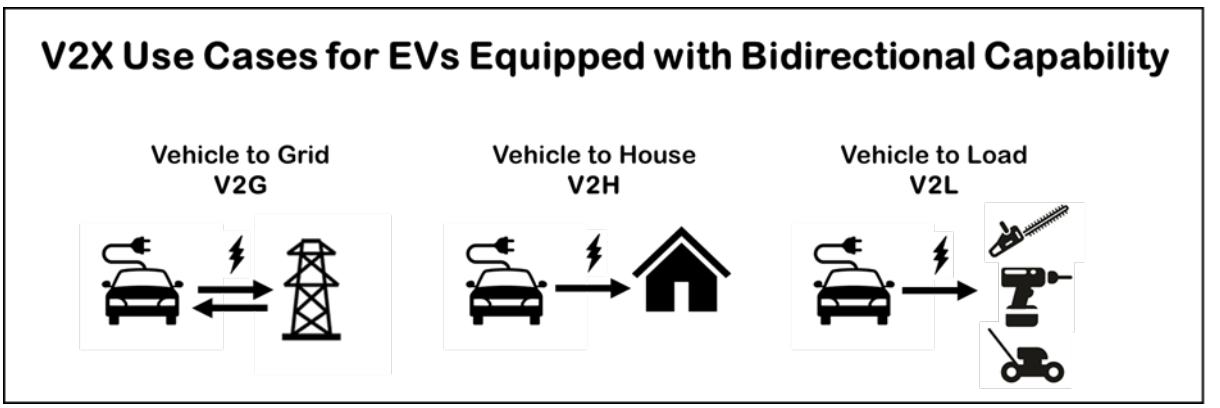
[34] Lipman, Timothy, Alissa Harrington, and Adam Langton, Total Charge Management of Electric Vehicles, California Energy Commission, Dec. 2021. Available at: https://www.energy.ca.gov/sites/default/files/2021-12/CEC-500-2021-055.pdf
[35] Press release of WeaveGrid and Toyota released February 22, 2024, available at: https://www.weavegrid.com/news/weavegrid-and-toyota-collaborate-to-empower-ev-drivers-and-optimize-charging-for-the-grid
[36] Press release of EnergyHub and Toyota released on March 6, 2024, available at: https://www.energyhub.com/blog/energyhub-and-toyota-collaborate-to-support-the-electrical-grid-and-improve-ev-ownership-experience/
[37] https://www.nationalgridus.com/News/National-Grid-Launches-Off-Peak-Electric-Vehicle-Charging-Program-for-Massachusetts-Customers/
[38] https://www.coned.com/en/save-money/rebates-incentives-tax-credits/rebates-incentives-tax-credits-for-residential-customers/electric-vehicle-rewards
[39] DTE Press Release, "BMW joins Ford, GM in DTE Energy's Smart Charge Program, integrating electric vehicle charging with their net zero carbon emissions goals," May 9, 2022. Available at: https://ir.dteenergy.com/news/press-release-details/2022/BMW-joins-Ford-GM-in-DTE-Energys-Smart-Charge-Program-integrating-electric-vehicle-charging-with-their-net-zero-carbon-emissions-goals/default.aspx

ALLIANCE FOR AUTOMOTIVE INNOVATION

BIDIRECTIONAL CHARGING TECHNOLOGY

Many of the new EV models arriving on the market will be capable of bidirectional charging, commonly referred to as vehicle-to-everything (V2X). Examples of bidirectionally-equipped EVs that are available today include the Ford F-150 Lightning and the Chevrolet Silverado RST pickup trucks. These EVs can discharge their battery directly to the grid (V2G), a house (V2H) or equipment (V2L), providing many types of services to the grid, the public and drivers (See Figure 5). The range, scale, and value of the services bidirectionally-capable EVs can deliver will grow as battery storage capacity continues to increase. Fully commercializing bidirectional charging technology requires pricing, managed charging programs, and policies that support a sound business case for automakers to invest in developing it and installing it on vehicles. Technical standards are also needed to ensure the safety of consumers and utility personnel.

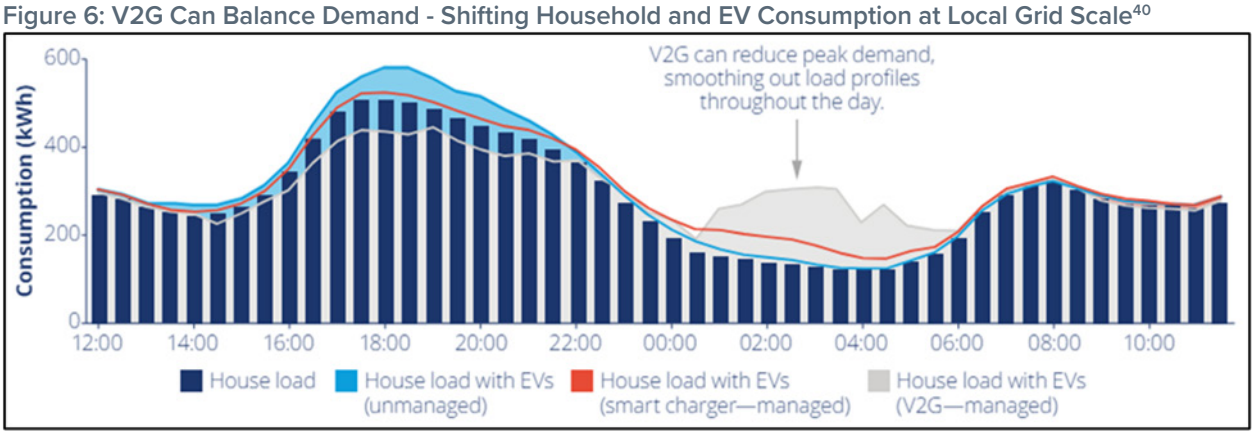
Figure 5: Examples of V2X Use Cases for EVs Equipped with Bidirectional Capability



Bidirectional EVs can provide a range of services to drivers, the public and the grid

Bidirectional EVs effectively function as mobile batteries that can provide many of the same services as a stationary battery, including frequency regulation, spinning reserves, and load shifting. Their ability to charge and discharge multiple times while plugged in significantly augments their value relative to standard EVs (See Figure 6). They can also travel to sites where electricity is most needed. In an electrical outage or other emergency, a bidirectional EV could power a home, an emergency shelter, a hospital, or another critical facility for several hours, reducing the need for alternative power sources, such as expensive diesel generators. Similarly, they can provide clean, quiet power at campgrounds, parks, and job sites.

Figure 6: V2G Can Balance Demand - Shifting Household and EV Consumption at Local Grid Scale[40]



[40] Reproduced from Cutler, Harry, Ted Davidovich, Erika H. Meyers, A Regulatory Roadmap for Vehicle-Grid Integration, Smart Electric Power Alliance, Dec. 2020. Available at: https://sepapower.org/knowledge

ALLIANCE FOR AUTOMOTIVE INNOVATION

BIDIRECTIONAL CHARGING TECHNOLOGY

Across the country, V2X pilots and demonstrations are proving out the benefits of V2X technology.[41] Many focus on school buses, which offer a unique use case because they have big batteries and are typically idle during the summer and daytime hours when demand peaks in many utilities' service territories.[42] Fleets of light-duty vehicles with regular routes and predictable schedules can also function in similar fashion. In a pilot project at the Los Angeles Air Force Base, a fleet of 29 electric vans, trucks, and cars delivered frequency regulation services to the California Independent Systems Operator's wholesale electricity market.[43] New York ridesharing operator Revel is currently collaborating with Consolidated Edison and aggregator Fermata to assess the tradeoffs between earning revenue from ridesharing operations versus parking fleet vehicles to earn revenue by providing grid services during peak hours. Revel expects to earn approximately $10,000 a year from three bidirectionally-equipped Nissan Leaf vehicles enrolled in the utility's Value of Distributed Energy Resources (VDER) tariff.[44] In Florida, Duke Energy is exploring the viability of using the batteries in Ford's F-150 Lightning pickup truck for a variety of residential use cases, including how the vehicle interacts with rooftop photovoltaic solar and customer home batteries, how the truck's battery performs in powering homes during an outage, how the electric pickup trucks will be used to feed the grid during peak times of use, and how these uses might impact the trucks' batteries over a longer period of time.[45]

» **RECOMMENDATION**: *Utilities and their regulators should disseminate best practices, findings on benefits and value streams, and lessons learned about how to overcome barriers to V2X deployment.*

Appropriate incentives are needed to capture the value of V2X technology

Adding V2G capability to an EV is costly. Automakers need to see sufficient consumer demand before making the option widely available. Drivers and fleet operators, in turn, need ways to monetize bidirectional services to justify the added expense. Offering cost-based incentives will enhance V2X's value proposition, promoting adoption of bidirectionally-equipped EVs. For example, in 2022, California regulators approved PG&E's first-in-the nation V2G export rate for commercial EV fleets and chargers. The three-year pilot will offer upfront incentives to defray equipment costs and employ day-ahead hourly pricing to encourage discharging during times of peak demand and for backup power during outages.[46]

Successful commercialization of V2X technology requires action at both the state and federal level. Utilities and their regulators are well positioned to make significant contributions toward this end.[47]

» **RECOMMENDATION**: *Utilities, Regional Transmission Operators (RTOs), and regulators should adopt programs and policies that compensate EV drivers for exporting power to the grid.*

» **RECOMMENDATION**: *Utilities and their regulators should coordinate with other agencies to align incentives for drivers that provide other charging-enabled services to the public.*

[41] B. Blair, et. al., *The State of Bidirectional Charging in 2023*, Smart Electric Power Alliance (SEPA), Sept. 2023. Retrieved from https://sepapower.org/resource/the-state-of-bidirectional-charging-in-2023/.
[42] SAFE, Op.cit. pp. 17-18
[43] D. Black, et.al, *Final Project Report: Los Angeles Air Force Base Vehicle-to-Grid Demonstration*, California Energy Commission Alternative and Renewable Fuel and Vehicle Technology Program, 2018. Available at: https://www.energy.ca.gov/sites/default/files/2021-06/CEC-500-2018-025.pdf
[44] B. Blair, et al, Sept. 2023, *Case Study: Revel Rideshare Commercial Fleet V2G & Demand Response*, Smart Electric Power Alliance (SEPA). Retrieved from: https://sepapower.org/resource/the-state-of-bidirectional-charging-in-2023/.
[45] https://news.duke-energy.com/releases/electrifying-the-future-duke-energy-to-explore-how-ford-f-150-lightning-all-electric-trucks-can-serve-as-a-grid-resource-in-florida
[46] https://www.utilitydive.com/news/pge-launches-dynamic-export-rate-for-commercial-electric-vehicle-fleets/635622/
[47] The discussion and recommendations in this section draw upon *Advancing Vehicle to Grid Technology Adoption*, SAFE and the Electrification Coalition, June 2022. Retrieved at https://2uj256fs8px404p3p2l7nvkd-wpengine.netdna-ssl.com/wp-content/uploads/2022/06/Advancing-Vehicle-to-Grid-Technology-Adoption.pdf

BIDIRECTIONAL CHARGING TECHNOLOGY

Technical standards for V2X should be developed and adopted nationwide

Safety is a paramount consideration whenever a distributed energy resource injects energy into the grid or powers a building or piece of equipment. Interconnection processes and associated technical standards are needed to protect utility personnel, customers, and the public. Fortunately, it is not necessary to start from square one since V2X systems can usually fit within existing interconnection processes. For example, islanded systems (V2H, V2L) can fit into processes for back-up generators, and V2G systems can fit into processes for exporting stationary energy storage systems.[48]

V2X demonstrations have provided a venue to develop the necessary interconnection rules and underlying technical standards. Under the auspices of the California Public Utilities Commission, automotive and utility engineers are working together to streamline interconnection processes, identify the need for new standards, and develop them. As both on- and off-board equipment are required to implement V2X use cases, a combination of standards from multiple bodies is required. These include the Society of Automotive Engineers (SAE), Institute of Electrical and Electronics Engineers (IEEE), and International Standards Organization (ISO). Other states should build on this initiative's successes to expand opportunities for V2X.

The U.S. Department of Energy (DOE) has also created a national forum, the Vehicle to Everything Initiative, to coordinate research and development on V2G technologies and disseminate findings. This effort between utilities, automakers, regulators, labor, technology companies, and national laboratories provides a platform for collaboration, innovation, and workforce development.[49] It will also serve as a resource for utilities and regulators as they develop pilots, tariffs, interconnection rules, and policies to capture the benefits of V2G technology.

- **RECOMMENDATION**: *Utilities and their regulators should adopt streamlined interconnection rules consistent with and informed by learnings from other jurisdictions.*
- **RECOMMENDATION**: *Utilities and their regulators should build off successful V2X pilots and demonstrations and incorporate the efforts of DOE's Vehicle to Everything Initiative to ensure that their efforts advance the electric utility and auto industries' understanding of and ability to benefit from bidirectional charging.*

[48] For additional recommendations see Vehicle Grid Integration Council, *V2X Bidirectional Charging Systems: Best Practices for Service Connection or Interconnection*, August 2022. Available at: https://static1.squarespace.com/static/5dcde7af8ed96b403d8aeb70/t/62fd4c3cfc19490ee68d71eb/1660767294489/VGIC-Special-Initiative-2022.pdf.
[49] https://www.energy.gov/technologytransitions/articles/department-energy-announces-first-its-kind-collaboration-accelerate

ALLIANCE FOR AUTOMOTIVE INNOVATION

CONCLUSION

The auto industry is supportive of expanding vehicle electrification. Automakers are producing the electric cars and trucks of the future today. They need the utility industry's full support to ensure that EV drivers can count on no-compromise mobility. The auto industry is committed to partnering with regulators, governing boards, utilities, retailers, Regional Transmission Organizations, and stakeholders to craft workable, cost-effective, win-win solutions that drive EV adoption and benefit all utility customers.

ALLIANCE FOR AUTOMOTIVE INNOVATION

REFERENCES

Alliance for Automotive Innovation, Planning for the Electric Future: Charging Station Attributes, 2021. Available at:https://www.autosinnovate.org/about/advocacy/Recommended%20Attributes%20for%20EV%20Charging%20Stations%2009DEC2021.pdf

Alliance for Automotive Innovation, The Future is Electric: Let's Drive Together, June, 2021. Available at: https://www.autosinnovate.org/committees/communications/The%20Future%20Is%20Electric%20Infographic_copy.

Blair, Brittany, G. Fitzgerald and C. Dougherty, The State of Managed Charging in 2021, Smart Electric Power Alliance, Nov. 2021, p. 8.

Brinkley, Stephanie, IHS Markit Forecasts EV Sales to Reach US Market Share of 7.6% in 2026, IHS Markit, May 28, 2019. Available at: https://ihsmarkit.com/research-analysis/--ihs-markit-forecasts-ev-sales-us.html.

California Public Utilities Commission, D.18-05.40, Decision on the Transportation Electrification Standard Review Projects, June 6, 2018, pp. 110-17.

California Public Utilities Commission, Decision Approving Application for Pacific Gas And Electric Company's Commercial Electric Vehicle Rates D.19-10.055, October 24, 2019.

California Public Utilities Commission, Decision Authorizing San Diego Gas & Electric Company Rate for Electric Vehicle High Power Charging, D.20-12-023, Dec. 12, 2020.

New York Public Service Commission, Order Establishing Framework for Direct Current Fast Charging Infrastructure Program, Case 18-E-0138, Feb. 7, 2019.

Edison Electric Institute, Electric Vehicle Sales and the Charging Infrastructure Required Through 2030, 2022. Available at https://www.eei.org/-/media/Project/EEI/Documents/Issues-and-Policy/Electric-Transportation/EV-Forecast--Infrastructure-Report.pdf

Environmental Defense Fund and ERM, Electric Vehicle Market Update: Manufacturer Commitments & Public Policy Initiatives Supporting Electric Mobility in the U.S. & Worldwide, April 2022.

Fitzgerald, Garrett, and Chris Nelder. DCFC Rate Design Study. Rocky Mountain Institute, 2019 (Rev. Feb. 2020). Available at: http://www.rmi.org/insight/DCFC-rate-designstudy

Reuters, Exclusive: Global carmakers now target $515 billion for EVs, batteries, Nov. 10, 2021. Available at https://www.reuters.com/business/autos-transportation/exclusive-global-carmakers-now-target-515-billion-evs-batteries-2021-11-10/

Smart Electric Power Alliance, Residential Electric Vehicle Rates that Work, Nov. 2019.

Southern California Edison Company, Compliance Filing of Southern California Edison Company (U 338-E), San Diego Gas & Electric Company (U 902 E), And Pacific Gas and Electric Company (U 93 E) Pursuant to Ordering Paragraph 2 of Decision 16-06-011, filed with the California Public Utilities Commission Docket No. R18-12-006, April 1, 2022.


ALLIANCE
FOR AUTOMOTIVE
INNOVATION