# Advancing Vehicle to Grid Technology Adoption

## Policy Recommendations for Improved Energy Security and Resilience

JUNE 2022

SAFE

Electrification Coalition

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# Introduction

Electricity, which has powered residential and industrial needs for the last 100-plus years, has been distinct from the energy needed to power transportation. However, a shift now is occurring in which electricity will power most residential, industrial, and transportation needs. Millions of electric vehicles (EVs) have been added to U.S. roads in the last several years, and this shift from internal combustion engines to electrification in transportation is set to add hundreds of millions more EVs.

Given electricity's central and growing role in the modern digital economy, it must be reliable, resilient, affordable, and secure. While this transition to a more electrified transportation future will increase electricity demand, threats to the electric grid from natural- and human-caused disruptions have also been growing, as has the shift to cleaner, intermittent sources of electricity, such as solar and wind energy. The North American Reliability Corporation, in its 2022 *Summer Reliability Assessment* warns of predicted "above normal temperatures for much of North America" that threaten the reliability of the electric system, particularly when combined with more severe weather events, drought, and wildfires, which are also expected, along with other human-caused threats.[1] The National Oceanic and Atmospheric Administration has also projected an above-average hurricane season.[2] Consequently, the Assessment also urges grid operators to anticipate an "elevated or high risk of energy shortfalls during peak summer conditions" and to prepare by mitigating these risks to the greatest extent possible.

If the grid cannot maintain reliability in the face of unprecedented threats and meet the requirements of a cleaner future that consists of the "electrification of everything," U.S. society, economy, and even citizens' lives will be at risk. The U.S. grid is seen by many as one of the greatest engineering achievements in history. Vehicle-to-Grid (V2G) technology is the next chapter in the story and could not come at a better time, as the grid faces more severe and extreme threats.

With some modest technological adjustments that enable two-way, also known as bidirectional, charging, as opposed to the one-way flow of electricity to the vehicle that has been the case to date, V2G technology will enable EVs to act as energy storage devices on wheels, powering homes, buildings, and the grid itself. This technological innovation will offer profound opportunities and challenges.

The myriad ways in which EVs acting as mobile energy storage units could provide power to the grid when needed and in emergency situations are profound and could save lives. For instance, an electric car or larger vehicle, like a school bus, with a larger battery and consistent routes at specific times of the day, could power a shelter or other critical facility during power outages from extreme weather events or other natural- or human-caused threats. When EVs are used in this manner, V2G has the potential to improve the resilience of U.S. critical infrastructure and thereby strengthen energy and national security.

V2G technology can also accelerate the adoption of EVs by unlocking additional value, or revenue, streams. The benefits of V2G-enabled EVs, and the grid services they provide, go beyond resilience and supporting load management, and can create value streams and cost savings for EV owners and operators

1 North American Electric Reliability Corporation (NERC), *2022 Summer Reliability Assessment*, May 2022, available at: www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_SRA_2022.pdf.

2 National Oceanic and Atmospheric Administration (NOAA), "NOAA predicts above-normal 2022 Atlantic Hurricane Season," May 24, 2022, available at: www.noaa.gov/news-release/noaa-predicts-above-normal-2022-atlantic-hurricane-season.

by selling these services to utilities. These additional uses and associated benefits are described in further detail in the body of this report.

This paper focuses on why V2G technology is needed, how it can be utilized, what benefits are provided, as well as barriers that limit the scope and scale of deployment. Policy recommendations also include solutions to these challenges to facilitate and expedite the deployment of both V2G technology and EVs.

Recommendations in this report consist of the following categories:

- Incorporating V2G-enabled EVs into emergency planning and preparedness efforts to enhance critical infrastructure resilience, including prioritizing deploying bidirectional charging equipment to critical facilities.
- Development of national technical standards to facilitate seamless communications between EVs and other equipment, which will enable V2G-capable EVs to provide grid services.
- Regulatory treatment of, and compensation for, grid services that V2G-enabled EVs provide, using treatment of stationary energy storage as a model or precedent.
- Strategies to improve coordination across the different levels of government, from federal to local, and with the private sector to facilitate V2G technology deployment, especially for resilience.
- Development and implementation of federal, regional, and state technical and policy roadmaps to help guide the direction of advancing and expediting the widespread use of V2G technology.
- Federal and state incentives, primarily tax credits, as well as grants and rebates.

The recommendations also emphasize the need for expanded dissemination of pilot project results to policymakers at all levels of government, relevant stakeholders, and the broader public. Policies and pilot projects must be combined with broader and deeper education, awareness, and outreach highlighting V2G technology applications, opportunities, and challenges. In addition, developing and applying metrics will establish baselines for measuring progress toward pre-determined goals to advance this technology.

This report builds on an ongoing V2G Joint Initiative of SAFE and the Electrification Coalition (EC) that began with a Roundtable in April 2021, which brought together representatives that comprise the ecosystem of relevant stakeholders across the transportation, energy, equipment manufacturing, and other sectors.[3] Since then, SAFE and the EC, along with partners and other stakeholders, have succeeded in leveraging opportunities to advance V2G capabilities in several federal policies enacted on a bipartisan basis into law in the *Infrastructure Investment and Jobs Act* (IIJA).[4] Appendix B elaborates on these policy accomplishments. These measures will expand funding and ensure that EV- and EV charging infrastructure-related programs do not inadvertently miss opportunities to utilize V2G technology. Accordingly, recommendations are based on outstanding and updated policy needs.

## Brief Description of Vehicle-to-Grid Technology and Its Capabilities

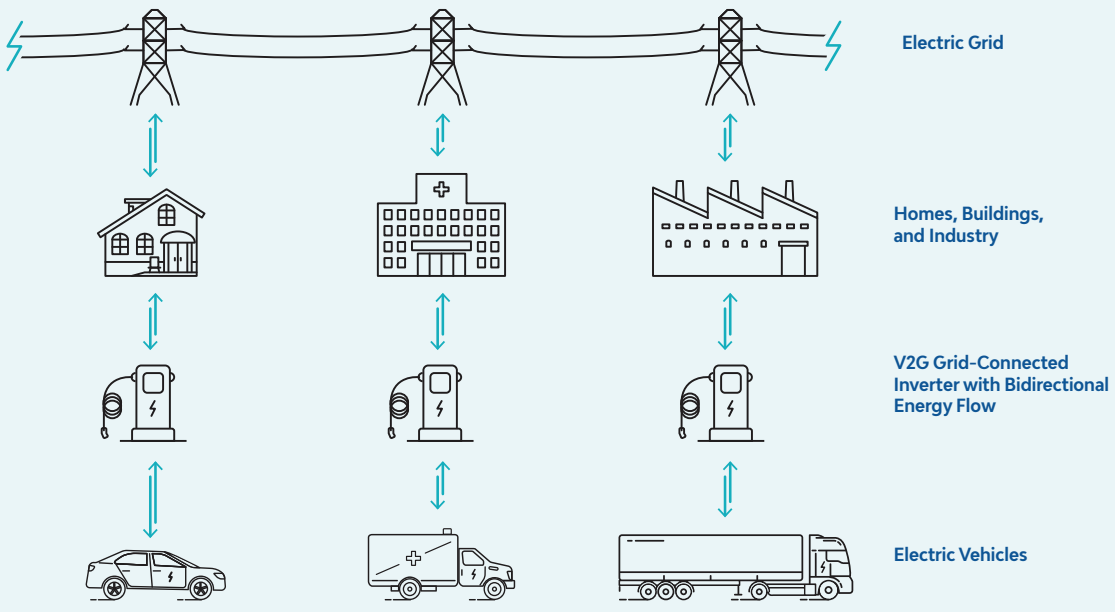
V2G capability refers to an EV with bidirectional charging and a battery that provides onboard energy storage, which acts like a mobile energy storage unit or mobile power unit that can provide energy through a bidirectional charger interconnected with the grid. The text box on the following page contains more specific definitions of V2G and related terms.

In this report, SAFE and the EC examine these issues broadly and refers to the terms (defined on page 4) collectively as V2G. In other words, SAFE and the EC do not always distinguish between V2H, V2B, and V2G. Additionally, SAFE and the EC do not refer to these terms collectively as V2X because of its much broader applications. However, SAFE and the EC look forward to expanding the scope of future efforts to include a broader exploration of V2X.

3 The V2G Roundtable hosted by SAFE and the EC uniquely brought together leading experts and stakeholders representing electric utilities, automobile manufacturers (OEM), equipment manufacturers, electric vehicle (EV) charging providers, the energy storage industry, as well as fleet operators, education and advocacy organizations, and academia. In addition, representatives from federal, state, regional, and local entities, such as from Regional Transmission Organizations (RTOs)/Independent System Operators (ISOs), and state Public Utility Commissions also participated. As noted above, the recommendations herein build on the Roundtable but are not exclusive to that event.
*Note: Neither individual Roundtable participants, nor their organizations, endorse all, or any particular, recommendations herein. Policy makers and regulators who participated in the Roundtable event are not able to endorse or advocate for recommendations contained herein.*

4 *Infrastructure Investment and Jobs Act (IIJA)*, Public Law 117-58, 117th Congress, November 15, 2021, available at: https://www.congress.gov/117/plaws/publ58/PLAW-117publ58.pdf (hereinafter referred to as IIJA).

Figure A: Vehicle-to-Grid Applications




## Key Definitions

**Vehicle-Grid Integration (VGI):** "Any method of altering the time, charging level, or location at which grid-connected electric vehicles charge or discharge, in a manner that optimizes plug-in electric vehicle interaction with the electrical grid and provides net benefits to ratepayers by doing any of the following: (a) increasing electrical grid asset utilization; (b) avoiding otherwise necessary distribution infrastructure upgrades; (c) integrating renewable energy resources; (d) reducing the cost of electricity supply; and (e) offering reliability services," that adhere to certain California regulatory specifications. (California Public Utilities Code Section 740.6).[5]

**Vehicle-to-Grid (V2G)**: Two-way, or bidirectional, charging and discharging between EVs and the grid. This enables "vehicles to discharge stored power back onto the grid or into a building or local power system," particularly in times of need, such as a natural disaster or other grid outage situation.[6]

**Vehicle-to-Home (V2H) or Vehicle-to-Building (V2B)**: Despite the previous definition of V2G, most sources define V2H and V2B as situations in which the EV battery provides power to a home or building, but that power is "islanded" and not exported all the way back to the grid.[7]

**Vehicle to Everything (V2X)**: "An all-encompassing term for a vehicle's connected communications." It includes, for example, vehicle-to-vehicle communications as well as V2G, V2H, and V2B.[8]

5 California Joint Agencies Vehicle-Grid Integration Working Group, *Final Report of the California Joint Agencies Vehicle-Grid Integration Working Group*, California Public Utilities Commission DRIVE OIR Rulemaking (R. 18-12-006), June 30, 2020, available at: VGI Working Group Final Report 6.30.2020 (gridworks.org).

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

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

8 Teague, Chris, "Everything You Need to Know About V2X Technology," Autoweek, May 3, 2021, available at: https://www.autoweek.com/news/technology/a36190311/v2x-technology/.

# Why V2G is Needed

### Resilience and Security Opportunities and Benefits

V2G-enabled EVs can provide a range of grid services and can serve as valuable grid assets to a range of stakeholders—from emergency managers to policy makers and individual households. For example, they can provide power back to the grid or to specific buildings, such as emergency shelters, hospitals, other critical facilities, or an entire neighborhood during power outages. Electric utilities could also use V2G for back-up generation, such as during public safety power shut-off events in California, and engage additional partners as needed.

In doing so, mobile energy storage units enhance infrastructure resilience while aiding emergency planning, preparedness, and response efforts. The need for additional power sources to bolster critical infrastructure resilience and reliability will continue to increase, due to the rise in extreme weather events as well as cybersecurity and physical security threats.

In the United States, the EV fleet has "ten times more capacity" than all electric power plants.[9]

> V2G-enabled EVs can provide enough power to support critical loads for up to several days. For instance, one Nissan LEAF is estimated to be able to provide enough power for two days' worth of household electricityworth of household electricity.[10]

Electric school buses and other medium- and heavy-duty (MHD) EVs are of particular value. These often have large batteries, are operated by fleet managers with predictable routes and use profiles and are not on the road during extreme weather events.

> One electric school bus can store enough energy to "power the equivalent of five operating rooms for more than eight hours, and a single operating room for 43 hours."[11]

EVs with onboard energy storage and bidirectional charging capabilities can also reduce the need to deploy additional diesel generators or separate stationary energy storage units for emergency situations. This reduces the costs associated with purchasing a separate back-up power source and reduces the environmental impacts of diesel generators.

### V2G-Facilitated Resilience Contributes to Greater Equity in Hard-Hit, Underserved Communities

Underserved communities are often hit the hardest by and following extreme weather events, such as hurricanes, floods, tornadoes, or wildfires. Thus, mobile power units could be particularly useful in enhancing resilience in these areas. Equity-oriented V2G policy and project approaches exist, yet more thought and work are needed in this regard.

### Additional Uses and Benefits of V2G Technology

V2G technology has the potential to accelerate the adoption of EVs by creating additional value or revenue streams for individuals and fleets, providing valuable grid services during normal operations, often at a lower cost than other resources.[12] With the appropriate policies in place, EV owners could receive compensation, mitigating the total cost of ownership that, in some cases, is already less over an EV's lifetime than that of an internal combustion engine vehicle. These benefits can apply to all vehicle sectors, from light-duty passenger vehicles to MHD trucks and buses.

9 Kempton, Professor Willett, and Letendre, Steven, "Electric Vehicles as a New Power Source for Electric Utilities," Transpn. Res.-D, Vol. 2, No. 3, 1361-9209/97, page 157, 1997 (hereinafter referred to as Kempton article).

10 Nissan Motor Corporation, "Power to the People—Vehicle-to-Grid," December 8, 2015, available at: https://europe.nissannews.com/en-GB/photos/photo-140310-power-to-the-people-vehicle-to-grid.

11 Environment Texas Research and Policy Center, *Electric School Buses and the Grid*, March 17, 2022, available at: https://environmenttexas.org/reports/txe/electric-school-buses-and-grid.

12 Fleet Forward Staff, "Vehicle-to-Grid Technology Saves $950 in 4 Months," Automotive Fleet, December 8, 2021, available at: https://www.automotive-fleet.com/10157483/vehicle-to-grid-technology-saves-950-in-4-months.


Photo credit: Nuuve

According to a June 2020 report by the California Joint Agencies Vehicle-Grid Integration Working Group, pilot projects have highlighted a multitude of promising use cases and associated benefits.[13] These projects have demonstrated that V2G can reduce electric system congestion, as just one example of the types of potential applications with an important grid benefit.

V2G applications can also facilitate EVs' charging and discharging ability to improve load management. For instance, electric school buses with onboard storage and V2G capabilities could provide power as needed, when they otherwise would be idle, especially during the summer months. In this way, they would help manage load when electricity demand is at its peak in many parts of the country, due to high air conditioning usage, conveniently when many children are not in school and the buses are idle. Avoiding EV charging during peak periods will reduce consumer and wholesale power costs.

According to the same report, the benefits from just one V2G use case involving MHD EVs amounted to $16 million per year.[14]

## Barriers to V2G Deployment

Several factors have limited the United States' ability to utilize promising V2G technology and associated value streams, including insufficient awareness and a lack of coordination among key stakeholders. EVs and EV charging infrastructure already have high up-front costs, and EV owners and operators are reluctant to spend more to add V2G capabilities without being aware of and assured of a commensurate return on investment for V2G grid services. On the technological front, progress has been slowed by an absence of uniform national technical standards and concerns that charging and discharging EV batteries for grid services would degrade the batteries beyond levels typically associated with driving and could lead to warranty issues.

Electric system operators, electric utilities, and regulators have concerns, such as to the impacts of EVs on the grid as well as the treatment of and compensation for services provided by mobile energy storage units, and want a larger body of data and pilot project results. The use of EVs with bidirectional charging and their provision of grid services have encountered some policy and regulatory challenges similar to those previously encountered with respect to stationary energy storage.

The following section includes recommendations to overcome these challenges and unlock the critical potential of V2G technology for consumers, fleet managers, the grid, and the United States as a whole.

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

14 Ibid, Use Cases #2245 and 2248—small truck fleet charging for customer bill management.

# Policy Recommendations

The solutions identified in this section will help overcome existing challenges and barriers to deployment, but policymakers must act now.

**SUMMARY OF KEY POLICY RECOMMENDATIONS**

### Federal

- Extend and expand the "Alternative Fuel Refueling Property," or EV charging infrastructure, also known as Section 30C, tax credit to cover V2G capabilities.
- Incorporate V2G capabilities into emergency planning, preparedness, and response efforts for resilience purposes; and prioritize the deployment of bidirectional charging equipment at critical facilities.
- Convene a cross-disciplinary group to advance V2G policy and regulatory developments and deployment.
- Develop a national V2G Roadmap.
- Help future-proof policies to incorporate V2G make-ready capabilities into infrastructure planning processes.
- Modify and update the treatment of V2G-capable EVs as mobile energy storage units in policies and regulations in terms of their provision of grid resources using lessons learned from stationary storage and other Distributed Energy Resources.
- Facilitate the development and implementation of uniform national V2G-related technical standards.
- Conduct research and testing to ascertain the potential impacts of bidirectional charging on battery degradation and warranties.

### State and Local Governments

- Incentivize V2G deployment at the state and local levels.
- Streamline interconnection standards.
- Design or apply appropriate rate structures to compensate onboard batteries and V2G.
- Conduct demonstrations, share lessons learned and best practices, and scale V2G technology.

### Regional Transmission Organizations (RTOs)

- Develop or implement roadmaps that fully incorporate EV and Electric Vehicle Supply Equipment V2G capabilities.
- Develop or revise RTO requirements to facilitate V2G deployment, including for grid services in wholesale markets.
- Conduct V2G grid impact studies and disseminate results broadly.
- Conduct inclusive, transparent, and cross-sectoral V2G stakeholder processes.

It would be a missed opportunity if V2G capabilities were to become an afterthought to the electrification of the nation's transportation system, especially given the benefits that V2G technology can produce, combined with the growing threats facing the U.S. electric system. Retrofitting EVs and EV charging infrastructure with bidirectional charging capabilities would also be far more costly than incorporating them on the front end and future proofing infrastructure, as the United States is making a multi-billion-dollar generational investment.

In addition, the following two elements are essential to ensuring recommendations are as effective as possible:

- Conducting educational outreach to foster greater public awareness of V2G and its potential value and benefits.
- Establishing metrics to measure baselines and progress in V2G deployment, use of bidirectional charging services, efficacy of public financial assistance, and other factors.

Moreover, it is important to support traditionally underserved populations and communities gaining access to EVs and EV supply equipment (EVSE) or electric charging infrastructure with V2G capabilities, so they can gain from the resilience and other benefits that bidirectional charging can provide. To achieve this, decision makers should consider using an economic inclusion framework, or equity and inclusion principles, to examine and implement EV- and V2G-related policies.

## Federal Policy and Regulatory Recommendations

Federal policies are critical to overcoming barriers to V2G deployment, including potentially inconsistent state policies. Such federal policies are particularly important given the cross-sectoral nature of this technology and the range of diverse stakeholders involved. Federal and state agencies will need to enhance coordination among themselves and with Regional Transmission Organizations and Independent System Operators, collectively referred to as RTOs, as well as with private sector stakeholders.

### POLICY RECOMMENDATION

**Extend and expand the "Alternative Fuel Refueling Property," or EV charging infrastructure, also known as Section 30C, tax credit to cover V2G capabilities.**

Presently, the initial cost of EV charging equipment, combined with the added capability of V2G, increases the overall costs of this infrastructure. Modifications to the Section 30C tax credit would help defray the incremental V2G-related costs, incentivizing deployment of EV charging infrastructure and V2G technology. Currently, Section 30C provides a 30 percent tax credit up to $30,000 per EV charging property, referred to as a cap on the credit. This credit expired on December 31, 2021.

Pending modifications to the Section 30C tax credit would expand the definition of EV charging infrastructure, so that EV chargers with bidirectional charging capability would qualify. Changes would also extend and raise the current cap and apply to individual chargers, rather than overall properties. Thus, the package of clean energy tax credits that contains these revisions to the Section 30C credit should be passed by Congress and signed by the President into law.[15]

### POLICY RECOMMENDATION

**Incorporate V2G capabilities into emergency planning, preparedness, and response efforts for resilience purposes; and prioritize the deployment of bidirectional charging equipment at critical facilities.**

Expanding relevant decision makers' awareness of opportunities to use V2G technology and vehicles with onboard batteries to enhance resilience in emergency situations is critical, given that such awareness and coordination are often inadequate. Decision makers are also encouraged to consider incorporating such technology and capabilities into emergency planning, preparedness, and response efforts. Federal Emergency Management Agency (FEMA) Hazard Mitigation Plans, state emergency preparedness and response plans, and other relevant federal, state, and local emergency planning or management documents present prime opportunities to incorporate these capabilities and demonstrate their effectiveness in enhancing resilience.

While the focus is largely expected to be on MHD EVs for resilience purposes, light-duty EVs could play meaningful roles as well.

The primary agencies responsible for writing and/or overseeing the development, revision,

15 A package of clean energy tax provisions, including the Section 30C tax credit, is contained in the Budget Reconciliation infrastructure package that passed the U.S. House of Representatives in late 2021.

implementation, and management of relevant emergency preparedness and response plans are encouraged to consider:

- Ensuring these plans contemplate the capabilities and resources that V2G technology and onboard EV batteries can provide to enhance resilience, particularly during emergencies and prioritize critical facilities, such as shelters, schools, and hospitals, likely to need back-up power that V2G-enabled EVs could provide or support—whether connected to the grid, or islanded, for example, as a microgrid.
- Facilitating collaboration and coordination with fleet managers, school districts, and other relevant stakeholders, so V2G-capable vehicles can be readily deployed to critical facilities in an emergency.
- Coordinating with the relevant federal, state, and local public officials and private sector representatives to ensure such facilities and their surroundings have the requisite wiring, software, and/or hardware, so that V2G-capable vehicles can provide power where and when it is needed.

V2G-capable vehicles also could provide back-up power to U.S. Department of Defense facilities, especially those that are most critical to national security, many of which currently rely on commercial electric utilities to meet their electricity needs.

**POLICY RECOMMENDATION**

**Convene a cross-disciplinary group to advance V2G policy and regulatory developments and deployment.**

Federal, regional, state, and local actors from, for instance, the transportation, energy, environmental, and educational sectors, have not yet adequately coordinated or collaborated on using EVs and EVSE with V2G capabilities as mobile energy storage units. Nor have they sufficiently coordinated or collaborated with electric utilities or other relevant private sector entities. The structures, procedures, and personal contacts to facilitate communication and coordination across these industry sectors are likely lacking as well.

The National Association of Regulatory Utility Commissioners, National Association of State Energy Officials, U.S. Department of Homeland Security, FEMA, Federal Energy Regulatory Commission (FERC), U.S. Department of Energy (DOE), U.S. Department of Transportation (DOT), and the new Joint Office of Energy and Transportation, or some combination thereof, are encouraged to consider convening a cross-disciplinary group consisting of additional relevant public and private sector stakeholders to facilitate establishing procedures and contacts, and to develop policies to advance V2G deployment in a coordinated manner. Doing so would be particularly beneficial to emergency management and resilience situations. Engagement from additional federal, regional, state, and local agencies, ranging from the U.S. Environmental Protection Agency to school districts, as well as from electric utilities, charging providers, automobile manufacturers (OEMs), and others in the private sector will be vital to these efforts.

In April 2022, the DOE and its partners signed a first-of-its-kind V2X Memorandum of Understanding (MOU). This MOU represents progress toward the type of necessary cross-sectoral coordination and collaboration.

Undertaking such cross-disciplinary convenings should not preclude nor hinder progress on implementing other recommendations to advance V2G technology deployment.

**POLICY RECOMMENDATION**

**Develop a national V2G Roadmap.**

Industry has indicated a need for a roadmap to enhance V2G capabilities and deployment over time. This roadmap would focus on technology development and deployment. States also will likely need separate V2G policy roadmaps. Some combination of the federal agencies and national state-based organizations listed in the prior recommendation could lead the development and production of the roadmap(s). Ideally, these roadmaps would consist of:

- An overview of V2G applications and state of the industry.
- Relevant high-level steps and milestones.
- Metrics for industry to evaluate, report, verify, and monitor progress, without imposing overly burdensome or bureaucratic processes.
- Several use cases that demonstrate clear successes.

- Plans and timelines for widespread deployment.
- A set of core principles that balances the needs of vehicle owners or operators with those involved in deploying and managing V2G-enabled assets as grid services across a range of use cases.

Undertaking this effort should not preclude nor hinder progress on implementing other recommendations to advance V2G technology deployment.

**POLICY RECOMMENDATION**

**Help future-proof policies to incorporate V2G make-ready capabilities into infrastructure planning processes.**

It is important that relevant EV, EVSE, EV charging infrastructure, and building-related policies encourage, if not require, the incorporation of V2G make-ready capabilities at the front end of planning and development processes. Doing so will help avoid more expensive retrofits. EVs and EVSE should have the requisite wiring, software, and/or hardware installed, where practicable, to be capable of providing bidirectional charging.

The inclusion of up-front V2G make-ready capabilities could be considered for policies that pertain to:

- Construction or retrofits of schools, shelters, condominium buildings, or military facilities, with pertinent energy efficiency building upgrades as potential models.
- The deployment of EV charging infrastructure along national highway corridors and in communities across the United States, for instance, as part of the National Electric Vehicle Infrastructure program.
- Relevant building codes.

**POLICY RECOMMENDATION**

**Modify and update the treatment of V2G-capable EVs as mobile energy storage units in policies and regulations in terms of their provision of grid resources using lessons learned from stationary storage and other Distributed Energy Resources (DER).**

V2G and the use of EVs as mobile energy storage units have encountered several challenges, some of which are similar to those previously encountered with respect to stationary energy storage. However, the mobile nature of EVs and additional needs associated with ensuring vehicles can communicate and interconnect with stationary infrastructure, and that grid operators and electric utilities can see and manage such resources, create additional complexities and challenges that will need to be addressed.

Whether and how grid operators and/or utilities and regulators treat or classify EVs and the V2G-enabled grid assets they provide will have a profound impact on their future deployment. From the technological and energy resource management standpoints, multiple stakeholders contend that parallels should be drawn between the treatment of stationary energy storage and mobile energy storage units, in terms of policy or regulatory processes and desired outcomes.

> FERC Order 2222, which enables DERs to participate in wholesale markets through aggregations, specifically mentions EVs and EV charging infrastructure among the eligible DERs.[16]

Though much will be determined by state public utility commissions (PUCs), additional clarity at the federal level, nevertheless, could be beneficial in certain policy circumstances. Please see the State Policy Section for more details.

The perception of these assets or resources, is what matters in terms of how they are, or will be, treated from a federal, regional, or state regulatory perspective and, ultimately, how these resources will be compensated for their ability to discharge to provide grid services. In many places, V2G is not fairly compensated or incentivized in the same manner as stationary storage or is often ineligible for compensation at all. However, some progress is occurring on this front, California's Public Utilities Commission (CPUC) recently approved an Emergency Load Reduction Program, which is a 5-year pilot program designed to pay electric consumers for reducing energy consumption or increasing electricity supplies during grid emergencies.[17] V2G is a critical part of the program, and the "CPUC has guaranteed participating V2G charging sites at least 30 hours"

16 Federal Energy Regulatory Commission (FERC), "FERC Order No. 2222: Fact Sheet," September 17, 2020, available at: https://www.ferc.gov/media/ferc-order-no-2222-fact-sheet.

17 California Public Utilities Commission (CPUC), Emergency Load Reduction Program, available at: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/emergency-load-reduction-program.

as a grid resource with "lucrative" incentives, such as paying $2,000 per megawatt-hour.[18]

The following recommendations apply to policies and regulations affecting the management and use of grid services provided by mobile energy storage units:

- Continue to examine federal, RTO, and state policies and regulations that pertain to stationary energy storage to analyze their applicability to, and treatment of, mobile energy storage units as grid resources.
- More specifically, improve market access for V2G-enabled grid resources, including by providing incentives similar to what stationary energy storage has historically received.
- Design policies and programs to be technology neutral to not preclude future V2G innovation.
- Enable consideration of the cumulative financial benefits of V2G-enabled grid services, for purposes of compensation.
- Ensure underserved communities have access to V2G. The revenue generated by a V2G program could cover much of the cost of a lease payment for an EV.[19]
- Consider the policy and regulatory implications of co-locating EVs with solar and/or stationary storage in certain circumstances. For example, load management might be aided by pairing EVs and V2G grid services with solar energy and stationary energy storage.[20]

**POLICY RECOMMENDATION**

**Facilitate the development and implementation of uniform national V2G-related technical standards.**

Uniform technical standards are currently lacking. As a result, interoperability does not always occur seamlessly, for example, between different types of EVs and equipment. While OEMs already build and design their EVs, including product software and hardware, to certain technical standards,[21] they still face challenges developing or redesigning products for different state and international markets, when standards vary. Additionally, OEMs need to design products that meet customers' varying needs and desires, and such changes can be costly.

Uniform technical standards, such as UL or SAE standards, would better enable different types of equipment or parts of systems to successfully interface and communicate with one another, such as a bidirectional EV with a V2G-enabled bidirectional charger, to ensure effective and reliable operation. These uniform standards would also provide OEMs greater certainty surrounding their product design specifications with respect to V2G capabilities across the United States and globally. Nevertheless, such standards will need to be updated over time to keep pace with technological innovation.

**POLICY RECOMMENDATION**

**Conduct research and testing to ascertain the potential impacts of bidirectional charging on battery degradation and warranties.**

The number of times a battery is able to fully charge, and discharge is officially referred to as its cycle life. Some stakeholders and EV owners or operators have raised concerns that bidirectionally charging an EV battery for grid services could degrade the battery faster than would occur solely under typical driving conditions. Several experts note, however, that a vehicle providing power back to the grid, or a building does not result in a significant drain on, or degradation of, the vehicle's battery cycle life.

Related concerns among some EV owners and OEMs that could hinder V2G technology deployment are whether the use of an EV to provide power back to the grid could negatively affect or even void an EV battery's warranty and who has responsibility for covering the warranty.

Thus, more research and testing are needed to continue to advance battery technology and extend the cycle life. Doing so will also yield data in greater quantity and of better quality over time to demonstrate whether, or the extent to which,

18 St. John, Jeff, "Is `vehicle-to-everything' charging ready for prime time?," Automotive Fleet, April 27, 2022, available at: https://www.automotive-fleet.com/10157483/vehicle-to-grid-technology-saves-950-in-4-months.

19 Fleet Forward Staff, "Vehicle-to-Grid Technology Saves $950 in 4 Months," Automotive Fleet, December 8, 2021, available at: https://www.automotive-fleet.com/10157483/vehicle-to-grid-technology-saves-950-in-4-months.

20 Environmental Defense Fund (EDF), *Accelerating Electric Vehicle Infrastructure: A How-to Guide for Regulators*, February 15, 2022, available at: http://blogs.edf.org/energyexchange/files/2022/02/Accelerating_Electric_Vehicle_Infrastructure.pdf (hereinafter referred to as EDF Report).

21 SAE provides a collection of industry agreed-upon technical standards, which form the basis for many government regulations (e.g., NHTSA). UL provides technical standards; it also acts as a Nationally Recognized Testing Laboratory (NRTL), whereby it can test for compliance with these standards, or provide third-party independent certification or means for industry self-certification of standard compliance.

bidirectional charging affects a battery's cycle life. As is the case for other policy recommendations, creative, out-of-the-box thinking, and leadership are essential to address potential battery cycle life degradation and related warranty challenges.

## State and Local Policy and Regulatory Recommendations

State policy and regulatory actions are essential to advancing V2G deployment. Below are recommendations intended to be among those that will most facilitate and expedite this deployment.

**POLICY RECOMMENDATION**

**Incentivize V2G deployment at the state and local levels.**

As is the case at the federal level, to help reduce up-front costs:

- Ensure that bidirectional charging capability is eligible for any applicable state-level tax credit, grant, or other incentive program. Such incentives could also be tailored to light-duty and MHD EVs.
- Require applicants to consider incorporating V2G into relevant state EV and EV charging infrastructure grant programs—and reward them for doing so.

**POLICY RECOMMENDATION**

**Streamline interconnection standards.**

Implementing or complying with interconnection standards can be extremely challenging for DERs and, more so, for V2G applications, as states tend to have different interconnection regulatory processes. In addition, some states, such as Massachusetts, have processes that take two or more years to finalize an interconnection agreement and add grid storage capabilities.[22] It is important to streamline and better align interconnection standards and agreements to facilitate the use of V2G capabilities as grid resources.

As an example of a way to ameliorate this problem, the CPUC is working to help facilitate the use of V2G for grid services, including streamlined interconnection processes and recently approved interconnection rules.[23]

22 Brown, Gwen and Sky Stanfield, "Improving interconnection timelines: The need for data and enforcement," PV Magazine, February 1, 2022, available at: https://pv-magazine-usa.com/2022/02/01/improving-interconnection-timelines-the-need-for-data-and-enforcement/.

23 St. John, Jeff, "Is ` vehicle-to-everything' charging ready for prime time?," Canary Media, April 27, 2022, available at: https://www.canarymedia.com/articles/ev-charging/is-vehicle-to-everything-charging-ready-for-prime-time.

**POLICY RECOMMENDATION**

**Design or apply appropriate rate structures to compensate on-board batteries and V2G.**

One challenge that state regulators and electric utilities face is how to structure or apply rates, such as Time-of-Use (TOU) rates and performance-based ratemaking to accommodate and facilitate the use of V2G-enabled EVs as grid resources. This includes fairly compensating EV owners or operators for their ability to discharge and export energy back to the grid. Grid operators or utilities, and state PUCs, should consider designing or applying rate structures to compensate mobile energy storage resources, or in other words, consider the applicability of performance-based or TOU rate structures. Relevant stakeholders should work together to address these rate issues.

When EVs are deployed as mobile energy storage assets, they can help with load management by supplementing or shifting periods of peak demand on the grid. TOU rates can be used to further shift hours of peak demand, referred to more technically as the "duck curve,"[24] and to send price or market signals that indicate the need for grid resources, which could be met through grid services provided by V2G-enabled EVs. In addition, V2G exports to the grid should be encouraged through compensation mechanisms that represent the full value stack, or collective revenue streams or benefits, that V2G offers. Electricity rate structures should also incent EV charging to occur during off-peak periods, when it will impact the grid the least.[25]

When policymakers and regulators fully consider the range of benefits that mobile energy storage units provide, they will be better able to determine optimal ways in which to treat and compensate these resources. The experience gained from the policy and regulatory processes regarding the treatment of stationary energy storage and other DERs can serve as models and offer parallels and lessons to facilitate mobile energy storage treatment and resource compensation. Results and knowledge gained from demonstrations and early deployment also will instill confidence, leading to more widespread V2G deployment.

In addition, electric utilities are encouraged

24 For more on the "duck curve," please see U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, "Confronting the Duck Curve: How to Address Over-Generation of Solar Energy," available at: https://www.energy.gov/eere/articles/confronting-duck-curve-how-address-over-generation-solar-energy.

25 EDF Report.

to consider incorporating V2G grid assets into their Integrated Resource Plans and other relevant planning processes.

**POLICY RECOMMENDATION**

**Conduct demonstrations, share lessons learned and best practices, and scale V2G technology.** Pilot or small-scale programs involving bidirectional vehicles and charging infrastructure are relatively easy to implement and can provide many lessons learned. However, pilots often lack cohesiveness and the ability to bring their cumulative impacts to bear and result in major change. Scaling up such efforts could also pose challenges for procurement and deployment. In other words, pilots are not a permanent solution to deployment issues.

To ensure V2G pilots have a substantial, even outsized, impact and truly contribute to the scaling up of V2G technology, more needs to be done to amplify their results. This includes ensuring they serve as proofs of concept for multiple stakeholders by further sharing best practices and lessons learned.

Underscoring the importance of such efforts, the first step of the aforementioned V2X MOU that the DOE and its partners signed in April 2022 is to focus on demonstrations and scenarios. Building on the resilience and security points emphasized in this report, having a greater number of future V2G use cases and demonstrations on using V2G-enabled EVs for resilience and back-up applications would create valuable opportunities to increase visibility and produce quantitative and qualitative results. This includes, for example, replacing back-up generators and/or functioning as a microgrid in homes, workplaces, and multi-unit dwellings.

Multiple pilot programs have already been deployed that take advantage of the additional revenue streams or cost-saving potential that V2G capabilities provide.

States and other relevant stakeholders are encouraged to consider the following steps:

- Begin by assessing V2G programs and pilots across the United States, if not globally.
- Demonstrate the need and value of V2G across different types of use cases in various parts of the country, including rural and urban settings, to highlight diverse and equitable applications.
- Conduct cost-benefit analyses as one way to support the value of V2G with concrete data.
- Disseminate best practices, benefits and value streams, and lessons learned from these demonstrations to facilitate V2G deployment going forward and to help overcome challenges encountered to date.
- Use positive results to help educate and gain the support of relevant federal, RTO, state, and local decision makers.
- Enhance communications and messaging efforts to amplify the benefits and value streams of V2G technology, tailoring messaging to different audiences.
- Work to scale V2G technology to a greater extent.
- Federal government agencies, such as the DOE, could play a role in streamlining and facilitating the aforementioned steps.

Appendix A contains case studies that highlight the need for and key successes of V2G, which could facilitate deployment on a broader scale. Disseminating the successes of V2G pilot projects and increasing the understanding of the benefits and value streams that EVs can provide when equipped with V2G capabilities will help more communities around the country access the benefits of V2G.

## Regional Transmission Organization Policy and Regulatory Recommendations

RTOs have differing market structures and requirements, which can contribute to the challenges facing V2G technology deployment. The treatment or classification of V2G as a grid resource within these regional power markets, at the wholesale versus retail levels, as well as associated compensation and rate structure issues could pose additional challenges.

On the other hand, RTO actions that facilitate grid services provided by V2G-enabled EVs could expedite the use of these resources in a range of situations. Doing so also has the potential to drive state PUCs to act in a manner that expedites V2G technology deployment. With this in mind, RTOs could consider acting on the following recommendations.

- **Develop or implement roadmaps that fully incorporate EV and EVSE V2G capabilities.** This will help RTOs better plan for the future and achieve greater consistency for improved interoperability.
- **Develop or revise RTO requirements to facilitate V2G deployment, including for grid services in wholesale markets.** This

recommendation would apply to the different types of markets, such as energy, capacity, and ancillary services markets.[26]

- **Conduct V2G grid impact studies as needed and disseminate results broadly.** Such studies would enable RTOs to better map the effects of V2G and mobile energy storage assets on the grid at the regional, if not also at the state level. For example, ISO-New England is seeking to incorporate V2G into some of its grid reliability study efforts, yet it recognizes the associated data and modeling limitations.[27] RTOs should consider collaborating with state PUCs and electric utilities when executing such studies.
- **Conduct inclusive, transparent, and cross-sectoral V2G stakeholder processes.** While recognizing that RTO stakeholder processes can be lengthy and cumbersome, their inclusive and transparent nature serves a vital function in ensuring policy and regulatory development consists of representatives covering a breadth and depth of affected entities. Here, RTOs are encouraged to involve relevant electric, transportation, and other industry or infrastructure sector representatives when advancing V2G-related policies or regulations.

26 Energy market: The sale or purchase of electricity to meet consumers' needs in real time or for the next day (i.e., "day-ahead"). Capacity market: Provide or purchase electricity to meet future, longer-term electricity needs. Source: PJM, Learning Center, available at: https://learn.pjm.com/three-priorities/buying-and-selling-energy.
Ancillary services market: Ancillary services help balance the system and ensure continued reliable operations (e.g., when a loss or increase of load or resources occur). An ancillary services market is for the "efficient acquisition and pricing" of ancillary service "products that are most beneficial to the system." Source: Webb, Jerry, "Ancillary Services Markets," Indiana Utility Regulatory Commission, Presentation, September 2007, available at: https://pubs.naruc.org/pub.cfm?id=5375186A-2354-D714-51D9-83D16B591C58.

27 Coste, Wayne, "Developing a GridView Flexible Electric Vehicle Charging Model, Future Grid Reliability Study," ISO New England, Presentation, February 26, 2021, available at https://www.iso-ne.com/static-assets/documents/2021/02/a03c_ev_penetration_and_modeling_2021_02_26.pdf.

# Conclusion

V2G technology is available today and the time to deploy it is now as the United States moves to a more electrified transportation future and the electric grid faces increasing natural- and human-caused threats. V2G technology offers substantial opportunities to help enhance critical infrastructure resilience and, in doing so, energy and national security, and much more. The solutions identified in this report—from federal and state incentives to national technical standards, improved regulatory treatment, enhanced planning and roadmaps, and expanded dissemination of pilot project results combined with broader and deeper education and outreach—will help overcome existing challenges and barriers to deployment to reap the benefits that this bidirectional charging technology offers. Political will and leadership are also often essential to advancing policies that will help unleash the vast benefits of this significant technological innovation.

# Appendix A: Case Studies

Promising V2G applications exist within both the light-duty and MHD EV sectors. An accelerated adoption of V2G, or bidirectional charging, technologies and policies will help maximize value to consumers and help enhance the reliability and resiliency of the electric system. For example, V2G capabilities can help manage system load and provide power back to the grid during times of need.

V2G technology also can help to accelerate the adoption of EVs by unlocking additional revenue, or value, streams. The resulting revenue can be reinvested into the purchase of additional EVs for fleet operators or provided back to the EV owner. Multiple V2G benefits and several promising use cases are already being explored through various pilot projects.[28] The following highlights from several of these pilots demonstrate several applications of V2G and the associated benefits.

### Roanoke Electric Cooperative V2G Pilot Project[29]


Photo credit: Fermata Energy. Photo is of Electronic Instrumentations Technology (EIT), Fermata testbed, Danville, VA (2019).

**Type of Vehicle:** Nissan Leaf passenger light-duty EV

**Short Project Summary**: Roanoke Electric Cooperative and Fermata Energy conducted a V2G pilot in North Carolina with a Nissan LEAF vehicle and Fermata Energy's bidirectional charger.[30] Clean Energy Works, a project partner, provided advisory services for accelerating investment in grid-edge solutions. The project assessed how V2G can be used to "determine the additional financial value of using the batteries on-board an electric vehicle when the car is parked at its home base," which also helped create value for Roanoke's member-owners.[31] This project also helped to provide power back to the grid during periods of peak demand, which Fermata Energy previously had demonstrated its bidirectional charger could accomplish. The project also aimed to help meet resilience needs.

**Key Results and Findings**: This pilot demonstrated additional value streams of V2G, helped manage load, and saved the utility and its ratepayers money. It also helped increase system resilience and efficiency. More specifically, this pilot reduced Roanoke Electric Cooperative's load by approximately 14 kW, on average, during demand reduction calls, and project utility savings of more

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

29 Cash, Cathy, "'Proving the Concept': Roanoke Electric Tests Innovative EV-to-Grid Charger," Cooperative.com, February 11, 2021, available at: https://www.cooperative.com/news/Pages/Roanoke-Electric-Tests-Innovative-EV-to-Grid-Charger.aspx.

30 Brodd, Kristi, "Roanoke Electric Cooperative to Pilot Cutting-Edge Vehicle-to-Grid Technology," Advanced Energy, November 30, 2020, available at: https://www.advancedenergy.org/2020/11/30/roanoke-electric-cooperative-to-pilot-cutting-edge-vehicle-to-grid-technology/.

31 Brodd, Kristi, "Roanoke Electric Cooperative to Pilot Cutting-Edge Vehicle-to-Grid Technology."

than $2,600 per year.[32] The pilot also had positive results on the resilience front: the V2G capability was proven to enhance resilience by providing the back-up power to Roanoke Electric's microgrid during the times when it was islanded from the grid.

### Beverly, Massachusetts Electric School Bus Pilot[33]


Photo credit: Proterra

**Type of Vehicle:** Electric School Buses (MHD EVs)
**Short Project Summary**: A Highland Electric school bus, built by Thomas and powered by a Proterra battery system, was deployed by the electric utility, National Grid, for a V2G pilot in Beverly, Massachusetts to help reduce peak demand. This is one of the first instances in which an electric school bus was used for this type of grid support with V2G.[34]
**Key Results and Findings**: Over the course of a summer, the electric school bus responded to 30 different demand response events.[35] Over 50 hours, the bus discharged approximately 3 MWh of electricity back to the grid, which is equivalent to the amount of electricity it takes to power 100 homes for one day.[36] [37] The electric school bus's ability to consistently discharge to the grid during summer periods of peak demand contributed to the program's success.[38]

### Durango, Colorado Electric School Bus V2G Deployment[39]


Photo credit: La Plata Energy Association

**Type of Vehicle**: Electric School Buses (MHD EVs)
**Short Project Summary**: In 2021, La Plata Energy Association (LPEA) teamed up with Blue Bird and Nuvve to deploy V2G electric school bus projects to help reduce peak demand and reduce overall total cost of ownership for the Durango School District. The project delivered one Blue Bird V2G capable Type C school bus and Nuvve's 60kW DC fast charger, with the ability to bidirectionally discharge energy to and from the electric grid. The bus is capable of discharging at a rate of 60kW back to the grid.
**Key Results and Findings**: LPEA saw the potential value of investing upfront and, co-wrote the grant and donated funds towards the Blue Bird bus and Nuvve V2G DC 60kW bidirectional charging station. The V2G system has been interconnected and tested as a demand response resource.

32 Susser, Jonathan and Real, Daniel, "Roanoke Electric Cooperative, Fermata Energy Show Promise of Vehicle-to-X Technology," Advanced Energy, October 5, 2021, available at: https://www.advancedenergy.org/2021/10/05/roanoke-electric-cooperative-fermata-energy-show-promise-of-vehicle-to-x-technology/.

33 "Beverly Massachusetts Electric School Buses Make V2G Energy Transfer History," Thomas Built Buses, November 19, 2021, available at: https://thomasbuiltbuses.com/resources/articles/beverly-massachusetts-electric-school-buses-make-v2g-energy-transfer-history/.

34 "Massachusetts Electric School Bus Helps Power Electricity Grid in Breakthrough for Vehicle-to-Grid Technology," Proterra, October 13, 2021, available at: https://www.proterra.com/press-release/massachusetts-electric-school-bus/?fbclid=IwAR0JRTK1q45-5ad9_KivdXwb3XgyVyqPtSY54XhybvkkI1XC1olawbvqFko.

35 Ibid.

36 Ibid.

37 "Beverly Massachusetts Electric School Buses Make V2G Energy Transfer History," Thomas Built Buses.

38 Runyon, Jennifer, "Massachusetts school bus shaves peak demand in first V2G program for district," Renewable Energy World, October 19, 2021, available at: https://www.renewableenergyworld.com/storage/massachusetts-school-bus-shaves-peak-demand-in-first-v2g-program-for-district/.

39 "Nuvve and Colorado/West Equipment Deploy First V2G Electric School Bus Solution in Colorado," Nuvve, December 16, 2021, available at: https://nuvve.com/nuvve-and-colorado-west-deploy-first-v2g-electric-school-bus-solution-in-colorado.

## Highland Electric Fleets-Montgomery County Electric School Bus V2G Resilience Pilot[40]


Photo credit: Proterra

**Type of Vehicle**: Electric School Buses (MHD EVs)
**Short Project Summary**: The Montgomery County Public School system in Maryland partnered with Highland Electric Fleets using buses from Thomas Built, powered by Proterra's electric bus technology, and others to initiate a procurement of 326 electric school buses over four years, making this the largest electric school bus procurement in North America, at that time.[41] The buses' V2G capabilities are helping to support managed charging and grid resilience as well as offset fleet costs.
**Key Results and Findings**: The buses' V2G capabilities are providing grid services, including support for managed charging and grid resilience, as well as offsetting the costs of electrifying the fleet and the charging infrastructure.[42]

## Nuvve-SDG&E V2G School Bus Pilot[43]


Photo credit: San Diego Gas & Electric

**Type of Vehicle**: Electric School Buses (MHD EVs)
**Short Project Summary**: Nuvve worked with San Diego Gas & Electric (SDG&E) in California to interconnect bidirectional electric buses in three school districts for participation in California's summer Emergency Load Reduction Program (ELRP).[44] The electric school buses were provided by the Lion Electric Company and Blue Bird Corporation. This program builds on traditional demand response structures by adding a mechanism for utilities to compensate behind-the-meter resources that export energy when the California grid operator (CAISO) issues a grid alert.
**Key Results and Findings**: The V2G buses will participate in SDG&E's ELRP in the Summer of 2022. The ELRP compensates V2G experts at $2.00/kWh for a minimum of 30 hours and up to 60 hours per summer season (May – October).[45]

40 "Montgomery County Public Schools approves the nation's largest procurement of electric school buses with Highland Electric Transportation," Thomas Built Buses, February 25, 2021, available at: https://thomasbuiltbuses.com/resources/news/montgomery-county-public-schools-approves-the-2021-02-25/.

41 Irvin, Ken and Irvin, Chet, "V2G's Next Frontier: Modeling the Success of Electric Bus Batteries with Tractors," T&D World, May 7, 2021, available at: https://www.tdworld.com/electrification/article/21163578/v2gs-next-frontier-modeling-the-success-of-electric-bus-batteries-with-tractors?msclkid=774307fbae-c211ec9f5952172476d57e.

42 Ibid.

43 "Vehicle-to-Grid Pilot: Leveraging Big Batteries on Electric School Buses to Support the Grid," SDGE, April 21, 2021, available at: https://www.sdgenews.com/article/vehicle-grid-pilot-leveraging-big-batteries-electric-school-buses-support-grid.

44 Ibid.

45 "Emergency Load Reduction Program: Get paid for reducing your energy," SDGE, accessed June 8, 2022, available at: https://www.sdge.com/emergency-load-reduction

# Appendix B: Policy Accomplishments

Following are federal V2G policy accomplishments to date designed to help advance V2G capabilities.

## V2G Policies in IIJA

IIJA contains the following V2G federal policies. These policies are among the first that seek to facilitate and expedite the deployment of V2G capabilities and represent major progress for unlocking V2G value streams.

- **Surface Transportation Block Grant Program (Section 11109)**: Installation of EV charging infrastructure and V2G infrastructure are specifically included in this multi-billion-dollar Program.[46]
- **Grants for Charging and Fueling Infrastructure (Section 11401)**: V2G is one of the factors applicants must demonstrate they have considered when applying for these grants.[47]
- **Smart Grid Investment Grants or "Deployment of Technologies to Enhance Grid Flexibility" (Section 40107)**: V2G is explicitly included in this DOE grid modernization program, which provides $3.5 billion for smart grid technologies including V2G.[48]
- **Study of Codes and Standards for Use of Energy Storage Systems Across Sectors (Section 40111)**: The study aims to examine types and commercial applications of codes and standards applied to stationary and mobile energy storage to identify barriers, foster collaboration, and enhance uniformity; it will also analyze use cases, including V2G integration.[49]
- **National Electric Vehicle Formula Program**: V2G is specifically incorporated into this program that provides $5 billion to establish National EV Charging Corridors in that, when developing guidance for this program, DOT and DOE must consider V2G integration among other factors.[50]
- **Joint Office of Energy and Transportation**: One of the specific roles of this new office to be run jointly by the DOE and DOT is to plan, coordinate, and implement technical assistance on V2G issues.[51]

## V2G Policy in Pending Federal Legislation

The following provision is part of the tax portion of the Budget Reconciliation infrastructure package that passed the U.S. House of Representatives in late 2021. The energy tax provisions are among the measures that remain viable to ultimately become law.

- **Alternative Fuel and Refueling Property (Section 30C) Tax Credit**: V2G, or bidirectional charging, capability has been added to the definition of EV charging infrastructure in this tax credit, also known as the Section 30C credit. If enacted, this credit would not only help defray the up-front cost of EV charging infrastructure but would also help cover the additional cost of incorporating bidirectional charging capability.

46 *Infrastructure Investment and Jobs Act (IIJA)*, Public Law 117-58, Section 11109, p. 34, 117th Congress, November 15, 2021, available at: https://www.congress.gov/117/plaws/publ58/PLAW-117publ58.pdf.

47 IIJA, Section 11401, p. 120: ". . . infrastructure installation that can be responsive to technology advancements, such as accommodating autonomous vehicles, vehicle-to-grid technology, and future charging methods."

48 IIJA, Section 40107, p. 513.

49 IIJA, Section 40111, p. 518.

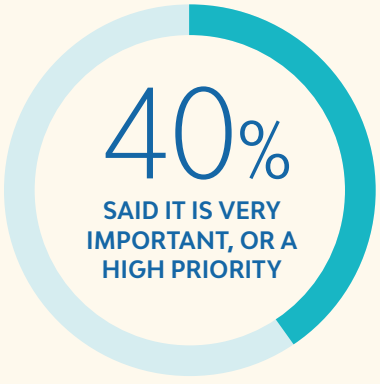
50 IIJA, Title VIII, U.S. Department of Transportation Appropriations, p. 995. Within this Title, there is $5 billion for a National Electric Vehicle Formula Program.

51 IIJA, Title VIII, U.S. Department of Transportation Appropriations, p. 997.

# Appendix C: V2G Survey Results

SAFE and the EC polled the participants in their V2G Roundtable on two telling questions about V2G viability and timing. The results are as follows:

**In terms of V2G's degree of importance to the participants and their organizations:**





**In terms of the length of time it will take to get V2G deployed on a more widespread commercial scale, for example, 50 percent or more of electric vehicles, fleets, or buses:**

# Appendix D: V2G Roundtable Participants

ABB

American Public Power Association (APPA

AMPLY

Arrival Ltd

California Energy Commission

Clean Energy Works

Consolidated Edison, Inc

Cox Automotive

DTE Energy

Edison Electric Institute

Energy Storage Association

EVGo, Inc.

Federal Energy Regulatory Commission

FedEx Corporation

Fermata Energy

Ford Motor Company

Francis Energy

The General Motors Company

Highland Electric Fleets

Kia Corporation

Krevat Energy Innovations

The Lion Electric Company

LS Power

National Association of Regulatory Utility Commissioners

National Electrical Manufacturers Association (NEMA)

Nestlé USA

Nuvve

Parsons Corporation

PJM Interconnection LLC

Proterra

Regulatory Assistance Project

Rhombus Energy Solutions, Inc.

Rivian Automotive, Inc.

Roanoke Electric Cooperative

ROUSH CleanTech

Ryder System, Inc.

SAFE's Energy Security Leadership Council

Schneider Electric USA

Shell Recharge Solutions (Greenlots)

Sustainable Capital Advisors

The University of California, Davis

The University of Delaware

Vehicle-Grid Integration Council

Volkswagen Group of America, Inc.

SAFE

SAFE is a nonpartisan, nonprofit organization committed to strengthening U.S. energy, economic, and national security by advancing transformative transportation and mobility technologies and ensuring that the United States secures key aspects of the technology supply chain to achieve and maintain its global strategic advantage. The transition to a more electrified transportation future calls for a more resilient, reliable, and secure electric grid, which is the focus of SAFE's Grid Security Project.

Electrification Coalition

The Electrification Coalition is a nonpartisan, nonprofit organization that advances policies and actions to facilitate widespread adoption of plug-in electric vehicles in order to overcome the economic, public health, and national security challenges that stem from U.S. oil dependence.

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