To: The U.S. Department of Energy's Vehicle Technologies Office (EERE) and the Advanced Grid Research and Development Division (OE).

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Re: Comments from the GridWise Alliance on the Request for Information (DE-FOA-0002528) on Integrating Electric Vehicles onto the Electric Grid

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The GridWise Alliance (GridWise) is pleased to submit this response to the Request for Information (RFI) recently issued seeking guidance for integrating electric vehicles (EVs) onto the electric grid. GridWise commends you for soliciting stakeholder input in this regard.

The mission of GridWise is to champion the principles, policies, and investments needed to transform the electricity grid by understanding the diverse perspectives and priorities of all stakeholders. Since 2003, GridWise uniquely serves the electricity industry by leveraging diverse stakeholder perspectives to articulate the numerous benefits of grid modernization. We help create a common understanding of the numerous and transformational operations-focused and policy-related changes taking place across the electricity industry and our members include investor-owned utilities, municipal utilities, rural cooperative utilities, grid equipment manufactures and technology companies, vendors, national laboratory and research institutions, and others.

Due to our diverse membership, GridWise is well positioned to provide feedback on EV integration to the grid. Indeed, in 2018 GridWise published a report[1] to advance the understanding of transportation electrification given the interdependent relationship between consumers, these vehicles, the grid, and charging infrastructure. We encourage DOE to review this resource, in which GridWise articulates the range of benefits EVs offer consumers and society, describes challenges to the rapid adoption of EVs, and proposes possible approaches to overcoming said challenges. It is important to not only recognize the need to ensure that adequate charging infrastructure exists to drive consumer confidence, but also that the electric system must be able to manage the resulting load in a way that meets consumer demands and ensures continued reliable, resilient, affordable, and secure electricity delivery to all.

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[1] GridWise Alliance. *EVs – Driving Adoption, Capturing Benefits*. July 2018. https://www.gridwise.org/resource-downloads/GWA_18_EVs-DrivingAdoptionCapturingBenefits_Final.pdf

As you also work with other key stakeholders in this process, we encourage you to consider the following insights and resources. As requested, we have identified the category each point relates to using the numbering convention provided in the RFI.

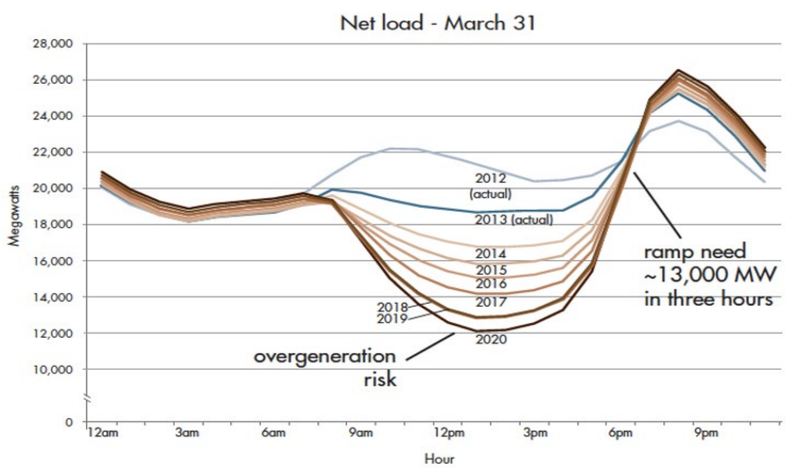
GridWise stands ready to be a resource to you and your colleagues and looks forward to continuing to work to modernize and integrate electric vehicles into the grid.

1. **Electric vehicle integration needs are highly dependent on unique grid conditions across regions. (Category 1)**

First, there is no single approach to integrating electric vehicles while maintaining the reliability of the electric grid. Regions across the United States have significantly different circumstances that will call for various means and methods for EV grid integration. For example, regions with existing high reliability, ample capacity, and low EV penetrations will look significantly different from regions with existing reliability challenges, tight capacity, and/or higher EV penetrations.

The famous California 'duck curve' (Figure 1) illustrates the load profile of one region and provides insight into one challenge the grid faces with EV integration. In Figure 1, solar generation peaks during the day, creating a period over-generation. As the sun sets, the need for non-solar power rises dramatically in the early evening. Current EV usage trend data show that most charging occurs at home, with owners plugging in their vehicles when they arrive home from work. If many electric vehicles are added to the grid in an uncontrolled manner, the added EV charging load will exacerbate the steep demand on the grid for electricity between 6-9 PM.

Figure 1. The 'Duck Curve' Illustrating Daily Electricity Demand in California[2]



[2] California ISO. *What the duck curve tells us about managing a green grid*. 2016. https://www.caiso.com/Pages/DocumentsByGroup.aspx?Group=FlexibleResourcesHelpRenewables_FastFacts.pdf/

However other states and regions have different capacity and load conditions and therefore their approaches to optimizing EV charging are designed for their particular needs. This means that grid operators, system planners, and policymakers need to be sensitive to regional variations. Identifying variables that contribute to differing grid circumstances (such as rate of EV adoption, DER generation profiles, local weather patterns, current and projected customer load patterns, etc.) and then understanding different technologies and services that may be needed to reliably integrate electric vehicles is key.

2. EV grid integration methods range from simple to complex (Category 1 and Category 3)

Given that regions across the country will encounter different challenges related to integrating EVs to the grid, a suite of approaches, technologies, software, and service offerings is needed. GridWise members are deeply familiar with these solutions and recognize that the ability to view, communicate, and control EVs as both a load sink and a dispatchable resource will grow in importance over time as EV numbers increase in the U.S.

These integration methods range in level of complexity, with some being relatively simple while others are more complex. Grid-optimized charging (V1G) is one such simple solution. When enabled, V1G works by charging vehicles when there is readily available capacity on the grid. As PNNL found in their recent study Electric Vehicles at Scale – Phase I Analysis: High EV Adoption Impacts on the Western U.S. Power Grid, *"Under a high-penetration scenario … we are not expecting resource adequacy issues. … EV resource adequacy can be doubled with managed charging strategies."* V1G can be relatively cost-effectively and simply implemented through time-of-use rates and other time-managed charging approaches, and has multiple benefits to both customers and the grid. Not only does this allow grid operators to charge vehicles at times that lower grid costs and optimize efficient generation use (such as reducing renewable curtailment and the need to turn on certain generation reserves), it also allows EV owners to save on their electric bill. Further, better utilization of the grid benefits all customers by placing downward pressure on rates.

Another solution involves vehicle-to-grid (V2G) connection where vehicles plugged into the grid can be used as storage devices, and provide power and other grid services back to the grid when needed. This type of arrangement is used in parts of Europe and Asia; however, some experts say the U.S. is still years away from widespread use of V2G. While a few utilities are beginning to test V2G implementation with pilot programs, there are still safety and engineering concerns to be addressed, technical problems to solve, and business cases to study.[3] Further, many jurisdictions have not addressed operating procedures and compensation models for V2G participants and ensuring utilities are fairly compensated for usage of the grid. These will be important considerations and shape the development and participation of permanent V2G programs. Two sample pilots are included below:

[3] Utility Dive. *2021 Outlook: The future of electric vehicle charging is bidirectional — but the future isn't here yet.* January 12, 2021. https://www.utilitydive.com/news/2021-outlook-the-future-of-electric-vehicle-charging-is-bidirectional-bu/592957/

- *Where:* New York. *What*: Con Edison partnering with e-bus provider Lion Electric to use electric school bus batteries to provide power to the grid at night.[4]
- *Where*: North Carolina. *What*: Duke Energy installing and owning 280 charging stations and replacing 30 diesel buses with electric buses for school district use.[5]

There is also interest in using EV batteries to serve other loads with V2G capabilities.

One tool for V2G integration for the purpose of providing grid services is Integrated Volt-Var Optimization (IVVO) software. This software can help manage distributed energy resources and can leverage smart inverters for reactive power compensation on the grid. IVVO provides recommendations to improve voltage quality, manage demand, and provide reactive support to the surrounding distribution system, and fully considers the voltage profiles that DERs can generate. IVVO models the dynamic nature of smart inverters as an input to the power analysis suite which enables IVVO to make use of this information. Deployment of IVVO software can also increase the available capacity of the network for supporting DERs in situations where voltage profiles would otherwise limit their deployment. By being able to dynamically adapt the network to accommodate voltage variations due to variable DER output, more DERs can be hosted than would otherwise have been possible without lengthy and costly reinforcement.

3. **Broad adoption of a unified communication standard is pivotal to enable V2G functionality (Category 3 and Category 4)**

To facilitate V2G functionality, execution commands need to be sent over a common communications protocol to communicate with and coordinate electric vehicle loads.

The IEEE Standard for Smart Energy Profile Application Protocol (IEEE 2030.5)[6] has been chosen by leading utilities as the standard communication protocol for connecting DERs to the smart grid. IEEE 2030.5 is the most advanced industry standard to interconnect to DERs – either single DERs, groups of DERs, or directly to aggregators. It builds on all existing standards (CIM, https, etc.) to provide a comprehensive data model and the ability to securely connect over the Internet to reach even the smallest, most granular DERs, including residential EVs. Smart inverters, discussed in the last section, are required to connect dispatchable EVs to the grid and are required to support IEEE 2030.5, among other standards (IEEE 1815 [DNP3], or SunSpec Modbus).

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[4] Con Edison. *Con Edison Test Driving E-school Buses Toward Improved Reliability and Cleaner Air.* December 10, 2020. https://www.coned.com/en/about-us/media-center/news/20201210/con-edison-test-driving-e-school-buses-toward-improved-reliability-and-cleaner-air

[5] Robert Walton. Utility Dive. *North Carolina OKs Duke's scaled-down $25M EV pilot.* December 1, 2020. https://www.utilitydive.com/news/north-carolina-oks-dukes-scaled-down-25m-ev-pilot-as-experts-see-momentu/589845/

[6] IEEE Standards Association. *IEEE 2030.5-2018 – IEEE Standard for Smart Energy Profile Application Protocol.* https://standards.ieee.org/standard/2030_5-2018.html

Given that EVs belong to the EV owner, and not the utility, it is important that a V2G communication protocol enables a full awareness of contractual operational constraints between an owner, aggregator, or grid operator (e.g., max number of times the DER can be dispatched per day/week/month, max ramp-up time, minimum advanced notice period before a dispatch, etc.). IEEE 2030.5 is well suited to meet both the needs of grid operators in controlling EV charge/discharge and any predetermined requirements or restrictions set by the EV owner. This is because it has been designed with a very rich data model to fully represent all DER parameters throughout their lifecycle while also enabling distribution utilities to interconnect to all DERs – big, small or aggregated. Operators are able to have a drill-down view, at any voltage level, of all DERs, along with their status, monitoring and availability for control (max kW, max kVar, power factor, local control modes). Under IEEE 2030.5 operators can perform dispatch for any single or group of DERs (per region, substation, feeder), all while fully respecting the contracts that prosumers signed up for.

EV manufacturers have also embraced the use of IEEE 2030.5 as evidenced by its inclusion in SAE J3072. The use of IEEE 2030.5 for managing EV charging, discharging, and other services (e.g., voltage and frequency regulation) allows EVs to be treated much like any other customer-owned DER. Further, the use of a global standard such as IEEE 2030.5 will ensure there are not interoperability issues across jurisdictional and utility boundaries. As mobile DERs, EVs naturally move across state lines and utility service territories and therefore it is critical to have consistent standards for communications across state and utility boundaries. There is also work underway to develop a testing and certification program specifically aimed at the use of IEEE 2030.5 in EVs, much like the CSIP that was developed in California for the testing and certification of DER using IEEE 2030.5.

A large challenge currently in the communication protocol space as it relates to vehicle to grid integration involves widespread adoption of the IEEE 2030.5 standard. In order to implement V2G functionality (and support DER orchestration more generally) grid operators would need to upgrade their control room software to be compliant with the IEEE 2030.5 standard.

Likewise, EV manufacturers would need to incorporate the standard into all EVs to ensure V2G communications interoperability across jurisdictional and utility boundaries. Ongoing work of SAE J3072 in recognizing IEEE 2030.5 for V2X communications and coordination is a promising start in the area.[7]

[7] SAE International. *SAE International Releases Updates for Two Major Electric Vehicle Charging Documents.* April 06, 2021. https://www.sae.org/news/press-room/2021/04/sae-international-releases-updates-for-two-major-electric-vehicle-charging-documents

4. Role of modeling and forecasting at both disaggregated and broader system levels (Category 3)

Because of regional differences, multiple applicable technologies, and varying levels of complexity, improved forecasting and modeling are needed for V2G integration at both disaggregated and system levels.

At the disaggregated level, forecasts for the impact of EVs are useful for real-time management. Already, distribution grid operators forecast load and intermittent generation for all entities on their grid. With increasing amounts of EVs connecting to the grid, utilities will need to continue to refine their forecasting, such as by reconfiguring their software to apply EV demand forecasting at different aggregation levels on their networks (including feeder and substation levels). This type of real-time situational awareness and coordinated control of generation assets and load is required to ensure the net load on any distribution asset will not exceed the thermal capacity or control loop response time of upstream equipment and ensure efficient grid operation.

Hierarchical, distributed control and grid edge analytics are needed in order to begin *predicting* customer behavior and load shapes with respect to local weather patterns and other external factors that require response times faster than a centralized control scheme can facilitate. One NREL report studied this issue, and found that there are strategies, based on data collection from AMI and sensors, that can make control decisions that improve grid quality, ensure reliability, and optimize energy management.[8]

Traditional use cases for demand response focus on the bulk generation and transmission systems, making use of the collective footprint of controllable loads to have an effect on extreme weather days. Effective use of V2G technologies could allow for deferral of distribution infrastructure upgrades by utilizing distributed sensing and control to create precise demand response events where they are most needed.[9] This allows the utility to get exactly the resources that are needed, when they are needed, without overpaying for demand response for circuits that are not affected.

Part of this necessary disaggregated system forecasting includes look-ahead power flow analysis. This type of analysis anticipates potential violations in the near future days and hours. These potential upcoming violations can then be reviewed based on time, grid location, type, and severity, at which point the grid operator can drill down and work out solutions in advance. These types of activities will be critical to managing the grid as more EVs are connected.

Getting forecasting right also involves considering the types of chargers and hosting capacity of the network. Medium- and heavy-duty vehicles (MHDV) and direct current fast chargers (DCFC) chargers have very different infrastructure and make-ready requirements than light-duty

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[8] NREL. *Multi-Lab EV Smart Grid Integration Study.* https://www.nrel.gov/docs/fy15osti/63963.pdf

[9] S. Kamboj, W. Kempton, and K. S. Decker. *Deploying Power Grid-Integrated Electric Vehicles as a Multiagent System.* Proc. of 10th International Conference on Autonomous Agents and Multiagent Systems 1 (2011): 13–20

vehicle (LDV) Level 2 chargers. While most focus has been on deployment of Level 2 chargers, their impact on the grid is minimal compared to the impact of Level 3/DCFC or MHDV, which may need to charge at MW type of levels and could have implications on transmission infrastructure.[10]

EV grid integration is not just a distribution issue -- when charging needs and decarbonization goals at scale are considered, a least cost solution with a smaller environmental impact could be a larger-scale solution, such as building out transmission. Thus, system level modeling and long-term planning is another key component to further evaluate.

As one example, consider New York, where transmission owners are currently moving forward with transmission and distribution upgrades to address the State's Climate Leadership and Community Protection Act (CLCPA) mandates, which require 70% of power in electric generation sector to come from renewable sources by 2030 goal. National Grid will be upgrading over 1,000 circuit miles of transmission across its Upstate NY service area to unbottle current and planned renewable generation and ensure delivery to customers. Concurrently considering fleet and public charging needs during this process could support the CLCPA goals, while also preemptively addressing infrastructure needs due to EVs. A similar approach could be taken to build transmission to accommodate current and future DCFC and MHDV loads along highways and large clusters of electrifying fleets.

Another example is in considering the overall electricity demand of a region. As more vehicles are electrified and electricity demand increases, it's possible that some regions could become winter peaking systems due to the reduced range of lithium ion batteries in cold temperatures. This type of broad system shift needs further research, as it will significantly affect grid operators in those regions.

5. Cybersecurity considerations (Category 5)

Cybersecurity conversations must be a key feature of integrating EVs to the grid. Cyberattacks have significant consequences in the physical world, as seen with the recent Colonial Pipeline attack, and there are several unique challenges related to cybersecurity for vehicle to grid integration. These challenges include:

- EVs needing to be designed to operate with a consumer's firewall with no intervention;
- Ensuring that the EV owner's link into the grid is secure from attacks nor a source of insecurity or hostility to the grid;
- Lack of physical protection from hostile entry; and
- Longevity of devices that are connecting to the system.

[10] National Grid and Hitachi ABB Power Grids include further information and a detailed report in their independent responses to this RFI, discussing the potential impacts of fleet MHDV charging on electric networks and recommendations to support long-term, large-scale vehicle electrification. Please refer to their RFI submissions on this.

A focus on cybersecurity responsibilities should rest first with automaker and vehicles – these will be increasingly connected and are the real control point for charging activities. Note as well that not all charging needs to be networked into the grid. Home charges are a good example of this. If chargers aren't networked, then an avenue of potential attack is removed, and there are fewer cybersecurity threats to address. Chargers that are networked will need to comply with cybersecurity requirements.

In terms of potential approaches to ensuring secure vehicle to grid integration, the IEEE 2030.5 standard has undergone a number of cybersecurity reviews and has been found to be more than adequate.[11] It uses modern, widely adopted cybersecurity protocols and includes the following features:

- Uses TLS 1.2 (the same security protocol used and proven throughout the Internet, including banking);
- Has mandatory ECC cipher suite for interoperability (ECDHE – NIST Suite B);
- Requires all devices have certificates and secures transactions through the use of certificates provided by a vetted PKI;
- Has registration tied to certificate hash (bidirectional verification); and
- Facilitates end-to-end security

[11] Sandia National Laboratories. *Recommendations for Trust and Encryption in DER Interoperability Standards.* February 2019. https://www.osti.gov/servlets/purl/1761841.
Also see IEEE 2030.5 is included in the Catalog of Standards which implies it passed a security review by SEPA/SGIP and NIST: https://sepapower.org/knowledge/catalog-of-standards/catalog-of-standards-complete-list-of-entries/.