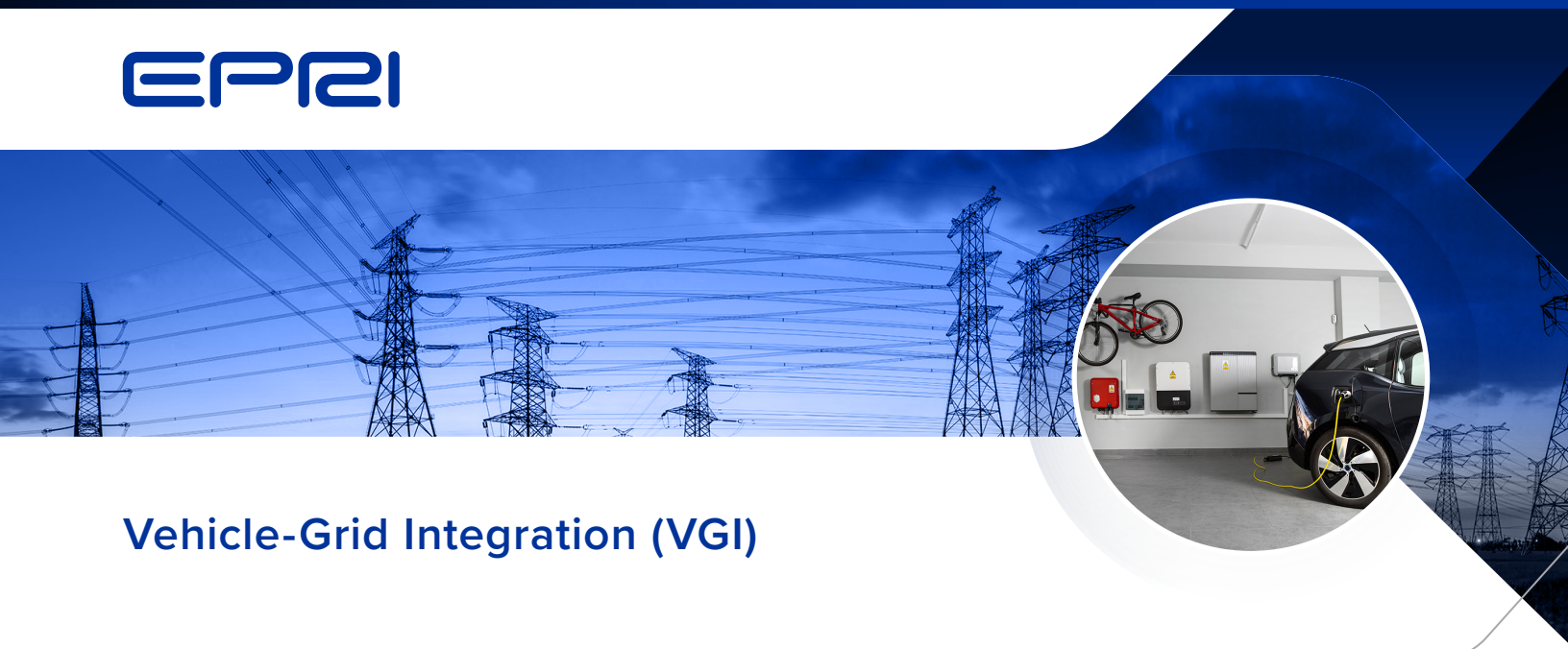

Vehicle-Grid Integration (VGI)

INTRODUCTION

Since 2010, there have been almost 5 million electric vehicles sold in the U.S. This constitutes 16 TWhs annual energy consumption—approximately 0.4 % of electricity used annually in the U.S. At the scale at which EV adoption is increasing, the transportation sector will depend more and more on the electric grid for increasingly clean and reliable sources of electricity, creating both a challenge and opportunity for the industry. Studies such as the Kevala study estimates that it could take ~$50 billion in grid infrastructure investments to prepare grids for just Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E) alone Investments at this scale will translate into decreased energy affordability for consumers. The use of electric vehicle technology as a grid resource, usually called vehicle grid integration (VGI) could prove to a valuable solution to the energy affordability challenges designing the grid to accommodate the approximately 30 million vehicles projected to be on U.S. roads by 2030.

WHAT IS VEHICLE-GRID INTEGRATION?

Vehicle-Grid Integration (VGI) presents a suite of tools for utilities to integrate and connect electric vehicles (EVs) to the grid. VGI solutions offer the potential to optimize grid operations by reducing stress during peak demand periods—minimizing the need for dispatching generation during peak energy times, potentially deferring the need to invest in utility infrastructure, and being used in a manner that reduces energy consumption at certain times mitigating power outages. Furthermore, VGI can facilitate the integration of renewable energy sources while minimizing both energy costs and emissions intensity. See Figure 1. These solutions can either be products and solutions that help optimize the charging of electric vehicles (labeled V1G figure) or require power to flow to and from an electric vehicle (often called vehicle-to-X or V2X).

The concept of utilizing electric vehicle (EV) technology as a grid resource is not new. For over two decades, industry leaders like EPRI have been exploring, developing, and deploying VGI solutions. However, initial efforts primarily focused on establishing technical feasibility through proof-concept demonstration activities. The industry is now actively seeking VGI solutions that can both enable energy affordability and enhance grid resilience in areas of rapid technology change.

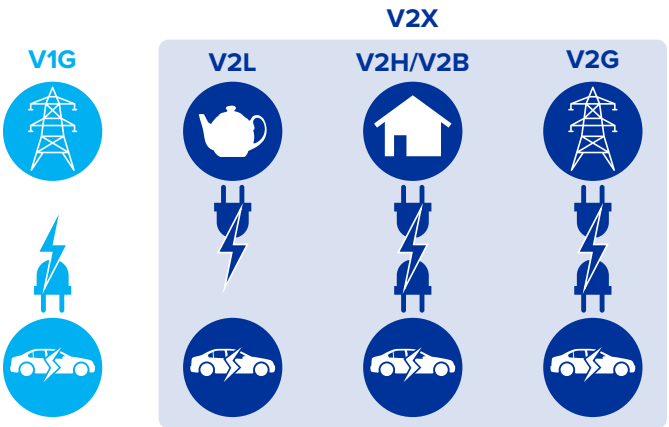

Figure 1 Vehicle-Grid Integration offerings

HOW ARE UTILITIES APPLYING THESE TOOLS?

VGI solutions are consistently evolving technologies and tools to potentially help support an affordable and reliable energy system. These tools include, but are not limited to:

- Energy management programs that incentivize EV owners to charge at certain times. Examples include demand response programs that could reduce generation need.
- Smart charging infrastructure that potentially manages a customer vehicle's charging to defer building, campus, or electrical infrastructure needs.
- Because V2X technologies enable bi-directional power flow to and from the vehicle, batteries inherently found in EVs could potentially be used to provide backup power to a community or building during an outage.
- Energy costs based on the time of day such as time-of-use (TOU) or other programs that encourage charging during periods of high renewable energy generation.
- Other charging infrastructure programs where smart charging and VGI solutions is used to buy down the total cost of ownership of electric vehicles and charging infrastructure needed.

EPRI recently investigated utility offerings for VGI programs and found that roughly 15% of electric vehicles in the United States participate in some form of utility VGI program, encompassing a variety of pilots, demonstrations, and established offerings (as of July 2023). This translates to approximately 700,000 EVs contributing 2.5 TWh of flexible load to the grid, according to EPRI estimates. While significant, this participation rate also highlights the substantial untapped potential. To evaluate and catalyze this industry, EPRI has and is working with key industry stakeholders to assess, evaluate, and scale VGI solutions that could lower the cost and increase the resiliency of the infrastructure needed to support transportation electrification. These activities include:

INNOVATION

EPRI has been working for over 20 years on work looking at developing and demonstrating advanced technologies and solutions that show how vehicles can be used as grid resources. Starting in 2012, the Open Vehicle to Grid Integration Platform (OVGIP) has and is working with utilities and many of the major global automotive manufacturers to develop standards-based methods for utilities and OEMs to work together to enable scalable VGI solutions. Other technology advancements such as the development of vehicle to building-enabling technology for home energy management shows how the batteries in vehicles can work alongside other technologies and distributed energy resources (DER) to enhance a building's resiliency against and during power outages.

EVALUATION

In an area of rapid technology change, EPRI evaluates the performance of emerging technologies and approaches through demonstration and implementation activities—understanding how these technologies perform. For example, EPRI recently evaluated an emerging vehicle to building product for performance and safety for a range of use cases. EPRI also works with technology leaders to understand how an electric vehicle's battery may be impacted by increased charging and discharging associated with enabling VGI solutions. EPRI has built sectoral expertise to be able to evaluate the impact of emerging technologies to support vehicle charging needs—incorporating these results into applicable codes and standards, utility programs, and grid planning and operation practices.

INSIGHTS

The VGI industry is an ever-evolving industry that involves a variety of stakeholders. This makes it challenging for industry decision makers on better ways to contextualize outside information and reports in action plans. Providing insights into the decarbonization potential of VGI solutions as well as proposing how VGI are and can be used as ways to provide new programs and services to customers.

COLLABORATION

Through its 35 years of collaboration with utilities, auto makers, and technology providers, EPRI has developed a repository of tools, reports, and other ways the industry can gain information into the current state of VGI solutions, technologies, industry standards, and programs. It develops forums for information sharing across automotive, charging, and other industries via EPRI's Infrastructure Working Council, industry events such as Electrification 2024, and utility collaboration opportunities such as the Electric Transportation Program to help inform stakeholders on advancements in VGI.

APPLICATION

Electric utilities are looking to better understand how best to apply technology advancements into their current and future planning, operation, and management practices with the hopes of maintaining affordability and reliability of the grid. In 2023, EPRI completed two projects—one looking at current practices integrating EV and electric vehicle supply equipment (EVSE) into utility distributed energy resource management systems (DERMS) and another on investigating how utilities are thinking about including demand flexibility solutions like VGI into its planning practices.

STANDARDIZATION

Standards-based approaches are a method to enabling scalable VGI solutions reliability and affordably. EPRI continues to work with standards organizations such as IEEE, ISO, and SAE to harmonize and updates standards—considering current and emerging VGI approaches. It is currently working with the industry to update California's DER interconnection standards considering VGI.

REFERENCES

(1) Electric Power Research Institute. "Overview." Accessed October 1, 2024. https://www.epri.com/research/programs/053122/overview.

(2) U.S. Energy Information Administration. "Use of Electricity." Last modified October 2, 2023. https://www.eia.gov/energyexplained/electricity/use-of-electricity.php.

(3) California Public Utilities Commission. "2022-2023 Wildfire Mitigation Plan Update." Accessed October 7, 2024. https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M508/K423/508423247.PDF.

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