Smart Electric Power Alliance

A Regulatory Roadmap for Vehicle-Grid Integration

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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 four pathways: Transportation Electrification, Grid Integration, Regulatory Innovation and Utility Business Models. 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.

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About this Report

The research in this report was generated through three methods: a literature review, a utility survey, and analysis of vehicle-grid integration related utility filings submitted between January 2016 and July 2020.

SEPA Utility Transformation Challenge & Utility Transformation Survey

SEPA launched the 2020 *Utility Transformation Challenge*, an assessment of U.S. electric utilities' efforts to embrace the transition to a carbon-free energy future. The SEPA *Utility Transformation Survey* included a Transportation Electrification section (among others), and was distributed by SEPA to U.S. electric utilities between the Spring and Summer of 2020. Participants completed the survey via a Qualtrics online survey platform. The Transportation Electrification section asked utilities to respond to 12 questions addressing their transportation electrification teams, programs, activities, goals, challenges and barriers. These survey results are included in this report and heretofore referred to as the *Utility Transformation Survey*. A total of 131 utilities responded to the survey with investor-owned utilities representing 71%, public power utilities representing 14.5%, and electric cooperatives representing 14.5%.

Executive Summary

The purpose of this paper is to give regulators the tools and information they need to facilitate VGI development and deployment in their state. Specifically, this paper helps regulators and their staff understand what VGI is and why it is important, why regulators are key to unlocking VGI, and the goals of a VGI roadmap and how to develop one.

U.S. electric vehicle (EV) forecasts predict that 10 to 35 million EVs will be on the road by 2030.[1] Electric vehicles (EVs) represent a unique load for the grid: large, flexible, and intelligent. With strategic investments in vehicle-grid integration (VGI) and a thoughtful customer-centric approach, EVs can be highly synergistic with the grid. However, without thoughtful planning, the missed opportunities and possible consequences for the grid are likely to be significant. EVs could increase peak load by 10-20 GW across the U.S. if VGI and other solutions to manage load around peaks and grid constraints are not widely implemented. These include EV time-of-use (TOU) rates (whole home or separately metered), dynamic or real-time pricing, direct/active load management or demand response, and the critical technological solutions that enable these VGI approaches.[2]

Without swift action to resolve the outstanding business, policy, regulatory, and technical barriers to VGI, utilities will not be able to capture the full value of EVs for the electricity system, customers and society. Just as we now have over a million distributed residential solar systems without advanced inverters due to long lag time in the development of standards, we could see millions of EVs charging without any kind of load management functionality. This could lead to grid constraints and increased transmission and distribution costs that prompt the construction of more peaker plants, unplanned grid upgrades, and other costly solutions to meet peak needs. To accelerate VGI adoption, solutions must be straightforward to implement, minimize risk, and provide benefits to the parties involved, including the customer, the utility, and other stakeholders. Moreover, a successful EV transition depends on regulators understanding VGI technology options and solutions and their benefits and costs.

However, according to SEPA research, utilities identified the lack of regulatory VGI knowledge as one of the top three barriers for VGI program development. Utilities also cited the lack of regulatory support as the number one internal barrier to getting a VGI program approved and executed.

One way for regulators to support the development of VGI is through a regulatory roadmap. A roadmapping process can help facilitate the development of regulations and policies to minimize the risks associated with VGI deployment, for both utilities and customers. The goals of a VGI regulatory roadmap include laying groundwork to enable increased capabilities and sophistication over time, increase standardization and interoperability of EV charging equipment, reduce risk of stranded assets, encourage better coordination among key stakeholders, provide policy and regulatory clarity (including with respect to analysis of benefits and costs), and identify near-term valuable use cases. There is precedent for this activity as regulators have taken proactive steps in the past on other high-stakes and critical energy issues.

Introduction

Electric vehicles (EVs) represent a unique load for the grid: large, flexible, and intelligent. With strategic investments in vehicle-grid integration (VGI) and a thoughtful customer-centric approach, EVs can be highly synergistic with the grid. Without a thoughtful approach to encourage EV load management and grid optimization, the predicted rapid growth in EV adoption could lead to costly distribution system impacts and infrastructure upgrades for utilities, while leaving significant beneficial load growth value on the table.[3] Beyond incenting behavior for off-peak charging,

1 The Brattle Group (2020), [Getting to 20 Million EVs by 2030](), pg. 7.

2 The Brattle Group (2020), pg. 12

3 While this paper focuses on VGI and the distribution system, dynamic, real-time load management can also help customers manage load, avoid capacity constraints and potentially mitigate demand charges.

encouraging active utility engagement with EV load is a practical next step and the focus of this paper.

U.S. EV forecasts predict that 10 to 35 million EVs will be on the road by 2030.[4] In order to serve 20 million EVs, The Brattle Group estimates that $75-$125 billion in investments will be required in areas such as generation and storage, transmission and distribution upgrades, and charging infrastructure.[5] Further, EVs could increase peak load by 10-20 GW if VGI and other solutions to manage load around peaks and grid constraints are not widely implemented. These include EV time-of-use (TOU) rates (whole home or separately metered), dynamic or real-time pricing, direct/active load management or demand response, and the critical technological solutions that enable these VGI approaches.[6]

One early success story has been the rapid deployment of EV-specific residential time-varying rates (a form of passive managed charging). Since forecasts predict much of the future charging load associated with EVs will occur at home, residential time-varying rates will be a valuable tool for utilities to manage system costs by influencing EV charging behavior.[7] However, these rates alone will not enable the electric utility industry to realize the full benefits of EVs and prevent avoidable costs.

As EV load management capabilities develop, utilities may be able to leverage the one-way charging (V1G) of on-board batteries for grid benefits, and in the future, bidirectional energy flow (V2G). Direct load control can act as an alternative or complement to time-varying rates and provide more dynamic grid services (a form of active managed charging). Direct load control can also minimize the challenges posed by the formation of new 'timer peaks' on the distribution system, which occur when many EV drivers program their EV or chargers to begin charging right when the off-peak time-of-use period begins.[8]

One recommendation from the 2019 SEPA report, *Residential Electric Vehicle Rates That Work: Attributes that Increase Enrollment*, was for regulators to develop a long-term strategy to transition from passive managed charging to active managed charging. Regulators should encourage

What is Vehicle-Grid Integration?

Vehicle-grid integration (VGI) includes any action taken via a grid-connected EV, whether directly through resource dispatching or indirectly through rate design, to alter the time, magnitude, or location at which grid-connected EVs charge or discharge, in a manner that optimizes EV charging and provides value to the customer and the grid.[9]

Table 1: Managed Charging vs. Vehicle-to-Everything

	Passive	Active
Managed Charging (V1G)	This includes behavioral load control strategies like text messages or time-varying rates.	This includes direct load control strategies where bi-directional or uni-directional commands are exchanged to turn up, turn down, turn on or turn off a charging event, in response to grid/system needs.
Vehicle-to-Everything (V2X)*		Similar to *Active V1G* but signals include both charging and discharging capabilities between the vehicle battery and either a local grid (building, campus, microgrid) or utility grid. It also includes autonomous functionalities where charge and discharge rate is adjusted based on local voltage or frequency deviations.

*V2X is an emerging technology and the appropriate capabilities and management approaches are developing.

Source: Smart Electric Power Alliance, 2020.

4 The Brattle Group (2020), Getting to 20 Million EVs by 2030, pg. 7.

5 The Brattle Group (2020), pg. 14

6 The Brattle Group (2020), pg. 12

7 See SEPA, 2019, *Residential Electric Vehicle Rates That Work: Attributes that increase enrollment*.

8 See SEPA, 2019, *A Comprehensive Guide to Electric Vehicle Managed Charging*, pg. 15.

9 This definition and additional industry definitions are available through resources such as the California Public Utilities Commission (CPUC) Vehicle Grid Integration Communications Protocol Working Group Glossary of Terms (http://www.cpuc.ca.gov/vgi), 2017.

What is Vehicle-Grid Integration? *(continued)*

The VGI approach a regulator may find appropriate will largely depend on a number of key parameters as shown in Table 2 below, such as the penetration of light-duty residential EVs (e.g., low penetration to high penetration), available distribution capacity (e.g., high amounts of available capacity to low available capacity), integration of intermittent loads (e.g., low penetration of intermittent loads to high penetration), and the cost of on-peak electricity (e.g., average cost to high cost). This table is meant to be illustrative (and not prescriptive), as numerous other parameters exist, including forecasted EV growth for light-, medium-, and heavy-duty vehicles, transmission costs, status of AMI deployment, and distribution capacity upgrade costs. These parameters—and others—are described further in Appendix B.

Table 2: Potential Residential EV Load Management Options Based on Utility System Conditions

EV Load Management Option	Penetration of Light-Duty Residential EVs	Available Distribution Capacity (including Substations/ Transformers/ Feeders)	Integration of Intermittent Loads (e.g., Solar, Wind)	Cost of On-Peak Electricity
Passive				
Behavior Load Control (e.g., text message during system peak)	Low	High	Low	Average
Generic Time-of-Use Rate	Low	High	Medium	Above Average
Generic Dynamic Pricing Rate	Low	High	High	High
EV Time-of-Use Rate	Medium	Medium	Medium	Above Average
EV Dynamic Pricing Rate	High	Medium	High	High
Active				
Managed Charging (designed to minimize distribution impacts)	High	Low	High	Above Average
Managed Charging (designed to minimize on-peak electricity costs)	High	Medium	High	High
Vehicle-to-Grid	High	Low	High	High

Source: Smart Electric Power Alliance, 2019.

forward-looking strategies that optimize EV load control options depending on the parameters or variables in Table 2, such as the forecasted penetration of residential EVs, available distribution capacity, the integration of intermittent loads (e.g., distributed solar), and the cost of on-peak electricity. Regulators should also ensure that any incentivized or otherwise supported EV charging solutions have the capability to serve asdynamic grid assets, even if the utility has no immediate plans for a managed charging program. While utilities will deploy customized solution sets based on the ultimate goals of their load management programs and the needs of customers, they may want to include VGI-capable smart chargers in any incentive program to ensure current customers can participate in any future load management programs.

Regulators have historically taken steps to provide incentives or remove disincentives to influence the activities of regulated utilities with respect to the deployment of new utility programs, investments and technologies where their benefits exceed their costs. For example, regulators in Massachusetts (and elsewhere)[10] modified the traditional regulatory framework, decoupling utility revenues from sales, to enable utility investments in energy efficiency.[11]

VGI is still in its infancy. Significant work remains to develop the best use cases and technology approaches where the benefits to the system, customers, and society exceed costs, such that a clear path exists for regulators to approve investments and expenditures. Similarly, utilities need to demonstrate that tariffs, such as TOU rates, meet criteria for regulatory approval (e.g., based on costs to serve, non-discriminatory). In early stages, regulators may allow pilots of programs and rates where customers can realize benefits without requiring a comprehensive benefit-cost analysis (BCA) or cost-effectiveness test, as a way to catalyze market transformation. With regulatory support, utilities can assess use cases and technology approaches before EVs become mainstream, potentially avoiding long-term consequences that could occur if regulators take a passive role on transportation electrification, and specifically VGI.[12]

One way for regulators to support the development of VGI is through a regulatory roadmap. A roadmapping process can help facilitate the development of regulations and policies to minimize the risks associated with VGI deployment for both utilities and customers. The goals of a VGI regulatory roadmap include laying groundwork to enable increased capabilities and sophistication over time, increase standardization and interoperability of EV charging equipment, reduce risk of stranded assets, encourage better coordination between key stakeholders, provide policy and regulatory clarity, and identify near-term valuable use cases.

The purpose of this paper is to give regulators the tools and information they need to facilitate VGI development and deployment in their state. Specifically, this paper helps regulators and their staff understand:

1. What VGI is and why it is important
2. Why regulators are key to unlocking VGI
3. The goals of a VGI roadmap and how to develop one

Why is Vehicle-Grid Integration (VGI) Important?

Leveraging on-board EV batteries has the potential to provide numerous benefits to customers, the distribution utility, bulk power operators, and society more broadly, as shown in Figure 1. From a financial perspective, a future without managed charging could result in billions of dollars of additional investment, including unnecessary grid upgrades and new generation. For example, an Illinois Citizens Utility Board report[13] estimated $856 million of required investment by 2030 due to EV-related stress to the grid caused by vehicle charging during peak demand times. Alternatively, the report estimated savings up to $2.6 billion by 2030 for both utilities and customers if the

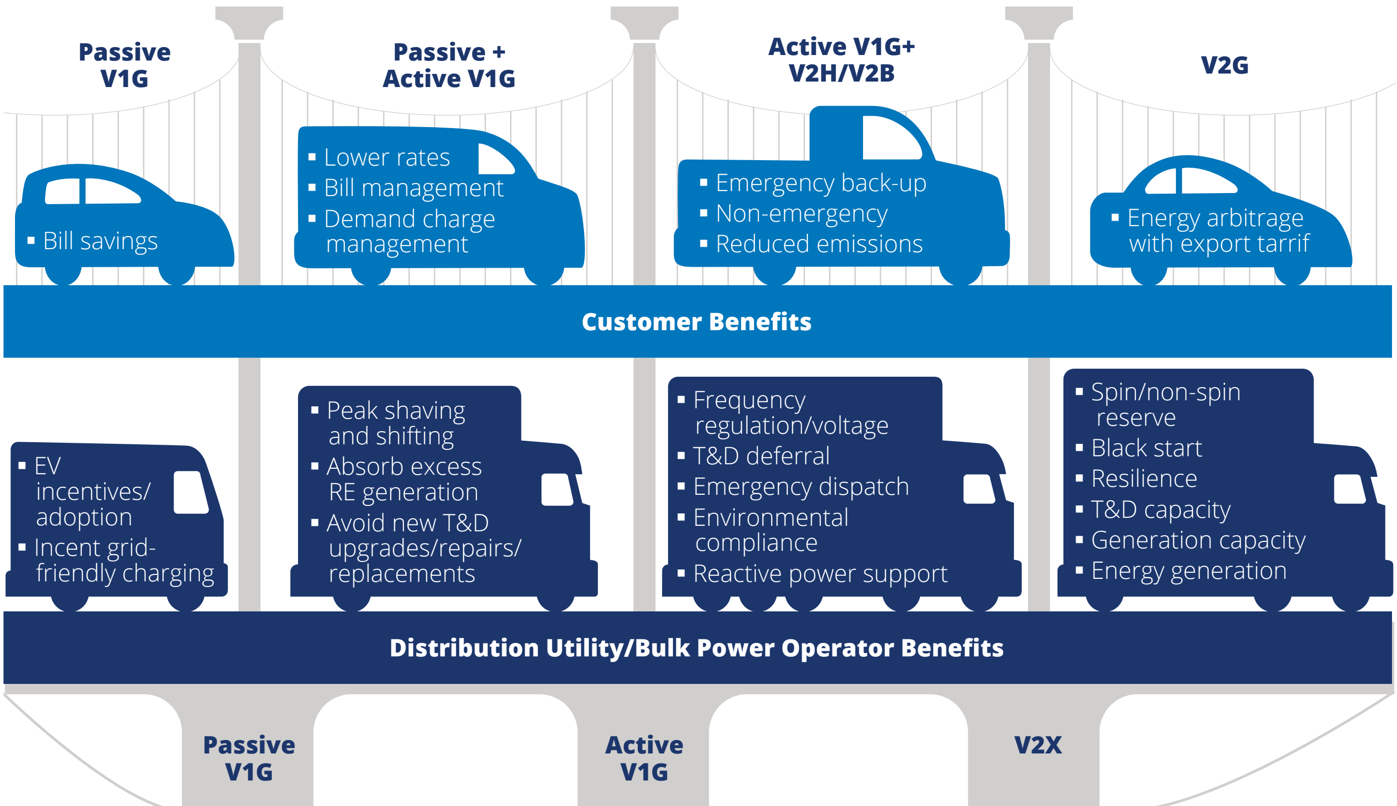
10 E.g., See Natural Resources Defense Council, 2017, https://www.nrdc.org/sites/default/files/decoupling-maps-package-01.18.17.pdf

11 Massachusetts Department of Public Utilities, Docket No. 07-50 (e.g., see first finding on p.87), accessed at https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/9299693. Note: Energy Efficiency is a resource where benefits frequently exceed costs and utilities are able to demonstrate this (as well as being required to) in their EE program filings.

12 See sources listed in Appendix A, e.g., Rocky Mountain Institute, 2016, *Driving Integration: Regulatory responses to electric vehicle growth*.

13 Illinois Citizens Utility Board, 'Charging Ahead," March 2019, https://www.citizensutilityboard.org/wp-content/uploads/2019/03/Charging-Ahead-Deriving-Value-from-Electric-Vehicles-for-All-Electricity-Customers-v6-031419.pdf.

Figure 1: Vehicle-Grid Integration Benefits Bridge



Source: Smart Electric Power Alliance, 2020.

state successfully encouraged off-peak charging. Deploying flexible, intelligent charging capabilities can increase overall grid asset utilization and reduce grid costs, even for utility customers who are not EV drivers. For example, according to a five-state economic analysis report by MJ Bradley & Associates, load growth and managed charging of EVs could lead to a cumulative net benefit of nearly $3,900 per person (or over $200 billion) derived from utility electric bill savings, direct savings for EV customers, and greenhouse gas emissions reductions benefits through 2050.[14]

Benefits of Vehicle-Grid Integration (VGI) Programs

The benefits of VGI accrue to customers, utilities, bulk power operators, solution providers and society at large.

Customer Benefits

- **Incentivizing adoption and supporting customers:** VGI programs can better respond to customer needs, incentivize customer EV adoption, and influence beneficial charging behavior, resulting in more reliable, predictable, and pronounced peak load reductions. Customer-centric programs can improve enrollment rates, make participation seamless, and benefit customers financially by lowering the cost of electric fueling, and thus the total cost of vehicle ownership.
- **Reducing energy supply costs:** VGI can enable greater use of lower-cost resources, limiting the use of highest-cost resources, benefitting both EV drivers and society more broadly.
- **Enhancing reliability/resilience:** EVs with V2G capabilities can provide benefits to customers via emergency back-up and non-emergency uses (e.g., off-grid applications).

14 MJ Bradley & Associates, 2017, Electric Vehicle Cost-Benefit Analyses, Results of Plug-in Electric Vehicle Modeling in Five Northeast & Mid-Atlantic States, https://mjbradley.com/sites/default/files/NE_PEV_5_State_Summary_14mar17.pdf. Based on a projected 2050 population in these states of 52.3 million people, up from 48.8 million today. Included: Connecticut, Maryland, Massachusetts, New York, and Pennsylvania.

Grid System Benefits

- **Reducing EV-related grid investments:** VGI can avoid or defer capacity investments and can reduce the cost of infrastructure upgrades / replacement / repairs, particularly transformers.
- **Providing transmission, distribution, and wholesale market services:** VGI services can include congestion and stress relief, resiliency, capacity, and ancillary services (i.e., frequency regulation, short-term energy and capacity, forward capacity, spinning, and non-spinning reserves) to support load-serving entities.
- **Future proofing the grid for EVs and EVSE:** As EV adoption grows, enabling an interoperable EV charging ecosystem will be critical to support effective VGI functionality and prevent future grid impacts. Interoperability is critical to future proof VGI solutions and prevent stranded assets. This occurs through aligned and open messaging-protocols and standards for management of EV chargers and EVs.
- **EV operation and maintenance (O&M) expense:** Unlike traditional generation where the utility is responsible for O&M, VGI participants are responsible for equipment costs and rewarded through an incentive mechanism (lower rates, etc.). This savings is then passed on through lower rates to all ratepayers.

Societal Benefits

- **Reducing pollution and GHG emissions:** By shifting demand to times when clean(er) energy sources are generating electricity, or by serving as an alternative, demand resource during peak periods, VGI can reduce local air pollution from generating stations and overall greenhouse gas emissions, as well as from simply driving an EV.
- **Providing economic benefits:** VGI can provide economic benefits for both EV and non-EV utility customers through grid efficiencies captured by off-peak charging (translating to lower costs and bill savings). Additional economic benefits for EV owners accrue from access to time-varying (static time-of-use or dynamic) rates and potential payments for the supply of energy and ancillary services from connected vehicles with battery capacity.
- **Enabling new business models for utilities, vehicle OEMs, or other aggregators:** VGI will enable new investments and open markets through novel virtual-power plant structures, such as vehicle batteries integrated with PV to sell services via long-term PPAs, non-wires alternatives (depending on the regulatory and market rules), peak/off-peak price arbitrage, and demand charge management. These new business models may supplement and, over time, reduce the need for ratepayer-funded public electric vehicle supply equipment (EVSE) investment by overcoming current market limitations with new opportunities to stack and create value, thereby expanding the market area served (including those that are underserved).

As shown in Figure 1, there are different VGI benefits for different actors. This graphic specifically highlights the benefits for customers and distribution utilities/bulk power operators, which regulators are most likely to consider. The benefits accumulate from the left side of the bridge with passive managed charging (V1G) activities to the right side of the bridge with vehicle-to-grid (V2G) options.

Utilities and regulators typically start the VGI journey with passive managed charging strategies, such as EV-specific time-varying rates, which encourage charging behavior beneficial to the grid. To avoid future impacts of timer peaks, where numerous customers begin charging their vehicles at the start of the off-peak period, utilities may want to eventually supplement static time-varying rates with an active load management program, or transition to active load management altogether. If a program incorporates multiple VGI values, it can stack those benefits and potentially reduce expenses.[15]

For example, a utility may have an EV time-of-use rate that can be enabled by programming an EV or smart EVSE. This sufficiently addresses off-peak charging requirements for most of the year. However, if the utility enables the smart device to provide active managed charging activities (via on/off controls)—or if the charger is a networked charger with its own internal metering—it could increase the value of that asset, for example, during a critical peak period in the summer months.[16] This type of program would ultimately lead to a better customer experience by providing bill management services to lower energy costs and minimize EV charging disruptions. Further, this type of program could help customers better leverage existing investments in smart chargers. Utilities could also opt to transition entirely to an actively managed program to deliver the same or greater benefits and value via a hybrid approach.

As utilities and regulators cross the VGI bridge in Figure 1, there is also a need for greater communication and coordination capabilities. Utilities must have sufficient capabilities to monitor and manage the grid with all types of DERs. This includes more robust metering networks

15 A regulatory journey from left to right will depend on parameters discussed in Table 2 and the timing will be different across jurisdictions.

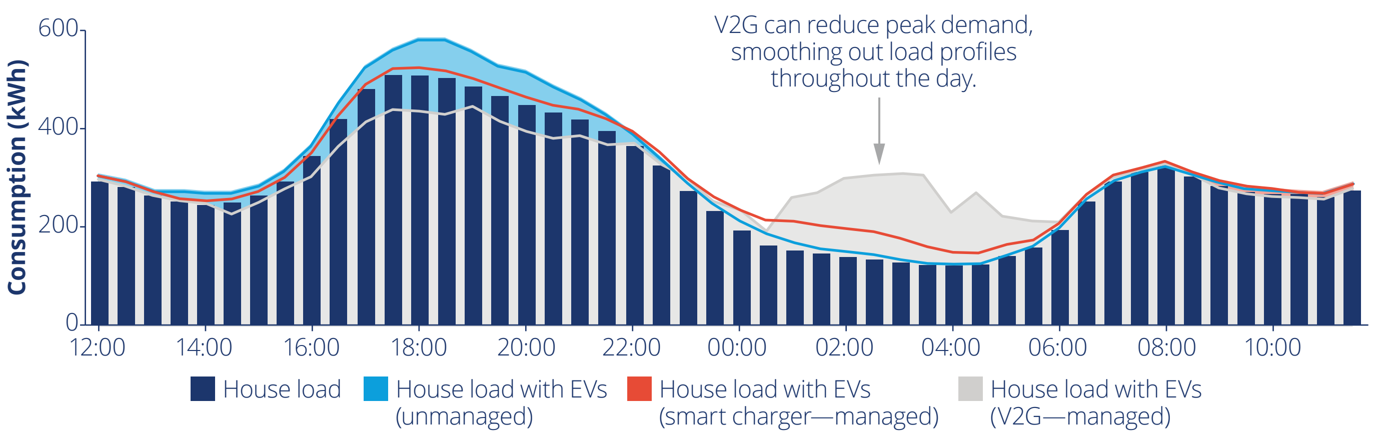
16 See example of AEP's EV time-of-use case study in SEPA's 2019 report, *Residential EV Rates That Work: Attributes that increase enrollment*.

Why Should Regulators Consider Residential Vehicle-to-Grid? A Review of OVO Energy Project Sciurus

In the U.K., OVO Energy's subsidiary (Kaluza) launched Project Sciurus in 2018, the largest residential V2G trial in the world, which targeted customers with Nissan LEAFs.[17] The project aimed to prove that residential V2G is a viable solution to decarbonize the emissions associated with electricity used for charging EVs. Participants received a free V2G charger and an OVO app to create settings for their car, including ready-by times, minimum charging level, and boosted charging. OVO's platform sends updates to the charger to direct the vehicle to export or import its energy in order to save the customer money. Kaluza made a number of preliminary observations on the project (which is still ongoing), including:[18]

- Extremely high customer engagement with V2G
- 5% of customers now say it is important that their next car is V2G capable.
- The majority of customers plug in every day to benefit from V2G energy exports.
- Clear presentation of energy data to the consumer is important to highlight energy savings.
- It is important to manage consumer concerns about battery health if the vehicle is constantly being charged and discharged.
- Policy issues led to inconsistent installation permit and cost requirements across the U.K. Without policies supporting the adoption of V2G, OVO was left to cover many unforeseen installation costs.
- Scaling V2G is challenging due to its low maturity. Current options have high installation and hardware costs. Options for EVSEs and EVs are limited. Flexibility of market entry for residential is limited.

Figure 2: V2G Can Balance Demand—Shifting Household and EV Consumption at the Local Grid Scale



Source: OVO Energy, 2020.

to better monitor bi-directional power flows on the grid, management systems to coordinate across VGI and non-VGI DERs, and back-office coordination between utility planning and operation teams. The key piece of the puzzle core to VGI is the need for aligned communication capabilities for both active V1G and V2X programs.

These capabilities must be built to consider the needs of the application, use case, or grid service provided. Information and data requirements, communication architecture scalability, and the performance requirements of the communication network are all important. Too often, communications are overlooked as a central part of the VGI discussion, however, they are a critical element to unlock VGI potential. For more on this topic,

17 Sources: Kaluza, July 2019, The World's Largest Domestic Vehicle-to-Grid Project, https://www.kaluza.com/case-studies/project-sciurus/ and https://forum.ovoenergy.com/vehicle-to-grid-v2g-chargers-90/everything-ev-webinar-unlocking-the-full-potential-of-vehicle-to-grid-v2g-7880

18 Observations provided by Kaluza via email in October 2020.

Automaker Telematics Can Have an Important Role To Play in VGI Communication

There are many communication pathways to achieve VGI. These pathways allow the utility or aggregator to send the appropriate signals to run the VGI program. Options include direct management, pass-through aggregation, aggregation, third-party charge network operators, and vehicle telematics.[19] A likely future is one where all are leveraged.

Vehicle manufacturer communication networks, known as automaker telematics, provide access directly to the vehicle. This capability is included in most modern vehicles and allows vehicles to share data with the manufacturer's cloud to provide customers with access to usage, maintenance information, and other benefits.

Industry needs better coordination and standardization of requirements for using telematics for VGI. Regulators can support this by providing guidance on requirements for sharing data and vehicle access to load serving entities, with customers' consent, and to reduce technical barriers such as charging data standardization and integration with third-party platforms.

Peninsula Clean Energy, San Mateo County's community choice energy program, is testing telematics-based charging management through a pilot with FlexCharging and is exploring how an EV load shifting program can be scaled to EV-owning customers.[20]

see the 2020 SEPA report, *Guidelines for Selecting a Communications Protocol for Vehicle-Grid Integration*.

Once V2X capabilities are available at scale, utilities may want to match managed charging programs with vehicle-to-home (V2H) or vehicle-to-building (V2B) options, and eventually vehicle-to-grid (V2G), to allow energy export from car batteries. Numerous barriers remain to enable that future,[21] but regulatory hurdles can be addressed today. Additional discussion on residential V2G is included in the callout box below on Kaluza's Project Sciurus in the U.K.

Regulators Are Key To Unlocking Vehicle-Grid Integration

Without swift action to resolve the outstanding business, policy, regulatory, and technical barriers to vehicle-grid integration, opportunities to capture the full value of EVs may be lost. This could lead to grid constraints and increased transmission and distribution costs that prompt the construction of more peaker plants, grid upgrades, and other costly consequences.

As illustrated in Figure 3 from a 2016 Rocky Mountain Institute report,[22] regulators are one of the most influential entities in EV deployment, EV charging infrastructure development, and charging behavior optimization. A successful future depends on regulators understanding vehicle-grid integration technology options and solutions.

A 2019 report by the National Association of Regulatory Utility Commissioners (NARUC)[23] identified future VGI-related gaps and research questions, including:

- **Interoperability and open standards**, which are important for cost-effectiveness, operations, and preventing stranded assets. The report identified interoperability challenges with four interfaces, including vehicle-to-grid interoperability and managed charging programs.
- **Obsolescence**, which concerns the rate of change in the industry leading to risk of stranded assets. This relates to ease of updating the hardware and software of investments, including those with VGI capabilities.

19 Smart Electric Power Alliance, 2020, *Guidelines for Selecting a Communications Protocol for Vehicle-Grid Integration*.

20 Information provided by Philip Kobernick, Peninsula Clean Energy, October 2020.

21 See SEPA, 2020, Hope or Only Hype for Residential V2G? https://sepapower.org/knowledge/hope-or-only-hype-for-residential-v2g/

22 Rocky Mountain Institute, 2016, *Driving Integration: Regulatory responses to electric vehicle growth*.

23 NARUC, 2019, Electric Vehicles: Key Trends, Issues, and Considerations for State Regulators, pp. 37-39.

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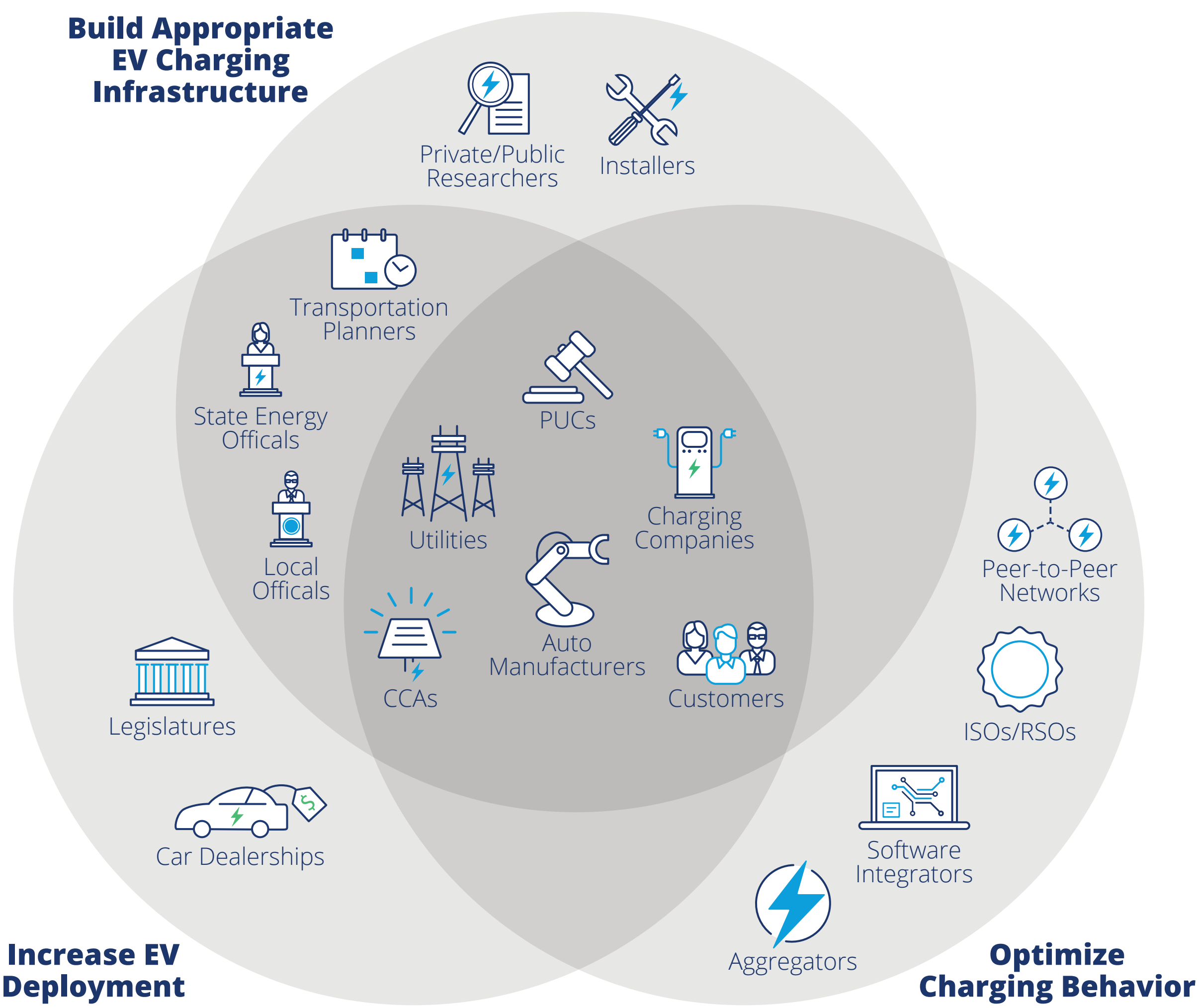
- **Vehicle-to-grid**, which has a number of regulatory and technology challenges, including how to compensate vehicle owners for potential battery degradation, how to reduce impacts on drivers who need access to the vehicle, software control, metering, and station hardware to name a few.
- **Cybersecurity**, which is not limited just to VGI issues, but with any device that is internet-connected and could disrupt the quality and flow of electricity through a local grid. Enabling the bi-directional flow of power may compound this issue.

Other related VGI topics that regulators are best positioned to address, include:

- **Determining the value of VGI,** which will help increase access and transparency to utilities and aggregators, facilitate industry investment decisions, and determine optimal use cases. See Appendix B for more information about potential benefits and costs to include in valuation development and design.
- **Developing VGI-enabling regulations**, which will identify how VGI resources can interact with the grid at the distribution and wholesale levels, including clarifying settlement processes, and signal/messaging interactions. In large part, this should be able to dovetail with processes developed for grid interactions of other types of distributed energy resources.
- **Supporting VGI technology development**, by allowing utilities to use "innovation funds" for programs to test new equipment and partnerships with vendors and developing standards that support VGI aggregation, communication, and control requirements.

Figure 3: EV Deployment and Integration Stakeholder Map



Source: Rocky Mountain Institute, 2016.

Vehicle-Grid Integration (VGI) Delay Due to Regulatory Concerns

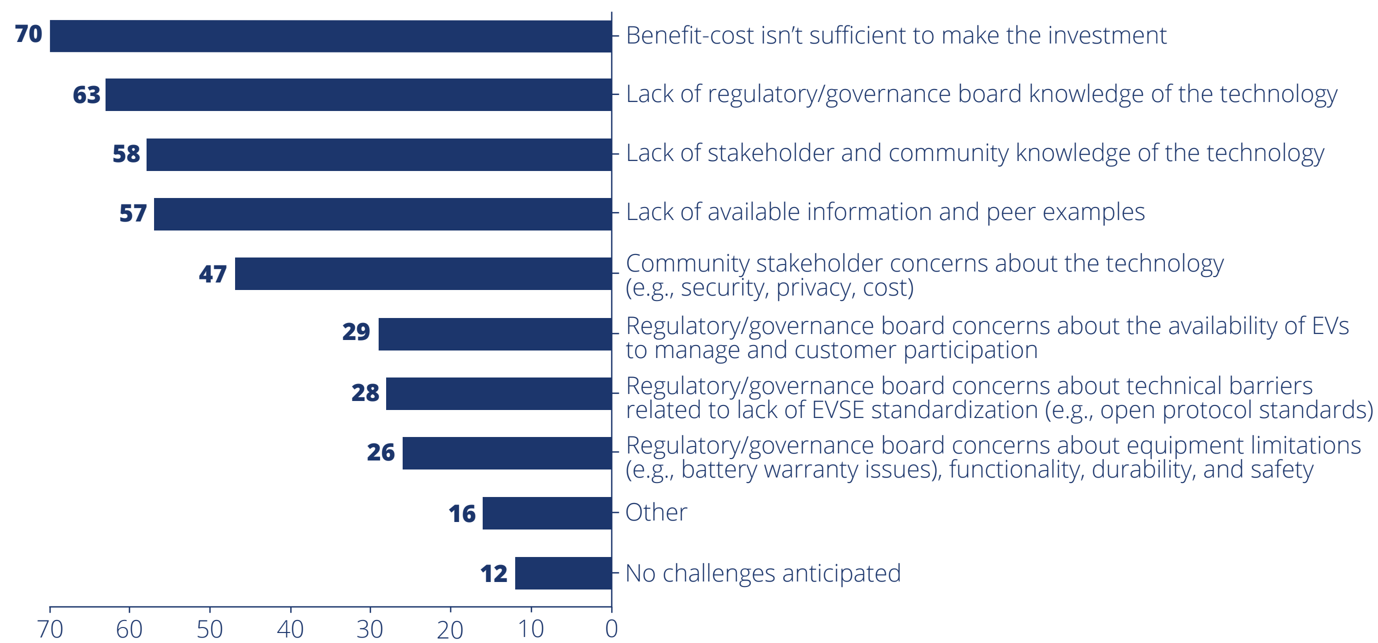
The SEPA *Utility Transformation Survey* identified utilities' major concerns for VGI programs from a regulatory approval and internal company approval perspective. Based on 120 responses to the question on VGI regulatory barriers,[24] utility respondents identified benefit-cost analysis insufficiencies, the lack of regulatory and stakeholder knowledge of the technology, and the lack of available information and peer examples as challenges.

More specifically, utilities noted gaps in available data related to implementation, resourcing, and operational costs needed to conduct benefit-cost analysis and ultimately identify a program's net-value. Multiple respondents also noted challenges regarding soliciting customer participation in programs, concerns about non-participants subsidizing the program, and the competitiveness of VGI programs with other DER investments. Respondents also expressed concerns about the availability of networked EVs to provide grid services.

According to 115 responses about the internal utility barriers for VGI,[25] the utilities' most common concerns similarly related to obtaining regulatory approval and benefit-cost analysis. Other concerns included regulatory, statutory, and/or other legal limitations, uncertainty around customer participation, and technology issues.[26]

Utilities also noted a lack of data to conduct benefit-cost analysis on potential VGI programs and suggested more large-scale pilots to capture this information. From a technology integration standpoint, utilities highlighted the cost, complexity, and infancy of VGI technology as a program deployment barrier.

Figure 4: VGI Program Approval Challenges from Regulator/Governance Board



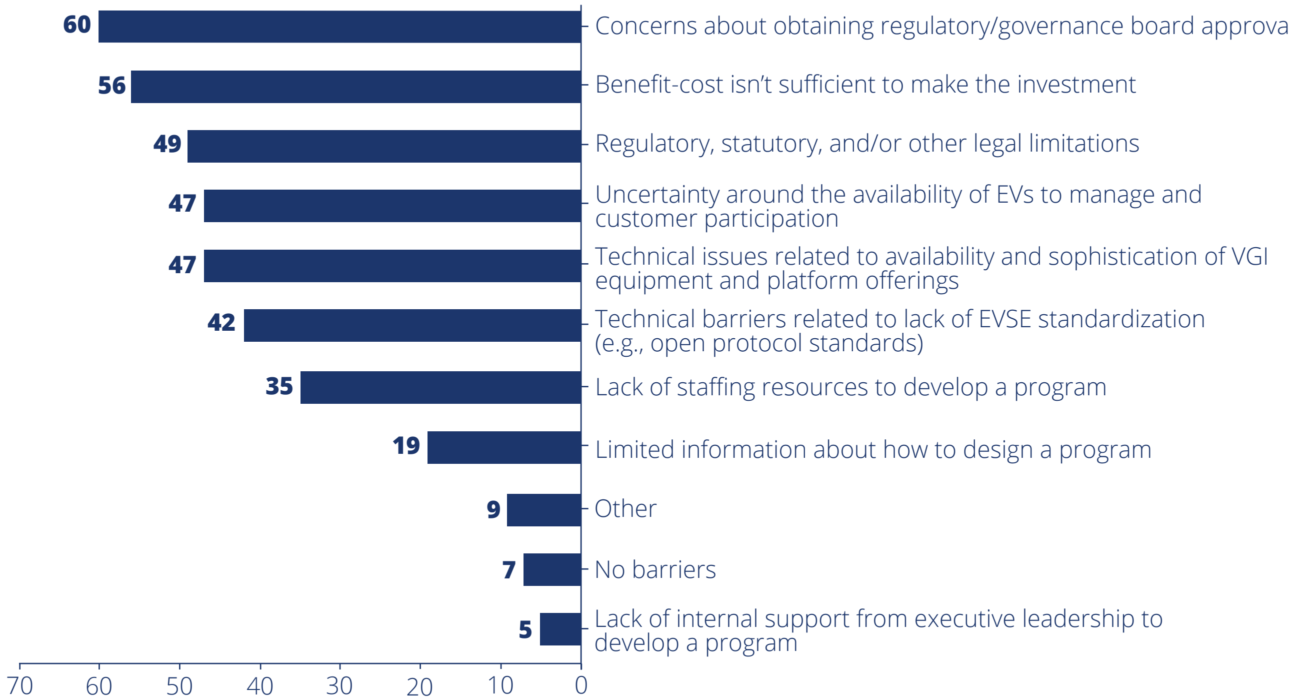
Source: Smart Electric Power Alliance, 2020. N = 120

24 Question: "What VGI program approval challenges do you anticipate from your regulator/governance board? (Select all that apply)".

25 Question: "What are the internal barriers to getting a VGI program approved and executed? (select all that apply)".

26 Note: As this was a multiple choice question, details about the nature/specifics of the regulatory, statutory, and legal limitations were not identified as part of the survey.

Figure 5: Internal Utility VGI Program Approval Challenges



Source: Smart Electric Power Alliance, 2020. N = 115

Developing a Vehicle-Grid Integration (VGI) Regulatory Roadmap

Some states, such as California, have developed a Vehicle-Grid Integration Roadmap in order to chart a path to develop solutions that enable EVs to provide grid services and still meet consumer needs. It can also guide a unifying and coordinated investment and regulatory plan.[27]

In addition, a roadmapping exercise can address a number of regulatory process challenges. This section includes potential approaches and tools a regulatory body could employ to develop a VGI Regulatory Roadmap.

Goals of a VGI Regulatory Roadmap

- To lay the groundwork that will enable increased VGI capabilities and sophistication over time, to the benefit of all customers.
- To provide a forum for consideration and resolution of distribution system technical issues, such as interoperability through aligned and open messaging protocols to network platforms, EV chargers, EVs, and other points of aggregation.
- To address concerns about obsolescence and the associated risk of stranded assets.
- To facilitate a more consumer-friendly charging experience across utility service territories and among different OEM and charging manufacturers.

27 California Vehicle-Grid Integration Roadmap: Enabling vehicle-based grid services, February 2014.

- To encourage better coordination between utilities and bulk power operators and the EV industry, including EV and EVSE stakeholders.
- To better determine VGI value and valuation methodologies across different use cases.
- To provide policy and regulatory clarity for utilities, stakeholders, and solution providers on expectations and outcomes.
- To identify use cases that are most valuable in the near-term for load management.
- To address cybersecurity concerns.
- To align federal, regional, and state policy and regulatory goals (including climate change mitigation and social equity).

VGI Regulatory Process Challenges

A roadmapping process can help facilitate the development of regulations and policies to minimize the risks associated with VGI deployment. The SEPA Renovate Initiative[28] - a project focused on identifying obstacles to the scalable deployment of new technology and operating practices - identified four problem statements describing the challenges that regulators, utilities, consumer advocates and other stakeholders face when considering investments in new technologies, such as VGI.[29] A VGI Roadmap could help to address each of them.

1. **People & Knowledge:** The steep learning curve for policy makers, commissioners, commission staff, industry, and other stakeholders in acquiring knowledge and understanding of new technologies, and the benefits and costs for customers can complicate and lengthen the decision-making process. Educating regulators and stakeholders about the capabilities of VGI technology and its benefits and costs would minimize barriers caused by limited technical understanding.
2. **Managing Risk & Uncertainty:** Current regulations and structures favor tried and true technologies, operations and approaches, in the name of prudence, strictly applying the "used and useful" principle. For new technologies and operating practices, there is uncertainty about the processes to identify and quantify benefits and costs, outline the full range of investment and operating options, and communicate and align incentives with agreed goals for the benefit of all customers. Regulatory mechanisms and approaches that minimize risk for customers (e.g., a pilot with a bounded budget) and utilities (e.g., by providing pre-approval of cost recovery or a tracker to recover costs in near real time) can encourage proposals for and enable regulatory approval of VGI programs.
3. **Managing Increased Rate of Change:** Regulatory proceedings on grid investments and customer programs often take so long that relevant technology providing customer benefit has advanced before a commission assessment can be completed or decision can be reached. By establishing a framework upfront and guidance on benefit-cost analysis, the regulatory review of VGI projects and programs can be made timelier.
4. **Complexity of Objectives / Cross-Coordination:** Commissions have a mandate to serve the public interest, but increasingly, they must consider and balance numerous priorities under an expanding definition of "public interest," including: reasonable rates, customer choice, customer protection, environmental protection, current system structure, and evolving system structure, with both short-term and long-term perspectives. By relating VGI investments to policy directives, such as those in states that have adopted zero-emission vehicle targets or greenhouse gas emission reduction targets, utility filings can be better aligned with policy and customer objectives.

Tools and Approaches to Developing a Vehicle-Grid Integration Regulatory Roadmap

Regulators can use the tools illustrated below to address these four regulatory process challenges and to better review and manage activities related to VGI investments or programs.[30]

Broad Public Stakeholder Engagement Before Formal Proceeding

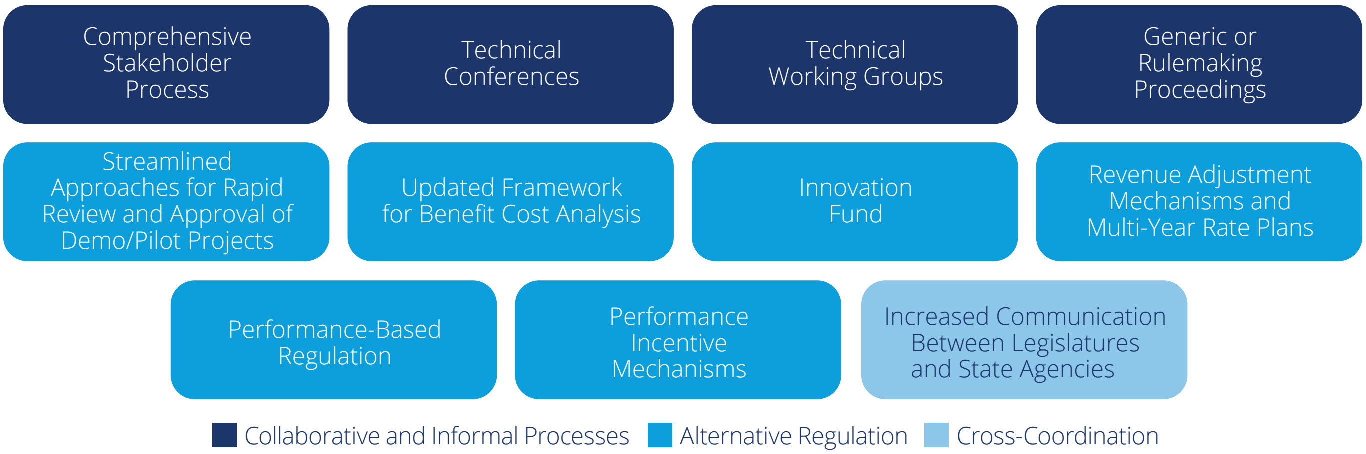
- Employing a comprehensive public stakeholder engagement process prior to a formal proceeding can

28 See SEPA Renovate Initiative Homepage: https://sepapower.org/renovate/.

29 See SEPA Renovate Solution Set, 2020, https://sepapower.org/resource/renovate-solution-set/.

30 See the SEPA Renovate Initiative Solution Set for more information.

Figure 6: Regulatory Tools and Approaches for Vehicle-Grid Integration Programs



Source: Smart Electric Power Alliance, 2020.

(1) build a common information/knowledge base about capabilities, benefits and costs of technology; (2) identify shared priorities and/or a common vision, and (3) enable agreement on new regulatory and / or business models and approaches.31 It can also reduce the time and resources needed for stakeholders to participate effectively in the regulatory process, especially those not traditionally engaged in it. It can help to answer certain key VGI questions, such as:

- What VGI benefits and costs will regulators consider?
- Can and should performance incentive mechanisms be adopted for VGI programs?
- Are dedicated EV rates or programs needed? If and how should non-utility metering be utilized to implement such rates and programs?
- What EV deployment market trends would trigger the need for more VGI technology and solutions?

Technical Conferences Provide a Way to Explore Technology and Process Issues In Detail

Technical conferences can provide an avenue to explore technology and process issues in detail more effectively than traditional, litigated regulatory proceedings and can inform a subsequent regulatory review that may be required. They can be part of a generic or rulemaking proceeding, be held during an adjudicated proceeding, or take place independently. Topics can range from providing stakeholders an overview of the electricity system to focusing on a particular area such as VGI technology capabilities. Staff whitepapers or draft proposals may result from technical conferences.

Working Groups to Address Technical and Regulatory Issues Among Stakeholders

Similarly, working groups can address both technical and regulatory issues on an ongoing basis. Working groups can provide an opportunity for dialogue among stakeholders, identify and prioritize actions needed, develop recommendations to resolve issues, and develop near- and long-term action items. Commissions value consensus positions reached by working group members as well as working group feedback that can provide a pathway for, operate in parallel with, and continue after a proceeding. Even if the working group does not reach a consensus, the information it surfaces and shares can be helpful and provide guidance to commissions as they deliberate and make decisions. Commissions need to ensure that any working group recommendations or consensus is consistent with the law, regulation, and policy. Commissions should not necessarily constrain themselves to the outputs of working groups, where consensus positions can be limited, and following them strictly might suggest or lead to limited or insufficient action.

Generic or Rulemaking Proceeding to Establish Guidance for Utilities to Make Compliance Filings

A generic or rulemaking proceeding can establish a framework for new approaches to regulatory review or new requirements for utilities. These can include new (or

31 See SEPA, 2020, *Benefits of a Comprehensive Public Stakeholder Process: the Oregon Senate Bill 978 Experience*, https://sepapower.org/resource/benefits-of-a-comprehensive-public-stakeholder-process-the-oregon-senate-bill-978-experience/

existing) legal mandates, policy goals, and utility proposals (e.g., EV-specific time-varying rates) for all utilities regulated in a jurisdiction. This is in contrast to a utility-specific rate case. Once a new framework is set, utilities can make compliance filings demonstrating how they will meet (or comply with) the new requirements.[32] A generic or rulemaking proceeding operates with a different set of rules that enable more flexible participation by a broader range of stakeholders (e.g., legal representation is not required to participate).

Establish a Streamlined Approach Based On Meeting Certain Criteria

Streamlined review can be particularly useful for testing new technologies and business models. Examples include the use of "regulatory sandboxes" that allow utilities to experiment with new business models within certain bounds without requiring changes in rules and regulations. This can be achieved through collaborative stakeholder discussions, a generic proceeding, technical sessions, or combination of all three. Another example is establishing a different and faster process for low risk, small expenditures (i.e., pilot programs) that requires only staff review and approval. Streamlined review can also follow from a generic proceeding that establishes a framework or guidelines for approval, which can come quickly when a utility demonstrates it has "complied" with the guidance.

An Updated Benefit Cost Analysis Framework that Allows for Both Quantifiable and Non-Quantifiable Benefits and Costs

A benefit-cost analysis (BCA) is the careful and systematic comparison of the benefits and costs of a potential action.[33] The specific action can be an investment, program, power purchase contract, alternative tariff designs, or alternative operating procedures. An updated BCA framework would allow for consideration of both quantifiable and non-quantifiable benefits and costs of new technologies and approaches, taking into account public policy priorities, beyond those included in traditional benefit-cost tests.[34] The costs of inaction or insufficient action, which may be the case with VGI and the integration of growing EV load, may warrant inclusion in a BCA. Once regulators have established a BCA framework, agreement on methodologies for its application can help to ensure that utility filings include all relevant information needed for regulatory and stakeholder understanding of a proposal and facilitate timely regulatory approvals.

Establish a Budget to Bound Risk for Customers and Utilities

Designation of a budget for deployment and testing of innovative new technology and operating practices can help to bound risk for both utilities and customers. Creation of an Innovation Fund is one way to do this. Setting expected outcomes or targets for projects and evaluating results against them advances learning. Providing rewards and penalties based on project performance targets is another option that can help to share risks. A VGI pilot or demonstration project may be a good starting point, which then can scale depending on success metrics. Budgetary guidelines can also be developed to inform but not necessarily limit individual filings that have yet to be developed.

Establish a Mechanism for Timely Cost Recovery

Mechanisms to enable timely cost recovery are also important to address financial and administrative regulatory challenges for new technologies and practices that may be encountered under a traditional cost of service regulation (COSR) approach. Examples include: cost trackers or riders, interim rates and formula rates (that can follow from a generic proceeding and allow timelier and procedurally efficient recovery of capital and other types of costs). Mechanisms such as revenue decoupling can help to protect customers as well as the utility. For example, revenue decoupling would adjust customer rates downward as EV charging increases energy usage, which would otherwise increase utility revenues above allowed levels. Likewise, decoupling ensures utilities recover allowed revenues when energy usage decreases due to programs such as energy efficiency.

Evaluate Options for Performance Based Regulations

Performance-Based Regulation (PBR), also known as "outcomes-based regulation," is a forward-looking regulatory framework that can help to assure alignment

32 A commission may still retain flexibility and discretion to consider a utility filing that may depart on some respects from the framework.

33 See SEPA, 2020, Developing a Comprehensive Benefit-Cost Analysis Framework: the Rhode Island Experience, https://sepapower.org/resource/developing-a-comprehensive-benefit-cost-analysis-framework-the-rhode-island-experience/ and the 2020 National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources https://www.nationalenergyscreeningproject.org/national-standard-practice-manual/.

34 Examples include the Societal Cost Test (SCT), the Utility Cost Test (UCT), the Participant Cost Test (PCT), and the Ratepayer Impact Measure Test (RIM).

of policy goals, customer expectations and utility actions.[35] PBR links utility revenues or cost recovery to specific performance objectives or outputs, rather than focusing on (often historical) inputs or the costs of serving customers, known as cost of service regulation (COSR). A variety of regulatory tools and mechanisms generally fall under the heading of PBR. Under a PBR framework, utility revenues can change based on a forecast or formula, adjusted for the utility's ability to meet specific performance objectives or metrics. PBR can consist of elements layered onto a COSR framework, or can be a more comprehensive and integrated alternative regulatory framework. The financial impact of incorporating PBR mechanisms can vary, ranging from a limited dollar amount tied to a particular objective (e.g, energy efficiency incentives) to a more significant amount of utility earnings (under a comprehensive PBR framework like the UK's RIIO[36]). PBR can also mitigate capital bias concerns that arise in the COSR framework and enable new utility operating practices and approaches, including investments in cloud-based software solutions and partnerships with competitive service providers and customers to improve performance, which can reduce total costs.

Consider Options for Performance Incentive Mechanisms

Performance Incentive Mechanisms (PIMs) are another regulatory mechanism, which provide incentives to utilities to achieve certain outcomes. They consist of specific metrics, targets, or incentives designed to achieve desired utility performance. They can operate as an incremental addition to traditional COSR or as an element of a larger PBR framework intended to better align utility planning, investments, and operations with customer and societal goals. PIMs can be applied positively (e.g., reward utilities for achieving specified metrics), negatively (e.g., generate financial loss for missing targets), or symmetrically. PIMs are an important tool within PBR frameworks to ensure that utilities meet desired objectives. VGI-related PIMs could be included in utility filings as implementation advances; in the meantime utilities could collect and report information on EV and VGI deployment and performance against objectives such as peak load reduction.

Strong Communication Between Commissions and Other State Policymakers Is Instrumental

Particularly where state policy goals affect the electricity industry and utilities, strong communication and collaborative relationships between state legislatures (and governors) and commissions are instrumental to ensure that commissions have the authority and tools they need to implement state-mandated policies and objectives and that implementation of such policies and mandates by commissions is feasible and practical. Further, stakeholders must communicate about their ultimate objectives for VGI, in the spirit of working towards consensus on an appropriate approach.

Conclusion

As EV deployment expands, VGI will be essential to providing benefits for all customers while avoiding unintended consequences. While EV penetration is currently low in much of the country, we know that the day is coming (and in areas of high penetration, may have already arrived) when a more sophisticated approach such as VGI will be required.

In order to prepare for that future, we need to start laying the groundwork today. Regulators are essential to enabling the necessary and appropriate investment, and providing incentives to utilities to experiment and test certain use cases, deploy technology solutions, and solve problems related to standards and interoperability.

At a minimum, EV charging infrastructure deployed with the support of utility investments should consider a

35 See SEPA, 2020, *Renovate Best Regulatory Practices "Toolkit" Series: Performance-Based Regulation - Part 1*: https://sepapower.org/resource/renovate-best-regulatory-practice-toolkit-series-performance-based-regulation-part-i/; *Part 2:* https://sepapower.org/resource/renovate-best-regulatory-practice-toolkit-series-performance-based-regulation-part-ii/; and *Part 3:* https://sepapower.org/resource/renovate-best-regulatory-practice-toolkit-series-performance-based-regulation-part-iii/.

36 RIIO framework ("Revenue=Incentives+Innovation+Outputs") set by the Office of Gas and Electricity Markets (Ofgem), the government regulator for the electricity and downstream natural gas markets in Great Britain.

utility's long-term VGI plan to ensure that devices installed today will support capabilities required in their lifetimes[37] to avoid stranded assets or early replacement.[38] This occurs through standardization and support for open communication protocols. We encourage regulators and regulatory staff to use your complimentary SEPA membership to learn more about VGI and join our ongoing research activities.

Key Takeaways

- Without a thoughtful approach to encourage grid-optimized charging, the predicted rapid growth in EV adoption could lead to costly distribution system impacts and infrastructure upgrades for utilities, while leaving significant beneficial load management value untapped.
- Utilities' major concerns with respect to regulatory approval of VGI are primarily due to benefit-cost analysis (i.e., the need and their ability to demonstrate that benefits exceed costs) and regulatory and stakeholder VGI knowledge.
- Utilities and regulators often start the VGI journey with passive strategies, such as EV-specific time-varying rates, which are a way to encourage positive charging behavior. To avoid future impacts of timer peaks where numerous customers begin charging their vehicles at the start of the off-peak period, utilities could supplement time-varying rates with an active load management program (i.e., direct load control programs) to derive even more benefits, or switch to direct load management altogether.
- Customer experience is essential to the future of VGI. People do not buy EVs to support the grid; they buy them to get from Point A to Point B. VGI programs must be easy to enroll in, painless to participate in, and deliver tangible financial benefits in order to maximize impact.
- Numerous technical barriers remain to enable the full range of VGI capabilities, though regulatory hurdles can be addressed in parallel.
- Developing a comprehensive benefit-cost analysis (BCA) framework that can be applied to transportation electrification could help overcome challenges with the disparate cost-effectiveness tests we see in some utility filing debates today.[39]
- In addition to programmatic expenditures, regulators can enable rates / tariffs and wholesale market pathways so customers can realize net benefits which benefit the grid and do not compromise mobility.
- A roadmapping process can help facilitate the development of regulations and policies and minimize the risks associated with VGI deployment.
- The goals of a regulatory roadmap include: laying groundwork to enable increased capabilities and sophistication over time, increasing standardization and interoperability of EVSE equipment, reducing risk of stranded assets, encouraging better coordination among key stakeholders, providing policy and regulatory clarity, and identifying near-term valuable use cases.

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37 EVs have a comparable, if not longer, lifespan than internal combustion engines and EV charging equipment is designed for ten or more years.

38 See SEPA, 2019, *A Comprehensive Guide to Electric Vehicle Managed Charging*.

39 SEPA, 2020, *Developing a Comprehensive Benefit-Cost Analysis Framework: The Rhode Island Experience*, https://sepapower.org/resource/developing-a-comprehensive-benefit-cost-analysis-framework-the-rhode-island-experience/.

Appendix A: Vehicle-Grid Integration Resource Library

Atlas Public Policy, 2019, Vehicle-Grid Integration: A review of available approaches and existing programs.

California ISO, 2014, *California Vehicle-Grid Integration Roadmap: Enabling vehicle-based grid services*.

California Joint Agencies Vehicle Grid Integration Working Group, 2019, *VGI Valuation Method*.

California Joint Agencies Vehicle Grid Integration Working Group, 2020, *Final Report of the California Joint Agencies Vehicle Grid Integration Working Group*.

M.J. Bradley & Associates, 2019, *Electric Vehicle Cost-Benefit Analysis: Results of plug-in electric vehicle modeling in seven U.S. States*.

National Association of Regulatory Utility Commissioners, 2019, *Electric Vehicles: Key Trends, Issues, and Considerations for State Regulators*.

Smart Electric Power Alliance, 2019, *A Comprehensive Guide to Electric Vehicle Managed Charging*.

Smart Electric Power Alliance, 2019, *Electric Vehicle Time-Varying Rates That Work: Attributes that increase enrollment*.

Smart Electric Power Alliance, 2020, *Guidelines for Selecting a Communications Protocol for Vehicle-Grid Integration*.

Smart Electric Power Alliance, 2020, *Renovate Best Regulatory Practices "Toolkit" Series: Performance-Based Regulation – Part 1, Part 2, and Part 3*.

Smart Electric Power Alliance, 2020, *Developing a Comprehensive Benefit-Cost Analysis Framework: The Rhode Island Experience*.

Smart Electric Power Alliance, 2020, *Benefits of a Comprehensive Public Stakeholder Process: the Oregon Senate Bill 978 Experience*.

Rocky Mountain Institute, 2016, *Driving Integration: Regulatory responses to electric vehicle growth*.

Appendix B: Calculating the Cost-Effectiveness of Vehicle-Grid Integration

As noted earlier, applying a benefit-cost analysis (BCA) framework to transportation electrification has been challenging in these early days. Having a standardized approach to transportation electrification benefit-cost analysis could help overcome challenges with the disparate cost-effectiveness tests we see from utility filing debates today. For example, the Public Service Commission of Maryland stated:

> "Determining the cost-effectiveness of the EV Portfolio has been challenging, as the record lacks detailed cost effectiveness information, and the Utilities' own cost assessments are superficial at best. The Commission recognizes that there are challenges with identifying an appropriate cost-benefit test insofar as the EV industry is still nascent and evolving, and quality data remains sparse. Industry participants further point out that EV charging deployments do not fit well with any current cost-benefit test. Instead, a combination of tests may yield more successful results than any single approach."[40]

Fortunately, BCA is evolving as recommendations, such as those in the *National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources* are published, the technology and business models become more sophisticated and cost-effective, and more VGI research becomes available.

Significant work has also been done by the California Joint Agencies Vehicle Grid Integration Working Group.[41]

Transportation Electrification Benefit-Cost Analysis

The National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources provides information to jurisdictions looking to conduct benefit-cost analysis (BCA) on single or multiple DERs including electrification. According to the report, electrification is "substituting (i.e., increasing) electricity consumption for the consumption of other fuels" which can lead to an increase in electric system cost.[42] VGI can play a large role in reducing increased generation capacity and transmission and distribution (T&D) capacity costs brought on by electrification. DR programs (e.g., managed charging programs) and EVs with V2G capabilities were identified in the manual as potential ways EVs can be used to mitigate increased energy and system costs by reducing system peaks and, in the case of V2G, utilizing the EV's storage capabilities for increased reliability.[43] The report noted that these benefits are inherently dependent on vehicle owner participation in utility system initiatives and the accessibility of the vehicles during an event where the capability is needed.[44]

The four tables below summarize the potential benefits and costs of electrification resources, including transportation electrification. Each impact is described as a benefit, a cost, or either, depending on the most common applications of this technology. Specific notes are provided where VGI may be able to minimize the potential costs or amplify the benefits. All electrification utility system impacts presented in Table 3, should be included in all cost-effectiveness tests for electric utility electrification resources. The remaining electrification impacts presented in the Tables 4 through 6 should be included in a jurisdiction's primary test if that would be consistent with the jurisdiction's applicable policy goals.[45]

40 Public Service Commission of Maryland, Docket 9478, Order No. 88997, pg. 43, https://www.psc.state.md.us/search-results/?q=9478&x.x=18&x.y=16&search=all&search=case.

41 California Joint Agencies Vehicle Grid Integration Working Group, June 2020, https://gridworks.org/wp-content/uploads/2020/09/GW_VehicleGrid-Integration-Working-Group.pdf

42 National Energy Screening Project (NESP) (2020), National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources,
p. 178.

43 NESP (2020), p. 168.

44 NESP (2020), p. 176.

45 See NESP (2020), Chapter 3. See also Table 8-1, which presents the potential benefits and costs of electrification on the electric utility system (see Section 4.2). Many electrification measures have the potential to function as DR resources; also, EVs with V2G capability can function as storage resources (see Chapter 9). Note that the impacts of DR and storage are addressed in Chapters 7 and 9, respectively. The impacts of multiple DERs—which would encompass the combination of electrification and DR, for example—are discussed in Section IV of the manual.

The characterization of impacts in Table 3 as benefits or costs addresses only the electrification features of these technologies because: (1) not all electrification measures can provide DR and/or storage functionality; (2) for any DR or storage functionality to have impact it must be activated through a utility system initiative; and (3) not all EVs, heat pumps, electric water heaters and/or other electrification technologies with DR and/or storage capability that are installed as a result of a utility system electrification program will get enrolled in complementary DR and/or storage initiatives.

Table 3: Potential Impacts of Electrification: Electric Utility System

Utility System Impact	Benefit of Cost	Notes/Typical Applicability
General		
Energy Generation	■	A cost because electrification increases electricity generation. Cost for many measures can be reduced through economic dispatch using DR and further reduced through use of storage capabilities of V2G EVs. (See Chapters 7 and 9.)
Generation Capacity	■	A cost because most controlled electrification measures will add some demand on system peak (electric heat in summer peaking system is a possible exception). Resulting capacity cost for many measures can be reduced through DR; it can be eliminated or even made negative (i.e., a grid benefit) if storage capability of V2G EVs is utilized. (See Chapters 7 and 9.)
Environmental Compliance	■	By adding load to the grid, electrification can increase electric costs of compliance (but reduce other fuel costs of compliance).
RPS/CES Compliance	■	By increasing electricity load, the quantity of renewable needed to meet RPS increases.
Market Price Response	■	Any increase in electricity consumption will increase market clearing prices where there are competitive wholesale markets.
Ancillary Services	■	By itself, electrification could increase ancillary service costs. However, both EVs and water heaters offer the ability to provide ancillary services when enabled through DR; if that capability is utilized, this can become a benefit. (See Chapter 7.)
Transmission		
Transmission Capacity	■	Most controlled electrification measures will add some demand at transmission peak time (electric heat in summer peaking region a possible exception). Resulting capacity cost for many measures can be reduced through DR and eliminated or even made negative (i.e., a grid benefit) if storage capacity of V2G EVs is utilized. (See Chapters 7 and 9.)
Transmission System Losses	■	Any consumption increase will increase losses.

Table 3: Potential Impacts of Electrification: Electric Utility System *(continued)*		
Utility System Impact	**Benefit of Cost**	**Notes/Typical Applicability**
Distribution		
Distribution Capacity	■ (red)	Most uncontrolled electrification measures will add some demand at distribution peak time (electric heat in summer peaking area is a possible exception). Resulting capacity cost for many measures can be reduced through DR and eliminated or even made negative (i.e., a grid benefit) if storage capability of V2G EVs is utilized. (See Chapters 7 and 9.)
Distribution System Losses	■ (red)	Any consumption increase will increase losses.
Distribution O&M	■ (red)	Any consumption increase will increase O&M.
Distribution Voltage	■ (red)	Added loads will make distribution voltage more challenging to keep at desired levels.
General		
Financial Incentives	■ (red)	Costs, where relevant.
Program Administration Costs	■ (red)	Costs, where relevant.
Utility Performance Incentives	■ (red)	Costs, where relevant.
Credit and Collection Costs	■ (green)	A benefit because other fuel savings may make it easier for customers with electrified end-uses to afford electricity bills.
Risk	■ (red)	Adds risk to electric grid but may be offset by reduced risk associated with displaced fuel(s).
Reliability	■ (red)	By adding load to the grid, electrification will decrease electric system reliability. For many measures that effect can be reduced through DR; it can be eliminated or made negative (i.e., a grid benefit) if storage capability of V2G EVs is utilized. (See Chapters 7 and 9.)
Resilience	■ (gray)	Electrified building end-users do not affect electric system resilience; EVs functioning in V2G mode, could improve resilience by functioning as storage. (See Chapter 9.)

■ (green) = typically a benefit for this resource type; ■ (red) = typically a cost for this resource type; ■ (orange) = either a benefit or a cost for this resource type, depending upon the application of the resource; ■ (gray) = not relevant for this resource type.

Source: National Energy Screening Project, 2020.

Table 4: Potential Impacts of Electrification: Gas Utility and Other Fuel System Impacts

Non-Electric Energy System Impact	Benefit of Cost	Notes/Typical Applicability
Other Fuel: Energy		
Fuel and Variable O&M	■ (benefit)	Any decrease in demand for other fuels caused by electrification will produce other fuel cost reductions.
Capacity	■ (benefit)	To the extent electrification causes a decrease in peak demand for other fuels, it can avoid capital investment in system capacity. Electrification of new construction also eliminates capital cost associated with connection to other fuel delivery systems.
Environmental Compliance	■ (benefit)	By reducing consumption of other fuels, electrification may reduce cost of compliance with environmental regulations for those other fuels (depending on how the regulations are structured).
Market Price Response	■ (benefit)	Any decrease in consumption of other fuels as a result of electrification will lower market clearing prices where the are competitive wholesale markets.
Other Fuel: General		
Financial Incentives (e.g., Rebates)	■ (cost)	A cost to other fuel systems only if applicable to those systems (e.g., for natural gas non-pipe solutions).
Program Administration Costs	■ (cost)	
Utility Performance Incentives	■ (cost)	
Credit and Collection Costs	■ (benefit)	If total energy bills across all fuels decline, customers may be better able to pay all bills.
Risk	■ (benefit)	Lower consumption resulting from electrification should reduce risk (e.g., of exposure to future fuel price volatility.
Reliability	■ (benefit)	Lower consumption of displaced fuel should increase reliability of supply of that fuel.
Resilience	■ (benefit)	Reduced reliance on displaced fuels should reduce the amount of infrastructure for delivery of that fuel that needs to be replaced as a result of storms or other catastrophes.

■ = typically a benefit for this resource type; ■ = typically a cost for this resource type; ■ = either a benefit or a cost for this resource type, depending upon the application of the resource; ■ = not relevant for this resource type.

Source: National Energy Screening Project, 2020.

Table 5: Potential Impacts of Electrification: Host Customer		
Host Customer Impact	**Benefit of Cost**	**Notes/Typical Applicability**
Customer		
Host Customer Portion of DER Costs	■ (red)	Both the cost of the electric products (e.g., EVs or heat pumps) and possible costs to upgrade electric service necessary to use them (including EV charging equipment and related electrical upgrades).
Interconnection Fees	■ (gray)	Potentially a cost for V2G, otherwise not applicable.
Risk	■ (orange)	Potentially a cost due to reduced electricity fuel diversity; potentially a benefit due to reduced volatility of other fuel prices.
Reliability	■ (orange)	EVs can function in times of gasoline shortages and heat pumps can keep buildings heated if there are problems with fossil fuel access or with fossil fuel heating systems; conversely, there can be reliability issues tied to power outages.
Resilience	■ (green)	V2G storage capability can be a benefit to host customers if used as back-up power during grid outages; otherwise not applicable.
Tax Incentives	■ (green)	Potentially a benefit where relevant.
Host Customer NEIs	■ (orange)	Benefit or cost depending on NEI (see Section 10.4.5)
Low-Income NEIs	■ (green)	For low-income electrification only.

■ (green) = typically a benefit for this resource type; ■ (red) = typically a cost for this resource type; ■ (orange) = either a benefit or a cost for this resource type, depending upon the application of the resource; ■ (gray) = not relevant for this resource type.

Source: National Energy Screening Project, 2020.

Table 6: Potential Impacts of Electrification: Societal		
Societal Impact	**Benefit of Cost**	**Notes/Typical Applicability**
Societal		
Resilience	■	Depends upon whether reduced gas consumption affects critical customers and whether increased electricity consumption stresses the grid.
GHG Emissions	■	Depends on use case and hourly environmental profile of electricity grid relative to fossil combustion emissions displaced by appliance/vehicle.
Other Environmental	■	
Economic and Jobs	■	Potentially a net benefit or net cot depending upon fuels displaced.
Public Health	■	Same as GHG emissions and other environmental.
Low Income: Society	■	Potentially a benefit depending on siting an low-income participation.
Energy Security	■	Potentially a benefit depending upon the extent that petroleum products are being displaced.

■ = typically a benefit for this resource type; ■ = typically a cost for this resource type; ■ = either a benefit or a cost for this resource type, depending upon the application of the resource; ■ = not relevant for this resource type.

Source: National Energy Screening Project, 2020.

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