DOE Vehicle Technology Office and Advanced Grid Research and Development Division Response to RFI #DE-FOA-0002528

To: DOE Vehicle Technology Office and Advanced Grid Research and Development Division

From: Vehicle-Grid Integration Council,
with support from the following organizations:

Leadership Circle Members:
- *American Honda Motor Co., Inc.*
- *Enel X North America, Inc.*
- *Ford Motor Company*
- *General Motors Company*
- *Nissan*
- *Nuvve Corporation*
- *Stellantis N.V.*
- *Toyota Motor North America, Inc.*

General Members:
- *dcbel*
- *Fermata Energy*
- *The Mobility House*
- *Veloce Energy, Inc.*

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Executive Summary

Vehicle-Grid Integration:
Unlocking EVs as a Strategic Grid Resource

Vehicle-grid integration represents a unique opportunity for the DOE to establish and advance US leadership at the intersection of a decarbonized transportation and electric sector by ensuring the value from electric vehicle deployment and flexible electric vehicle charging is recognized and compensated in support of reliability, affordability, and efficiency.

The Vehicle-Grid Integration Council ("VGIC") is a 501(c)(6) membership-based advocacy group committed to advancing the role of electric vehicles ("EVs") and vehicle-grid integration ("VGI") through policy development, education, outreach, and research. VGIC supports the transition to a decarbonized transportation and electric sector by ensuring the value from EV deployments and flexible EV charging and discharging is recognized and compensated in support of achieving a more reliable, affordable, and efficient electric grid. Scaling VGI will help accomplish the following public policy goals:

- **Benefit drivers** by reducing the cost of ownership.
- **Decarbonize the transportation sector** by accelerating EV adoption.
- **Support decarbonization of the power sector** by providing essential grid services as renewable energy penetration increases.
- **Increase affordability** by reducing electricity bills for all customers.
- **Improve grid resiliency** and security during extreme weather events.
- **Foster economic activity** through innovation, competition, and market transformation.

With federal support, we believe this vision could become a reality and that EV drivers and owners across the United States can take part in the acceleration of both transportation electrification and grid decarbonization. **Our vision for VGI encompasses the following key elements:**

- **Ensure customer mobility needs are satisfied.** Drivers will be able to participate in a wide variety of VGI services, nationwide, without compromising their mobility needs.
- **Managed charging will provide benefits to EV drivers**: Drivers in every state will be given the choice to align charging with the times of day when electricity prices are low, reducing operating costs by 50% compared to unmanaged charging. Lowering the total cost of ownership will help to accelerate overall EV adoption by drivers and fleet managers.
- **EVs provide emissions-free emergency power during blackouts**: During extreme weather blackouts or other power outages, EVs can utilize two-way charging and discharging capabilities to send energy to a building or home, serving as a generator and providing safe backup power.
- **Electricity infrastructure costs become more affordable**: Smarter management of EV charging will help manage the cost of EV charging infrastructure, which reduces the overall cost burden on all electricity customers.

- **EVs provide necessary services to the grid and get paid for it**: V1G (unidirectional charging) and vehicle-to-grid ("V2G" – bidirectional charging) will enable EVs to both receive and/or feed power back to the grid, supporting advanced grid services such as frequency control, demand response, peak shaving, and more. Providing these services can unlock new revenue streams for EVs, lowering the total cost of ownership.

The VGIC appreciates the US Department of Energy's leadership in advancing VGI and transportation electrification ("TE") more generally. There are a number of areas where DOE and federal government leadership can significantly accelerate progress for VGI nationally:

I. **Conduct a comprehensive, real-world study on the latent potential for EVs to serve as a grid resource.** While VGIC hopes this RFI surfaces key insights for the report to be developed pursuant to the Energy Act of 2020, a comprehensive, large-scale study on the availability of EVs as a grid resource is needed. Such a study should analyze an availability factor across different customer types and regions using real-world data. This could be modeled after the DOE's *Customer Acceptance, Retention, and Response to Time-Based Rates from the Consumer Behavior Studies.*[1] An EV availability study should conduct randomized controlled trials, assessing the impacts of different rate structures and programs across different utilities and customers. It should also record which technologies were deployed and analyze the dataset to produce recommendations that can inform future programs and rates. Such a study could include 15 or more different partnering utilities, and several different customer types per region. The end result would be a robust dataset that could be open to the public for additional review and future study. This would also provide grid operators with greater confidence that the overall EV fleet can be counted upon (statistically speaking) as a robust and reliable grid resource, even if a single EV may not be available for grid services 100% of the time.

II. **Future-proof transportation electrification investments by building VGI capabilities into new infrastructure.** To meet the transportation electrification challenge, public and private entities across the US will need to invest in infrastructure to support EV charging. It is critical that smart charging/discharging and other VGI capabilities be built into these infrastructure investments as they are deployed – rather than after-the-fact. Incorporation of VGI technologies is not limited to physical infrastructure, but extends to communications and control architecture, as well. For example, stakeholders should consider the potential benefits of using in-vehicle telematics to enable certain VGI use cases. VGIC believes both charging station and EV-based VGI solutions should be enabled through the coming wave of infrastructure investments in support of TE. Together with the physical layer, the communication and control architecture needed to unlock VGI constitute the guardrails of VGI business models. VGIC recommends infrastructure investments remain open to supporting various EV aggregator business models, as it is too early – and not the federal government's role – to pick winners and losers in the VGI market. However, VGI should still be a core consideration of any infrastructure investments. Additionally, other infrastructure investments intended to support the reliability and resilience of the electric grid (e.g., microgrid investments and stationary energy storage or other distributed energy resources or "DERs") should account for the value of VGI.

[1] US DOE Electricity Delivery and Energy Reliability. *Customer Acceptance, Retention, and Response to Time-Based Rates from the Consumer Behavior Studies.* November 2016. https://www.energy.gov/sites/prod/files/2016/12/f34/CBS_Final_Program_Impact_Report_Draft_20161101_0.pdf

VGIC VEHICLE GRID INTEGRATION COUNCIL

III. **Prepare for the coming wave of commercial VGI offerings by educating fleets, homeowners, workplaces, and other customer groups.** The increasingly rapid penetration of electrified transportation across the US represents a paradigm shift rivaling the move from horses to cars. Moving customer thinking from "mpg" to "kWh" requires considerable outreach and education. In particular, education and outreach to fleets is critically needed to inform fleet managers of the potential value of switching to electric transportation. For many fleets, converting to electrified transportation is a significant undertaking that escapes their expertise. Given the potential complexity of VGI, more policy support is needed to direct funding toward educating fleets – as well as other customer types – not only of the benefits of electrification in general, but the enhanced value proposition that VGI technologies can offer. These value propositions include new potential revenue streams from grid services, reduced charging infrastructure costs, reduced charging energy costs, new bill management options, and enhanced resilience of mission critical facilities.

IV. **Facilitate harmonized interconnection policies across the country to support streamlined VGI operations.** In California, VGIC and other stakeholders have collaborated closely with utilities and their regulators to advance V2G functionality, including both V2G Direct Current ("V2G-DC") and V2G Alternating Current ("V2G-AC") configurations. This has ultimately led to the creation of a permanent V2G-DC interconnection pathway, and a temporary V2G-AC interconnection pathway. Despite this progress, it is not guaranteed that similar pathways will exist across the country since interconnection rules are governed individually at the state level. Meanwhile, original equipment manufacturers ("OEMs") must design products for a national marketplace and must contend with the possibility of a patchwork of interconnection rules. VGIC strongly recommends the DOE facilitate efforts to standardize V2G interconnection pathways across the U.S. to support and streamline VGI across the country. VGIC envisions a future where EVs move across utility service territories – and even states – with the ability to seamlessly charge and discharge energy. This is only possible if states follow a common framework, which the DOE could help establish through a standardized "VGI Playbook" approach.

VGI is a unique opportunity for the DOE to establish and advance US leadership in affordable, decarbonized, reliable, and resilient transportation and electricity. We are grateful to the US Department of Energy for opening this RFI. The VGIC would be happy to further discuss any part of this RFI response in a follow up meeting.

RFI Response

1.1.a – In a 2019 presentation to the California VGI Working Group convened by the California Public Utilities Commission ("CPUC"), Fermata Energy provided data from its pilot using a V2G system to perform customer bill management for a manufacturing facility in Danville, Virginia.[2] A Nissan LEAF and Fermata Energy's prototype FE-15 charger were used to discharge power to reduce the peak kW demand portion of the facility's monthly electricity bill, successfully reducing the facility's peak demand by 12.5 kW and leading to $776.51 in savings over five months or an annual savings of over $1,800 per deployed charger. This demonstration was performed with relatively low demand charges of $15.26/kW but illustrates the revenue potential of such V2G

[2] Fermata Energy. 2019. *What VGI use cases can provide value now, and how can that value be captured?* VGI Working Group. https://gridworks.org/wp-content/uploads/2020/06/Fermata-use-cases-providing-value.pdf

operation. In California, where demand charges are significantly higher, pro forma operating results using a 25kW charger could be as high as $9,000 per year.

Additionally, Nuvve Corporation, through the INVENT project funded by the California Energy Commission ("CEC")[3], piloted V2G to optimize integration of rooftop solar and mitigate demand charges. The INVENT project found that operating the fleet in V2G mode had a noticeably larger impact for both optimizations (i.e., solar and demand charge management) when compared to using EVs in V1G-only mode. However, the full potential of V2G was not unlocked due to the lack of rates and programs to facilitate these use case.

1.1.b – Nuvve Corporation has been successfully participating in frequency regulation markets in Denmark for the last five years using only EVs as resources, and earning an average of $1,400/EV/year in that market. Nuvve Corporation has also qualified for participation in PJM's frequency regulation-D market using EVs and is continuing to collaborate to ensure PJM's Federal Energy Regulatory Commission Order 2222 compliance streamlines EV access to markets. More recently, Nuvve Corporation's INVENT project demonstrated the technical ability to provide regulation up and regulation down services for the California Independent System Operator's ("CAISO") frequency regulation market.[4] However, current rules do not feasibly support the participation of EVs in CAISO's frequency regulation market.

1.1.c – While consideration of EV load within reliability and resilience frameworks (i.e., SAIDI and SAIFI) is important, the value of EVs as a resource within reliability and resilience frameworks – especially if bidirectional charging is unlocked – should not be overlooked. One new resilience metric that would support VGI is tracking how much EV-based backup power capability is available in a given location. Measuring the total backup storage capacity can be done by tracking the number and size of bidirectional chargers in a location. In areas of the country faced with resilience challenges like wildfires, extreme heat, hurricanes, and winter storms, the ability for utilities and grid planners to understand the backup power capacity of customers is critical.

1.2.b – Vehicle-to-home ("V2H") or vehicle-to-building ("V2B") systems can provide backup power support. The recently announced Ford F-150 Lightning can provide full-home power for up to three days, or up to 10 days if power is rationed.[5] A Pacific Gas & Electric pilot project documented that a system consisting of an EV paired with rooftop solar and stationary storage achieved 31.2 days of reliability during a summer power outage simulation, compared to 5.3 days with just the rooftop solar and stationary storage.[6]

To meaningfully support this use case and achieve scale, interconnection policies across the country should be harmonized to streamline adoption of V2H/V2B systems that provide backup power when a customer is islanded from the grid. In addition, low-cost solutions to remotely isolate customers should be leveraged, including utilizing smart meters for this purpose.

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[3] Nuvve INVENT https://nuvve.com/projects/ucsd-invent/. The project team has submitted the final report to the CEC, and anticipates it will be uploaded to the Energy Research and Development Reports webpage in the coming months: https://www.energy.ca.gov/resources/publications/energy-research-and-development-reports

[4] *Ibid.*

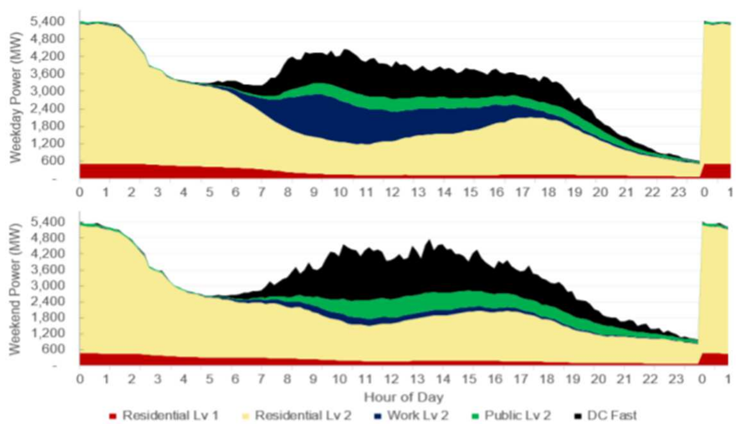
[5] Ford. 2021. *The Truck of the Future is Here: All-Electric Ford F-150 Lightning.* https://media.ford.com/content/fordmedia/fna/us/en/news/2021/05/19/all-electric-ford-f-150-lightning.html

[6] EPIC Policy + Innovation Coordination Group. 2021. *Transportation Electrification Workstream Report.* https://epicpartnership.org/resources/Transportation_Electrification_Workstream_Report_Final.pdf

2.1 – VGI services may help to meet policy goals and could enhance the EV value proposition but may also have a negative impact on overall battery durability. The impact of V2G activities on EV batteries varies depending on the V2G use case the vehicle/battery is supporting. Dispatching V2G functionality for a few hours per year for demand response requires significantly less battery cycling than daily uses that require frequent battery cycling. Any future studies on this topic should consider variations among different grid applications and duty cycles/driving styles. EV battery durability requirements, such as those being contemplated by the California Air Resources Board ("CARB") as part of its Advanced Clean Cars II regulation and the United Nations Council of Europe's Global Test Requirement, should consider the possible implications of those durability requirements on V2G.

2.2 – As national, state, and local policy and decision makers continue to shift their focus toward advancing EV adoption, there is increased attention paid to consumer protection. However, consumer protection standards set in one policy forum that is not focused on VGI may inadvertently limit the opportunity for VGI. Regarding OEM warranties, the VGI market is in its infancy. VGI business models, consumer behavior, and regulations will have implications on the battery state of health. Building on OEMs strong understanding of these factors, (e.g. technology, consumer behavior) and the potential implications on battery impacts, warranties, and driver confidence, OEMs must be integrally involved in VGI policy and program development, and will remain engaged on this issue.

3.1 – The CEC's AB 2127 Report projects the state's light-duty EV charging load in 2030:[7]



The projected load profile indicates a peak load of about 5.4 GW that occurs around midnight from the charging of nearly 8 million light-duty EVs. According to the report, this midnight peak, which occurs as a result of time-of-use ("TOU") rates with an off-peak period beginning at midnight, has the potential to overload distribution equipment and affect power quality. Infrastructure upgrades may be necessary to accommodate this instantaneous load of distribution circuits. The report also projects another 2 GW of on-road medium- and heavy-duty EV charging load.

[7] *Projected 2030 Statewide PEV Charging Load for Intraregional Travel of 8 Million Light-Duty ZEVs in EVI-Pro 2. See* California Energy Commission. 2021. *Assembly Bill 2127 Electric Vehicle Charging Infrastructure Assessment*. https://efiling.energy.ca.gov/getdocument.aspx?tn=238853.

3.2.a – Automated Load Management ("ALM") is the use of software or other behind-the-meter technologies strategically share charging capacity across multiple charging ports at the same charging site to help safely connect multiple charging ports whose total nameplate load would otherwise exceed the rated capacity of the customer connection. This in turn can avoid or defer the need to upgrade certain distribution system infrastructure to accommodate the new EV charging load. For example, if a multi-unit dwelling seeks to deploy a charging station with 5 ports, each with a 10-kW capacity, the distribution upgrades would normally be sized to accommodate 50 kW of incremental coincidental charging demand, equal to all 5 ports charging at full capacity. However, ALM can lower the coincident charging demand to 30 kW, or 6 kW per port on average, when all 5 ports are occupied, thus reducing distribution system upgrades to what is required for only 3 ports. In this scenario, when only 3 or fewer ports are occupied, the EVs can still charge at full speed. Having ALM available to customers as an option can lead to significant savings and ensure that investments in transportation electrification are used efficiently. Pacific Gas & Electric has worked with EV service providers to implement ALM solutions at 20 multi-unit dwelling and workplace host sites as of Q4 2020 and saved between $30,000 and $200,000 per project.[8] Southern California Edison also worked with EDF Renewables PowerFlex to implement ALM to deploy 168 charging stations at $3,000 per port, significantly less than comparable deployments at $10,000-$15,000 per port without ALM.[9]

Another key strategy to limit infrastructure upgrades is with a DER tariff like California's new Partnership Pilot, which aims to facilitate participation of behind-the-meter DER aggregations in distribution deferral opportunities. EVs, like other DERs, can support deferral by limiting load and/or exporting power during times that an additional traditional distribution investment would have been needed to meet local power needs.

3.2.b – Many low-income and other disadvantaged communities are served by outdated utility infrastructure (substations, transformers) that may require significant and costly upgrades to be able to accommodate EV charging load. The use of ALM can help mitigate these infrastructure upgrade costs by reducing the collective peak load at one site, therefore making charging infrastructure more affordable for disadvantaged communities. ALM is a VGI technology that is particularly well-suited for multi-unit dwellings, commercial buildings, workplace charging, and other non-single family home sites, where low-income customers may be more likely to charge.

3.3 – If unmanaged, EV charging load can occur during system peak periods, which for many drivers takes place in the late afternoon as they plug their EVs in to charge after arriving home from work. A careful approach to managed charging is necessary to ensure that EVs charge during off-peak hours to minimize system costs. Note that grid economic dispatch does not always align with periods of high renewable energy production. VGI can help address both issues through managed charging, such that EVs charge during off-peak hours that are also coincident with hours of high renewable energy production, where and when it is feasible. See section 3.5.a for details on managed charging approaches to mitigate the impacts of EV charging on the electric grid.

3.4 – VGIC believes customer outreach, education, and engagement are key issues for both retail and fleet customers. Fleets are a particularly promising set of EV resources; however, several key

[8] Pacific Gas & Electric. 2021. Presentation at CPUC ALM/EV EMS Workshop, Panel 2.
[9] EPIC Policy + Innovation Coordination Group. 2021. *Transportation Electrification Workstream Report*. https://epicpartnership.org/resources/Transportation_Electrification_Workstream_Report_Final.pdf

policy barriers remain. For example, education and outreach to fleets is critically needed to inform fleet managers of the potential value of VGI technologies. For many fleets, converting to electrified transportation is a significant undertaking that escapes their expertise. Given the relative complexity of VGI, more policy support is needed to direct funding toward educating fleets not only of the benefits of electrification in general, but the benefits of managed charging, ALM, bidirectional charging, and other VGI technologies.

3.5.a – Managed charging focuses on shifting or modulating charging, either by altering customer behavior or automatically shifting charging "behind the scenes" from the customer perspective. Managed charging can be promoted through rate design or other incentives to encourage off-peak charging. Many utilities have implemented TOU rates for EV charging. To be effective at shifting charging load, EV TOU rates must have a significant enough differential between peak and off-peak rates to provide a meaningful financial incentive for EV owners to respond to. Moreover, customers must be aware of and enrolled in these rates. More advanced rate designs are necessary to expand options for customers and ensure EV load is shifted to off-peak periods that are also aligned with renewable energy production. For example, Xcel Energy Colorado and Minnesota currently offer commercial and industrial customers an EV Critical Peak Pricing Rate, under which energy costs are considerably higher during utility-called critical peak events, on top of on-peak and off-peak pricing during non-event periods.[10] More dynamic rates can also be helpful. San Diego Gas & Electric currently offers the EV Grid Integration Pilot Program, a dynamic rate schedule that reflects day-ahead wholesale electricity prices.[11] Customer-centric VGI solutions can help customers understand and realize the benefits of advanced utility rate structures.

Meanwhile, many utilities have implemented programs that provide customers with a per kWh incentive for off-peak charging and/or monthly incentive for avoiding on-peak charging. For instance, National Grid in Massachusetts provides residential customers with an Off-Peak Charging Rebate of 3-5 cents per kWh (depending on the season) for all off-peak charging.[12] In New York, Con Edison offers the SmartCharge NY Program, which provides residential customers with a 10 cents per kWh incentive for off-peak charging, a $20 per month incentive for avoiding summer peak charging, as well as ongoing participation incentives.[13] Fleet customers are also able to participate in SmartCharge NY, earning 2.21 cents per kWh for off-peak charging and $250 per month for avoiding charging during demand response periods. Similar offers and rate structures should be available for EVs with bidirectional capability to compensate them for discharging during peak load periods and charging at periods of lower overall load. This one change in managed charging programs could provide significant economic benefits to EV owners with bidirectional capabilities as well as operational benefits for grid operators.

[10] Xcel Energy Colorado. 2021. *EV Critical Peak Pricing Information Sheet.* https://www.xcelenergy.com/staticfiles/xe-responsive/Programs%20and%20Rebates/Business/EV-CPP-Info-Sheet.pdf
[11] San Diego Gas & Electric. 2017. *Schedule VGI*. https://www.sdge.com/sites/default/files/elec_elec-scheds_vgi.pdf
[12] Massachusetts Department of Public Utilities. 2019. *September 30 Order*, pg. 340-341, 387-392. Proceeding 18-150. https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/11262053
[13] Con Edison. 2020. "ConEdison EV Managed Charging Filing." Case 18-E-0138. http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={F8F2D2E1-B190-4DB4-B3F3-2BDC127568F5}

Other managed charging solutions allow for a utility or third-party (e.g., EV service provider, aggregator) to control EV charging via the charger, vehicle telematics, or smart circuit breaker or panel. These strategies can enable an even greater degree of flexibility and optimization of EV load. A utility or a third party can "smooth" the EV demand curve by scheduling charging sessions. The Static Optimization program offered by Xcel Energy Colorado follows this approach.[14] Managed charging approaches can also be used to ensure EVs are charged during periods with the lowest energy costs or highest renewable energy penetration. For example, the Charge Smart Program offered by Central Hudson and Orange & Rockland in New York leverages networked chargers to shift EV charging to periods when greenhouse gas emissions from power generation are the lowest, using forecast and real-time emissions data.[15] Xcel Energy Colorado is also working with automakers to implement the Charging Perks Pilot, which uses vehicle telematics to shift charging to hours with the lowest day-ahead power production costs.[16] Meanwhile, Xcel Energy Minnesota offers an EV subscription service pilot, which allows drivers to lease and install a smart charger and offers unlimited off-peak charging for a fixed monthly charge.[17] Not only does this provide cost certainty, it also allows a driver to see an apples-to-apples comparison between the monthly cost of ownership compared to an internal combustion vehicle. Finally, managed charging can allow EVs to participate in demand response programs, like the Active Demand Reduction programs implemented by utilities in Massachusetts.[18]

Providing a variety of rate designs can help accommodate a diversity of customer needs and sophistication, thus creating more grid flexibility. The VGI Working Group convened by the CPUC identified over 1,000 use cases for VGI. Customers should have the ability to choose what works best for them. In addition, it should not be assumed that all customers will perform their own charge management. For example, customers may be allowing an aggregator to control their EV load and aggregate with other EVs – and even other types of DERs – to participate in demand response programs. Program structures and requirements should promote third-party participation to support customer choice.

3.5.b – Billing determinants for VGI rates and programs can be measured via the charger or the vehicle's onboard telematics. By not requiring a separate meter, this type of rate or program would accommodate certain VGI use cases that would otherwise be infeasible to measure and account for, such as using EVs to reduce a customer's load during a demand response event, discharging to mitigate a customer's demand charges, or coordinating with on-site solar or stationary energy storage resources. In addition, the use of these submetering strategies also lowers the cost of a

[14] Xcel Energy Colorado. 2021. "2021/2022 Demand-Side Management Plan," pg.262-263. https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Regulatory%20Filings/CO-DSM/CO_2021-22_DSM_Plan_Final.pdf
[15] Orange & Rockland Store. 2020. "Charge Smart Program." https://myorustore.com/s/ORU/content_charge_smart_program.html
[16] Xcel Energy Colorado. 2021. "2021/2022 Demand-Side Management Plan," pg. 263-265. https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Regulatory%20Filings/CO-DSM/CO_2021-22_DSM_Plan_Final.pdf
[17] Xcel Energy Minnesota. 2021. "EV Subscription Service Pilot." https://ev.xcelenergy.com/subscription-pilot-mn/
[18] Massachusetts Joint Statewide Electric and Gas. 2018. "Three-Year Energy Efficiency Plan 2019-2021." Appendix K. https://ma-eeac.org/wp-content/uploads/Exh.-1-Final-Plan-10-31-18-With-Appendices-no-bulk.pdf

second meter, which may be borne by the customer or socialized to all of a given utility's customers, and either approach would disproportionately impact low-income customers. According to Xcel Energy Minnesota, using the metering capability of smart chargers in lieu of a second meter saves customers an average $2,196 each in upfront costs.[19]

3.6 – Many V2G technologies have already been piloted and certified to relevant safety standards (e.g., IEEE standards for small generators), with more becoming commercially available soon (i.e., next 12-24 months). The challenges that remain are primarily policy and regulatory, rather than technological. Many use cases are technically ready but cannot be deployed without appropriate value streams, retail rates, interconnection processes, and coordination between EV and DER policy streams. Utility systems should be building capabilities now as infrastructure is being deployed to prepare the grid for these products. Below we highlight key bidirectional configurations, anticipated timeframe, and related barriers:

V2H/V2B Backup Power	Products Available Today; Projects Currently Being Installed[20]	1. Streamlined interconnection needed, including clarification and standardization of transfer switch operation and technical requirements 2. Lack of funding support for low-power DC EV supply equipment 3. Low-cost isolation technologies could support customer adoption 4. Nationally standardized regulatory regime needed for V2G-AC interconnection for customers looking to stack other bidirectional use cases
V2H/V2B Non-Export (e.g., demand charge management, TOU rate optimization, non-exporting demand response)	Products Available Today; Projects Existing[21]	*(See 1, 2, and 4 above)* 5. Standard interconnection pathway for V2G AC systems needed 6. Submetering protocols needed to enable V2H/V2B use cases, rather than separating EVs from other load 7. Standard utility interconnection agreement and consistent treatment of V2G systems

[19] Xcel Energy Minnesota. 2019. *Annual Report on Residential EV Charging Tariff and Residential EV Service Pilot.*

[20] *See, for example,* Baldwin Park Unified School District School Bus V2B Project as detailed in Southern California Edison Company's Advice Letter 4518-E at 64. https://library.sce.com/content/dam/sce-doclib/public/regulatory/filings/pending/electric/ELECTRIC_4518-E.pdf

[21] *See, for example,* Fermata Energy's project as detailed in Colorado Smart Cities Alliance's *Spotlight Series on Energy: V2B in Focus* https://coloradosmart.city/event/spotlight-series-on-energy-v2b-in-focus-panel-discussion/, Nuvve Corporation's V2G school bus project with Lion Electric in ConEdison service territory https://nuvve.com/inthenews/nuvve-corporation-activates-bidirectional-flow-of-energy-from-electric-school-buses-to-con-edisons-grid-in-new-york/, and Nuvve Corporation's V2G pilot with San Diego Gas & Electric at Cajon Valley Union School District http://www.sdgenews.com/article/vehicle-grid-pilot-leveraging-big-batteries-electric-school-buses-support-grid.

V2G Export (e.g., energy, capacity, ancillary services)	Product Available Today; Demonstration Projects Completed[22]	*(See 1, 2, 4, 5, 6, and 7)* 8. Export counting methodology needed

3.7 – Widescale adoption of smart charging management systems hinges on utility and public utility commissioner support for these systems. VGIC highlights the following key needed improvements and enhancements:

- Utilities should incorporate VGI strategies into TE infrastructure programs. This includes both deploying networked charging stations, communications platforms and integrations with automotive OEMs, and bidirectional charging stations.
- Offer outside of TE infrastructure programs. Customers installing chargers outside of TE infrastructure and make-ready programs should also be presented with VGI options, including a menu of technology incentives, VGI rate design, and options to leverage VGI to reduce installation costs.
- Add VGI to DER, demand-side management, energy efficiency, and/or demand response plans and programs. As a DER, EVs should be incorporated into utilities' existing DER strategy and placed on a level playing field with other flexible loads or energy storage technologies. Interconnection processes, eligibility, incentives, enrollment, and performance compensation should be open to EVs and reasonably modified to leverage the latent storage capacity of EVs.
- Educating fleets and municipalities on the benefits of VGI. Fleets and municipalities should be equipped with the tools needed to assess and deploy VGI technologies.

An example of smart charging management systems that have been developed is The Mobility House's work with Stockton Unified School District ("SUSD"), a disadvantaged community in California to deploy smart charging and management solutions for the district's bus fleet of 11 – funded by CARB. The Mobility House's active intelligent charging management system will save SUSD $500,000 over five years in charging costs.[23]

4.3 – VGIC recommends a standard interconnection pathway for DER systems be implemented, including for both configurations where the inverter is on-board the vehicle and inside a stationary charger. Based on our understanding, no state currently allows for the interconnection of commercial configurations where the inverter is on-board the vehicle, and several utilities still do not trat deployment of bidirectional chargers as equivalent to stationary energy storage systems.

[22] Nuvve INVENT https://nuvve.com/projects/ucsd-invent/. The project team has submitted the final report to the CEC, and anticipates it will be uploaded to the Energy Research and Development Reports webpage in the coming months: https://www.energy.ca.gov/resources/publications/energy-research-and-development-reports

[23] Taking into account variables such as fleet schedules, equipment requirements and utility rates. See Bloomberg. *The Mobility House to Save Stockton Unified School District $500k via Smart Charging of New Electric School Bus Fleet.* May 4, 2021. https://www.bloomberg.com/press-releases/2021-05-04/the-mobility-house-to-save-stockton-unified-school-district-500k-via-smart-charging-of-new-electric-school-bus-fleet