CAP/sf3 2/23/2018

FILED
02/23/18
12:11 PM

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Consider Alternative-Fueled Vehicle Programs, Tariffs, and Policies.	Rulemaking 13-11-007

ASSIGNED COMMISSIONER'S RULING SEEKING COMMENT ON VEHICLE-GRID INTEGRATION COMMUNICATION PROTOCOL WORKING GROUP ENERGY DIVISION STAFF REPORT

Summary

The attachment to this ruling is the California Public Utilities Commission (CPUC) Energy Division's Staff Report on the Vehicle-Grid Integration (VGI) Communication Protocol Working Group (Staff Report) and recommendations for the Commission to consider when evaluating programs to install certain transportation electrification infrastructure in future proposals from the investor-owned utilities.

The Staff Report includes hardware performance requirements that staff recommends be applicable to investor-owned utilities' investments that support Level 2, Alternating Current (AC), conductive, multi-user electric vehicle charging equipment to support protocols necessary to enable VGI. The Staff Report also includes recommendations for currently available communication

protocols that can support the high level communication[1] necessary to enable VGI.

Parties and participants in the VGI Communication Protocol Working Group are invited to comment on the Staff Report, the questions set forth in this ruling, and all of the attachments and Deliverables documented throughout the report that are available at www.cpuc.ca.gov/vgi. Any comments must be served on Carrie Sisto at cs8@cpuc.ca.gov, the service list to this proceeding,[2] and the VGI Communication Protocol Working Group[3] no later than March 21, 2018. Reply comments must be served by April 4, 2018. Energy Division staff will review the comments received, make edits to the Staff Report if necessary, and the final version will be attached to a future ruling or decision for entry into the record.

1. Background

In 2013, the CPUC opened its Alternative-Fueled Vehicles Rulemaking (R.) 13-11-007, in part to "evaluate the potential and value of vehicle-grid integration"[4] to support the state's zero-emissions vehicle (ZEV) goal established by Executive Order B-16-2012. Executive Order B-16-2012 ordered the California

[1] "High level communication" refers to driver authentication, clearing, and smart charging coordination information parameters. Select HLC parameters are described in the Functional Requirements.

[2] At the time of service, access the Service list for "A1311007" from the CPUC Service List website available here: https://ia.cpuc.ca.gov/servicelists/sl_index.htm. Then download the comma-delimited file (.cvs) that contains the names and email addresses of all parties to the proceeding.

[3] Email addresses for all working group participants are available at: http://www.cpuc.ca.gov/vgi/.

[4] The Order Instituting Rulemaking to Consider Alternative-Fueled Vehicle Programs, Tariffs, and Policies, issued on November 22, 2013. Available at http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M081/K996/81996327.PDF.

Air Resources Board (CARB), the California Energy Commission (CEC), the CPUC, and other agencies to establish benchmarks to help achieve by 2020 infrastructure to support 1 million zero-emission vehicles, including electric vehicle charging that "will be integrated into the electricity grid." The subsequent 2013 Zero-Emission Vehicle Action Plan,[5] which will be updated in 2018,[6] serves as the blueprint for the state agencies working to achieve California's ZEV goals.

In 2015, the Clean Energy and Pollution Reduction Act, SB 350, became law. It created new renewable energy and energy efficiency goals, and directed the CPUC to require the investor-owned utilities to propose programs designed to accelerate widespread transportation electrification.[7]

In September 2016, the CPUC provided the utilities with guidance on what types of programs they should propose.[8] The guidance directed the utilities to address in their applications how they would comply with the International Organization for Standardization and International Electrotechnical Commission's (ISO/IEC) 15118 Vehicle-to-Grid Communications Protocol in the transportation electrification infrastructure they were proposing to install, or explain what alternative approaches they proposed to meet VGI policy

---

[5] The ZEV Action Plan was updated in 2016. https://www.gov.ca.gov/docs/2016_ZEV_Action_Plan.pdf.

[6] Pursuant to Executive Order B-48-18. Available at https://www.gov.ca.gov/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/.

[7] The transportation electrification provisions of SB 350 have been codified as Public Utilities Code Sections 237.5 and 740.12.

[8] The September 2016 Assigned Commissioner's Ruling available at http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M167/K099/167099725.PDF was ratified by decision (D.) 16-11-005.

objectives. CEC and CPUC held a joint staff workshop in December 2016 to discuss the importance of VGI and the role of communication protocols in enabling VGI. During this workshop, participating experts and stakeholders did not reach clear consensus about which, if any, protocol is necessary to enable VGI to scale in the market. At the conclusion of the workshop, CPUC staff proposed developing a working group to evaluate the technical details of existing communication protocols and assess which, if any, might be appropriate for the CPUC to require to be used in ratepayer-supported infrastructure. The formation of this working group was later formalized in an April 13, 2017 Scoping Ruling of the Assigned Commissioner and Administrative Law Judges in Application 17-01-020 *et al.*

Energy Division staff worked with staff from the CEC, CARB, the California Independent System Operator, and the Governor's Office of Business and Economic Development to convene a working group comprised of 130 stakeholders interested in the state's pursuit of bringing VGI to market economically and at scale. The working group met over the course of seven months, from April through December 2017.

The attached Staff Report details the working group process and key deliverables, and includes Energy Division staff recommendations for hardware functionality requirements and suggested communication protocols. The recommended hardware requirements are proposed to apply to utility investments that support Level 2, AC, conductive, multi-user electric vehicle charging equipment.

2. Questions for Parties and Stakeholders

While Parties and Stakeholders are invited to submit comments on any aspect of the staff report, Energy Division staff particularly request comments that address the following questions:

1. Overall feedback on Staff Report
    a. Does the Staff Report accurately reflect Working Group discussions?
    b. Are there any key stakeholder comments that are missing from or misrepresented in the Staff Report?
    c. Are all of the Deliverables referenced in the Staff Report,[9] such as the VGI Glossary, complete and accurate based on Working Group discussions and findings?
2. Scope of electric vehicle service equipment (EVSE) hardware performance requirements
    a. Is it appropriate, as described in the Staff Report, to exclude single-user EVSE in privately-accessible locations (e.g., home charging) from the EVSE hardware requirements for utilities?
    b. Is it appropriate, as described in the Staff Report, to exclude workplaces or fleets that only use their EVSE for business vehicles from the EVSE hardware requirements for utilities?
    c. If a third party, such as an aggregator, plans to aggregate residential or private workplace charging loads to provide grid benefits, would the recommended hardware requirements be appropriate to apply to these use cases?
        i. If so, should the scope of the hardware requirements be extended to single-user residential or private workplace EVSE?

[9] All deliverables are available on: www.cpuc.ca.gov/vgi.

ii. If not, what EVSE hardware is necessary to enable an aggregator to provide VGI services (*e.g.* demand response) to residential and private workplaces in addition to any utility program offerings?

3. Identifying future VGI work

a. Are there specific research or technology pilots underway that could aid in identifying the value of use cases and/or the business case(s) for implementing VGI?
b. Are there ideas for new research, development, or deployment pilots that would help utilities, electric vehicle service providers, and/or automobile manufacturers to identify the value of use cases and/or the business case(s) for VGI?
c. Are there any policy proceedings not identified in the Staff Report that should be included in the VGI discussion going forward?

IT IS RULED that:

1. Parties and participants in the VGI Communication Protocol Working Group are invited to comment on the Staff Report, the questions set forth in section 3 of this ruling, and all of the attachments and Deliverables documented throughout the report that are available at www.cpuc.ca.gov/vgi.

2. Any comments must be served on Carrie Sisto at cs8@cpuc.ca.gov, the service list to R.13-11-007, and the VGI Communication Protocol Working Group no later than March 21, 2018.

3. Reply comments must be served on Carrie Sisto at cs8@cpuc.ca.gov, the service list to R.13-11-007, and the VGI Communication Protocol Working Group no later than April 4, 2018.

Dated February 23, 2018, at San Francisco, California.

/s/ CARLA J. PETERMAN
Carla J. Peterman
Assigned Commissioner

Attachment

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Carrie Sisto
Amy Mesrobian
CPUC Energy Division Staff

Energy Division
California Public Utilities Commission
February 2018

Table of Contents

1. Summary

Staff from the California Public Utilities Commission (CPUC) Energy Division, California Energy Commission (CEC), California Air Resources Board (CARB), California Independent System Operator (CAISO), and Governor's Office of Business and Economic Development (GO-Biz) in 2017 led a working group to develop a recommendation on whether the CPUC should require a communication protocol or protocols for the electric vehicle service equipment (EVSE) and associated infrastructure that investor-owned utilities (IOUs) support with ratepayer funding.

The Working Group evaluated the existing communication protocols utilized to enable Plug-In Electric Vehicle-Grid Integration (VGI) use cases in an effort to understand whether one protocol, or a specific combination of protocols, is mandatory to enable VGI economically and at scale. The group's work included creating a glossary of terms, identifying viable VGI use cases, extracting requirements needed to achieve the use cases, and mapping those requirements to the existing communication protocols. The process required many hours of technical analysis and expert feedback from a stakeholder group that numbered more than 130 participants.

One of the goals of the Working Group was to gather data and document analysis to help support State Agency decision making regarding what policies we need to adopt to support VGI. As state agencies, our overall goal is to reduce emissions both by incentivizing the switch from fossil fuel vehicles to zero-emission vehicles and by integrating those vehicles with the electric grid efficiently. The documentation, analysis, and work products completed through this Working Group are all available on the CPUC's website at www.cpuc.ca.gov/vgi.

The key deliverables, as described in more detail below, include a summary matrix of VGI use cases aligned to their use case and requirements categories; a matrix of functional use case requirements and the actors needed to achieve them; lists of non-functional, customer, alternative, and other requirements; and this Energy Division recommendation for specific hardware requirements and software recommendations.

While the CPUC only has jurisdiction over the IOUs and infrastructure they support, the Working Group considered the entire vehicle-grid integration ecosystem to attempt to identify communication protocols that would fully enable VGI from the grid to the vehicle. The Working Group considered every existing viable standard and non-standard communication pathway during the Working Group process. Some stakeholders interested in engaging in VGI at scale expressed the need to identify the business case for implementing VGI use

cases before choosing which strategies or protocols should be used to most economically achieve those use cases. Others identified protocols they believe must be implemented in preparation for impending deployment of vehicles. **Based on stakeholder feedback and guidance, Energy Division staff have determined it is not advisable to require the investor-owned utilities to only use a single protocol, or specific combination of protocols, for their infrastructure investments at this time.**

Given the rapidly evolving technology for electric vehicles and their associated infrastructure, and CAISO's ongoing work to identify and reduce barriers to potential VGI participation in its wholesale markets, it would be prudent at this time to allow all viable communication pathways to be available for VGI implementation.

That said, the Working Group did not consider the relative value – to drivers, ratepayers, automakers, utilities, the grid operator, and other stakeholders – of various use cases examined through this process. While the State Agencies' original Work Plan included a deliverable to assess the costs and benefits associated with each use case, the Working Group did not have the information available to make these types of assessments. The Working Group continued its work without assessing the value of the VGI use cases.

Further examination of the value of different VGI use cases could better identify if a standard communication protocol or combination of protocols would best enable a VGI product to be delivered at scale to the market. The CEC is leading a revision of the state's Vehicle-Grid Integration Road Map[10] and conducting ongoing research through its administration of Electric Program Investment Charge investments to help define the value of different VGI use cases, and Working Group participants have identified other potential pilots the state could focus on to help identify the business case for pursuing VGI.

This document contains recommendations from CPUC Energy Division staff developed with CARB, CEC, CAISO, and GO-Biz. As previously noted, Energy Division staff does not recommend requiring any specific protocol or protocols at this time; however, the hardware performance requirements identified in Section 5 will allow electric vehicle service equipment (EVSE) to accommodate any of the multiple protocols we think are necessary to enable VGI. The agencies also developed a list of recommended communication protocols that can be applied

[10] The VGI Roadmap was published in 2014 and is available at http://www.caiso.com/documents/vehicle-gridintegrationroadmap.pdf.

to enable VGI. This approach combines the flexibility to ensure future usability with the certainty that manufacturers need to invest in producing products. The current recommendation does not directly apply to any of the programs the IOUs have proposed in their current applications, but Energy Division staff believes the CPUC should consider applying the recommendation to any future IOU applications that fall within its scope.

This report summarizes the information and analysis completed by the full Working Group. CEC staff separately suggested that beyond formulating EVSE requirements, VGI solutions should meet three performance attributes. These suggestions, which were not fully analyzed by the Working Group, are included as Appendix A for the CPUC's consideration.

The Working Group's efforts will continue into 2018 through the CEC's VGI Roadmap update, the CEC's current Integrated Energy Policy Report (IEPR) docket, and CARB's implementation of SB 454, as discussed in more detail below.

2. Purpose of the working group

a. Prior policy efforts in Vehicle-Grid Integration

Executive Order B-16-2012 ordered CARB, the CEC, the CPUC, and other agencies to establish benchmarks to help achieve by 2020 infrastructure to support 1 million zero-emission vehicles, including electric vehicle charging that "will be integrated into the electricity grid." This order and the subsequent 2013 Zero-Emission Vehicle Action Plan[11] serve as the basis for the State's effort to accelerate the adoption of electric vehicles.

The increased electric load associated with more electric vehicle charging has the potential to seriously impact the electric grid, particularly if charging is not managed. In an effort to reduce any potential reliability issues, the state agencies began working to identify strategies to ensure vehicle charging occurs during off-peak hours. It became clear that electric vehicles could also serve as grid assets, if charging is properly managed, either by absorbing excess renewable energy during the day or by sending power back onto the grid or to a facility during times of peak demand. These use cases could provide ways to reduce overall operating costs for vehicle owners and building managers, delay or offset

[11] The ZEV Action Plan was updated in 2016. https://www.gov.ca.gov/docs/2016_ZEV_Action_Plan.pdf.

utilities' distribution upgrade and maintenance investments, and/or mitigate wholesale energy prices.

Two related documents have led California's policy development in VGI: the California Vehicle-Grid Integration Roadmap, developed collaboratively among the CEC, CPUC, and CAISO and stakeholders through workshops beginning in late 2012, and the CPUC Energy Division's whitepaper included in the Alternative-Fueled Vehicles rulemaking, R.13-11-007.

The Roadmap identified three tracks to direct the state's efforts: (1) Determine VGI Value and Potential; (2) Develop Enabling Policies, Regulations, and Business Practices; and (3) Support Enabling Technology Development. The VGI Roadmap identified activities intended to "increase consistency across technologies to enable interoperability and to provide guidelines for product development, while allowing for variety in VGI products and services." The Roadmap highlighted the importance of the use of existing, internationally-adopted standards where "a common standards format ensures compatibility among multiple technologies, eases adoption by customers and increases certainty for developers about the access their products will have and about how their technologies can work with others."[12]

The VGI Whitepaper highlighted a concern about the market's ability to resolve conflicts arising between parties who each have the potential to control the VGI resource. The Whitepaper suggested that to overcome the fragmentation of the actors' objectives that policymakers may need to "define the resource." In particular, it notes how existing communication standards will be required to send messages between the defined resource, aggregators, and utilities.[13]

In September 2016, the assigned Commissioner's ruling in R.13-11-007 stated an intention to overcome barriers that prevent expeditious actions toward effective VGI, particularly as the utilities were ordered to prepare applications to accelerate widespread transportation electrification pursuant to SB 350. CPUC Energy Division considered options for the adoption of a VGI communication standard in order to achieve the technology development and system reliability objectives enumerated in the VGI whitepaper, and recommended the use of the International Organization for Standardization and International Electrotechnical

[12] VGI Roadmap at 11.

[13] VGI Whitepaper at 30 and 34 http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M080/K775/80775679.pdf.

Commission's (ISO/IEC) 15118 Vehicle-to-Grid Communication Protocol. To develop additional record needed to inform decisions on this issue, CEC and CPUC held a joint staff workshop in December 2016 to discuss the importance of VGI and the role of communication protocols in enabling VGI. During the workshop, presenters and participants discussed other means of communication including charging or home area networks, an Open Vehicle-Grid Integration Platform, and vehicle telematics. There was no clear consensus among stakeholders on which, if any, protocol would best enable VGI. Additionally, technical experts disagreed about some of the capabilities of different protocols, particularly around issues such as cybersecurity. At the conclusion of the workshop, CPUC staff proposed developing a working group to delve into the technical details of the various communication protocols to better assess which might be appropriate for the CPUC to require to enable VGI.
In April 2017, CPUC, CEC, CARB, CAISO, and GO-Biz began convening a working group of stakeholders to understand whether the state agencies need to require communication protocols within charging equipment to enable VGI economically and at scale.

b. Current Proceedings/Dockets

The state agencies are considering VGI in their respective areas of responsibility and will each consider the outputs from this working group in accordance with their own regulatory processes and program timelines.
California Public Utilities Commission: Public Utilities Code 740.12, established via Senate Bill 350 (2015, de León), requires the CPUC to direct the electric investor-owned utilities under its jurisdiction to file applications for programs that accelerate widespread transportation electrification to meet the state's air quality standards, greenhouse gas reduction goals, and increase access to electric vehicles across the state. In compliance with this requirement, in September 2016,[14] the CPUC directed the state's six investor-owned utilities[15] to file applications proposing programs to accelerate transportation electrification. The CPUC on January 11, 2018 approved 15 pilots for IOU transportation

[14] Assigned Commissioner's Ruling in R.13-11-007.

[15] There are six electric IOUs in the state: San Diego Gas & Electric, Southern California Edison, Pacific Gas and Electric, PacifiCorp, Liberty, and Bear Valley.

electrification investments, and is currently reviewing 15 additional IOU project proposals.[16]

In some of the proposed projects the IOUs would directly purchase and own the EVSE, while in other proposals the IOUs would qualify EVSE models that customers receive a rebate for purchasing and installing. The working group recommendation was developed to apply to either ownership model.

California Energy Commission: The CEC is responsible for consulting with the CPUC on charging programs and standards pursuant to Public Utilities Code Sections 740.3 and 740.8. In addition, the CEC has authorities under Public Resources Code to adopt standards to avoid energy waste, manage peak load, and develop infrastructure plans for electric vehicles. The CEC's work pursuant to these responsibilities has principally been conducted in research and demonstrations pursuant to EPIC and statewide and regional charging infrastructure assessments and investments under the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP).

The CEC's research programs aim to identify and develop strategic opportunities for the use of interoperable standard protocols in charging infrastructure to support SB 350's transportation electrification objectives. As discussed in the 2017 Integrated Energy Policy Report,[17] the CEC initiated and oversees progress on technology research and development and invests in priority pilots in support of the VGI Roadmap. Advancing the Roadmap's goal of ensuring customers have immediate access to an advanced charging infrastructure network depends on the state of technologies used by vehicle manufacturers and charging providers. In addition, the CEC recommendations for transportation electrification as part of the publicly-owned utilities' Integrated Resource Plans consider how electric vehicles can provide flexible resources to manage variable renewable generation.

The CEC will use the information and deliverables from the Working Group to help ensure that the agency's research results in charging deployments with VGI functions that benefit ratepayers. The information gathered will help ensure future demonstration projects build upon past research results to improve VGI technology to support the development and deployment of widespread

[16] The SB 350 Transportation Electrification proceedings are A.17-01-020, et al. and A.17-06-031, et al.

[17] http://www.energy.ca.gov/energypolicy/.

advanced infrastructure. Information gathered through the Working Group and ongoing research efforts are also aimed at improving electricity demand forecasts associated with EV-related flexible load and mediating its overall system impacts.

California Air Resources Board: The Electric Vehicle Charging Stations Open Access Act[18] (SB 454; Statutes of 2013) gives CARB the authority to adopt requirements to ensure public charging stations in California have interoperable billing standards, including a transparent fee structure, and allow the use of multiple payment methods. As VGI services become more available, drivers utilizing public charging stations must be clearly informed of any change in price per kW/hr and have the ability to opt in or out of price changes. Participation in the working group has facilitated CARB's development of proposed requirements for publicly accessible charging stations.

c. Working Group Process

CPUC staff engaged a neutral facilitator to lead each Working Group meeting and staff from three California state agencies, GO-Biz, and the CAISO collaborated on organizing, administrating and directing the working group process and work plan. Over a nine-month period in 2017, the facilitator led 15 meetings of the full Working Group, which occurred either in-person or via WebEx. Additionally, as detailed in Section 3 of this report, four sub-working groups formed throughout the process to allow smaller groups of technical experts additional time for more in-depth discussions around specific topic areas. Each sub-working group had a leader, or co-leaders, to facilitate meetings and ensure the completion of a final report or deliverable to summarize the sub-working group's accomplishments.

More than 130 participants signed up for the Working Group email list, and more than 50 played an active role in the Working Group. Participants included representatives from state and federal agencies, academia, utilities, ratepayer advocates, EVSE equipment and component manufacturers/providers, EV service providers, automakers, standards experts, nonprofits, and other software and technology providers.

---

[18] SB 454, Corbett, 2013, available at: http://leginfo.legislature.ca.gov/faces/billPdf.xhtml?bill_id=201320140SB454&version=20130SB45492CHP.

Table 1. 2017 VGI Working Group Meeting Schedule

Date	Discussion Topics
April 24	Introduction to Working Group, Discussion of Work Plan Proposal
May 15	Presentations on Use Case Development, Stakeholder Feedback on Work Plan, Identification of Foundational Documents, Development of Use Case and Definitions Sub-Working Groups
May 30	Presentation and Discussion of Use Case and Definitions Sub-Working Group progress
June 12	Overview of and Discussion on Terms and Definitions and Use Cases, Use Case Exercise Demonstration and Discussion on Use Case Evaluation Methodologies
June 26	Proposals and Discussion by Joint IOUs and OEMs for Working Group Process Changes, Presentation of Use Case Requirements Template, Development of Requirements Sub-Working Group
July 10	Presentation of Deliverable 1 Outline, Development of Mapping Sub-Working Group
July 24	Presentation on Work Plan Updates, Discussion on Terms and Definitions Sub-Working Group progress, Status Update from Requirements Sub-Working Group
August 7	Requirements Sub-Working Group Presentation, Discussion on Requirements Deliverables, Kickoff Deliverable 2 with Presentations on VGI value
August 21	Review of Work Plan updates and Working Group Accomplishments, Updates from all Sub-Working Groups, Update on Cost-Benefits Process for Deliverable 2
September 18	Final Results Presentation from Requirements Sub-Working Group, Update from Mapping Sub-Working Group, Presentation on Rule 21 and its VGI Applicability, Cost-Benefits Spreadsheet Exercise and Discussion
October 16	Discussion on Work Plan Updates and Schedule Extension, Presentation on Future-Proofing the EVSE from Stakeholders, Review and Discussion of Mapping Sub-Working Group Outcomes
October 30	Presentation of Draft Proposal for Hardware Requirements, Discussion on Proposal and Working Group Next Steps
November 14	Discussion on Hardware Proposal, Review of Stakeholder Comments, Discussion on Potential Deliverable 2 Process and Next Steps

December 1	Presentation and Discussion on Amended Hardware Proposal, Discussion on DC Applicability, Identification of Additional Issues that Should Be Addressed, Discussion on Inclusion of Recommended Protocols
December 18	Presentation on Status of Glossary Sub Working-Group, Discussion on Applicability of Hardware Requirements to Current IOU Proposals, Discussion of State Agency Next Steps for VGI Policy Making, Presentation on California State Metering Requirements

d. Initial Work Plan Development

In preparation for the Working Group launch, the State Agencies developed a Work Plan for the VGI Communication Protocols Working Group to establish the scope and key questions for participants to consider. The initial Work Plan released in May 2017 outlined three deliverables for the Working Group to complete to provide a recommendation: (1) Map existing VGI use cases to communication protocols, (2) Assess the costs of adoption or absence of an adopted protocol, and (3) Identify market or policy actions needed to enable VGI. Based on stakeholder feedback, the State Agencies updated this document throughout the Working Group process as the discussion topics and schedule evolved.

The State Agencies formed this group to identify and assess opportunities in which VGI can create value[19] from multiple market participants' perspectives, by reviewing and discussing the technical details of existing communication protocols. The Working Group was also tasked with identifying policies or guidelines that would encourage utilities, automakers, electric vehicle service providers, aggregators, and others to develop pathways to market for VGI as a resource. The scope was limited to light-duty electric vehicles and only assessed existing communication protocols. It was never the Agencies' intent to create a new communication protocol.

The initial Work Plan envisioned focusing on the VGI communication programmed within the EVSE, because CPUC has jurisdiction over IOU

[19] The California Vehicle-Grid Integration Roadmap (2014) identified "value of VGI" as one of three barriers and identified "refining use cases" as an action item. Roadmap is available at: https://www.caiso.com/Documents/Vehicle-GridIntegrationRoadmap.pdf.

investments in EVSE. However, the Working Group discussed the entire VGI ecosystem to ensure any recommendations specific to IOU EVSE would be compatible with other actors, devices, and communication pathways necessary for VGI. Working Group analysis found that most VGI use cases will only be achieved through a complete communication path from the Power-Flow Entity (PFE), such as the utility or an aggregator, to the EV, which may or may not include additional actors such as the EVSE.

Through the Working Group process, discussed in detail in the following sections, stakeholders identified hardware performance requirements and recommended communication protocols for EVSE, determined that the potential value of VGI use cases needs further analysis, and potentially additional, large-scale pilots that identify the business case for enabling VGI as a resource.

3. Working Group Process and Results

a. Glossary Sub-Working Group

The Working Group was comprised of participants from a variety of sectors and that use slightly different nomenclature in their respective work. It was important for all participants to use the same terminology when discussing VGI concepts to ensure participants could communicate clearly and precisely. A sub-working group was formed to develop a glossary that included consensus definitions to key VGI terms from a wide selection of resources, including California State Agencies, Federal agencies, and private sector research and glossaries.

More than 12 participants contributed to the terms and definitions sub-working group to develop a common definition for terms widely-used by various participants in VGI research, development and deployment.

The final glossary is available on www.cpuc.ca.gov/vgi as 'VGI Glossary of Terms' under the Deliverables heading.

Terms in the glossary are grouped into the following sections and include a list of reference documents at the end:

- Key terms and context of how they relate to one another
- VGI communication terms
- General and technical terms
- Standards
- Acronyms

b. Use Case Sub-Working Group

Working Group participants submitted potential VGI use cases for consideration, without making any assessments about the costs, benefits, or market readiness of

those use cases. This was intended to allow full consideration of each use case without any ranking that could exclude any use cases at this initial step in the process.

Each use case has specific actors and communication needs associated with it and can deliver value to customers or provide grid services. The intent of evaluating all potential existing and near-term use cases, regardless of their value, was to identify all communication needs and determine whether a specific communication protocol would enable the use cases as a whole.

Working group participants categorized their submitted use cases with all of the relevant tags, some, but not all of which are mutually exclusive, as identified in the VGI Roadmap:

1. V1G: Use cases where charge only flows into the vehicle.
2. V2G: Use cases that allow charge into the electric vehicle battery system as well as discharge of electricity from the electric vehicle battery system.
3. Aggregated: Use cases in which an entity manages more than one load such as over an open vehicle-grid integration platform (OVGIP), Demand Clearing House (DCH), or an EVSE Service Provider.
4. Non-aggregated: Use cases in which an entity manages only one load.
5. Fragmented: Use cases in which the actors involved have different objectives.
6. Unified: Use cases in which the actors involved have the same objective.
7. Other: Use cases that do not fit into any of the above categories.

Members of the sub-working group assessed the accuracy and viability of each use case submitted by stakeholders. Each submitter presented details about their potential use case to this sub-working group, which held 12 meetings and reviewed 77 use case submissions. On average, 26 participants attended each sub-working group meeting.

The sub-working group participants asked use case submitters clarifying questions, which in some instances led to an action or correction and re-submission of the use case. Once all of the reviewing participants came to a consensus about each use case, they also finalized the relevant tags. Some use cases fit into more than one category.

A summary of the use cases that the sub-working group approved is available on www.cpuc.ca.gov/vgi as 'Use Case Summaries Spreadsheet' under the Deliverables heading.

The use cases fall into the following categories:

- Price Programs: These use cases influence drivers' charging habits by changing the price of electricity.

- Demand Mitigation: These use cases attempt to curtail peak demand use from commercial accounts and general service customers by encouraging those customers to charge during off-peak times.
- Direct Current Flow: These use cases focus on public DC charging infrastructure, and could include situations where there are one-way or two-way flows of electricity.
- Vehicle Two-Way Flow: These use cases can influence charging behavior and also allow EV drivers and business owners to use electricity from a car battery. This category includes vehicle-to-grid, vehicle-to-home, and vehicle-to-building use cases.
- VGI Services: These use cases allow actors to access VGI services through the use of telematics, building management systems, network service providers and other pathways. This category includes the VGI Benefit framework terms defined in the Glossary.

c. *Requirements Sub-working Group*

After developing the final list of use cases, the sub-working group identified what information entities must communicate between various actors to actuate the use cases.

Normalization of Terminology

The Requirements sub-working group first normalized the variety of terms used for different actors and types of equipment in the use cases list to ensure consistency in terminology across use cases and assist in analysis across use cases.

Figure 1. Normalized Terminology for VGI Use Case Actors and Equipment

3 entities | 5 equipment items

Decision & Choice Entities			Acting Equipment & Hardware				
EV Driver (EVD)	**Power Flow Entity** (PFE)	**Utility Customer of Record** (UCR)	**EV Battery System** (EVBS)	**DC Power Converter system** (DCPC)	**Electric Vehicle Supply Equipment** (EVSE)	**Energy Meter** (EM)	**Building Management System** (BMS)
Examples of common names used in use-case descriptions:							
• Driver • End User • Owner • Fleet transportation operator	• Aggregator • Utility • EV Service Provider • Energy Service Co. • Alt. Energy Supplier • Energy Portal • Clearing House	• Site Host • Ratepayer • Bill Payer • Home Owner	• Electric Vehicle • EV • BEV • PHEV • PEV	• Inverter • Rectifier • Bi-directional inverter	• Electric Vehicle Supply Equipment • Charger • Level 2 EVSE • Level 1 EVSE	• End-user meter device (EUMD) • Site meter • Sub meter	• Site controller • Building site controller • Energy management system • Home Energy Management System (HEMS)

Once the normalized terms were agreed upon, the sub-working group defined each normalized actor:

1. EV Driver – Individual or entity with authority to determine PEV charging preferences and priorities to meet transportation needs.
2. Power Flow Entity (PFE) – An offsite entity that is requesting or mandating VGI activities from other actors downstream.
3. Utility Customer of Record – Individual or entity identified as the meter customer account holder on the utility records with the authority to determine constraints on the utilization of energy at the meter account location.
4. EV Battery System (EVBS) – The vehicle energy storage management and charge control system that will provide direct interface and communication to process and execute VGI functions.
5. DC Power Converter System (DCPC) – The off-vehicle power converter that controls DC energy flow to or from the EV Battery System.
6. EV Supply Equipment (EVSE) – The equipment that inter-connects the AC electricity grid at a site to the EV.
7. Energy Meter – Measures the PEV charge or discharge (or site) energy. Can exist as a whole-house or whole-facility meter, separate circuit-level submeters, embedded EVSE meters, on-board vehicle meters, and EVSE-embedded meters.
8. Building Management System (BMS) – A collection of sensors and controls intended to automate management of energy flow and use at a site location or facility.

For each of the approved use cases, the sub-working group normalized the terminology for all of the use case actors and equipment to the eight terms identified above.

Identification of Requirements

After the use case descriptions were normalized, sub-working group participants began identifying the requirements necessary to enable those use cases.

There are different types of requirements needed to achieve each use case. These include:

- Functional requirements define specific inputs, behaviors, outputs or other functions needed to accomplish each use case from a system or technology. These include functions such as authentication, authorization, certification, reporting, and data collection.
- Non-Functional requirements define criteria about the use case's operation, rather than specific functions. These include attributes such as scalability, response time, reliability, data integrity, and interoperability and they can describe a system's interface, performance, and usability.
- Customer requirements ensure the customer has control over accepting or rejecting VGI services. These requirements can include interaction with the EV charging equipment, a smartphone or computer app, a building management system, or some other digital interface.

- Alternative requirements are methods of achieving a use case without any specific communication between the EV and the EVSE. For example, a customer can choose to charge at the lowest-cost time frame in its applicable time-of-use tariff, without any specific communication needed. Another example would be the capability of a utility to disconnect an EVSE to reduce its power draw during an emergency.
- Other requirements are any other criteria that could facilitate or improve a use case that do not fall into the four categories defined above.

To identify the necessary or optional communication pathways that could achieve certain requirements, participants considered the actors involved in accomplishing each use case. An actor is any entity who must send, receive, or request information, including companies or persons who will be starting and stopping the flow of electricity. Identifying the actors also helps determine who will control the power flow during the use case, and how it will be controlled. This is influenced by whether the power flow is controlled at the EVSE and/or within the EV itself.

Requirements can be met through communication between different actors in a use case. In some cases, specific communication pathways between specific actors are necessary to meet a requirement. In other instances, certain communication pathways can improve or enhance a use case's outcome, or make it easier to achieve. Participants considered both situations in identifying what, if any, communication pathways apply to each use case's requirements.

Participants also identified some methods to achieve use cases without the use of a communication protocol. These alternatives included an automaker's use of telematics to communicate directly to the car using proprietary software.

Once the group identified each requirement for each use case, they separated the requirements from the use cases, and consolidated the resulting list of requirements to remove any duplicates. The group categorized each requirement as functional, non-functional, customer, alternative requirements, or other.

The final list of requirements is available at www.cpuc.ca.gov/vgi as Final VGI Requirements Consolidated Spreadsheet under the Deliverables Heading.

A summary table indicating which Use Cases fall into each functional requirement category is available at www.cpuc.ca.gov/vgi as Use Case Summary Spreadsheet under the Deliverables Heading.

Most use cases did not involve all of the identified functional requirements or communication between all of the actors identified above.

Analysis of final requirements

The sub-working group determined that functional requirements are the ones that apply most directly to whether or not a protocol can support a use case; therefore the functional requirements should be used for the protocol mapping

exercise in the next step of the process. The functional requirements matrix identifies the communication pathways that must or should occur to meet each requirement. In some instances the communication must be bidirectional. **The final matrix is available at www.cpuc.ca.gov/vgi as 'Functional Requirements Consolidated Spreadsheet' under the Deliverables heading.** The Functional Requirements Matrix ultimately included 11 communication pathways:

1. Power Flow Entity (PFE) and Building Management System (BMS)
2. BMS and Electric Vehicle Battery System (EVBS)
3. BMS and DC Power Converter System (DCPC)
4. BMS and EVSE
5. PFE and EVBS
6. PFE and DCPC
7. PFE and EVSE
8. EVBS and DCPC
9. PFE and EV Driver
10. BMS and EV Driver
11. EVBS and EV Driver

The functional requirements matrix groups the functional requirements into seven categories:

1. Rule 21: communication of information needed to interconnect to the grid, including frequency and voltage, scheduling, dispatch location, and inverter type. These requirements are necessary for batteries to send power back to the grid (V2G).
2. Pricing: communication of different tariffs and variable price programs.
3. Load Control: communication of information needed to respond to demand response signals for specific events.
4. Smart Charging: communication of information needed to schedule charging sessions to maximize benefits for one or more of the actors involved or the grid.
5. Monitoring: communicating information about the charging session, including timing and electricity consumed and dispensed.
6. Restart: communicating information to affect the start of a charging session, including when charging is interrupted, to avoid overloading the electric system.
7. Miscellaneous: communicating other information needed to achieve certain use cases, including GPS location and a user's requirement to charge only when renewable electricity is available.

d. Mapping Sub-working Group

During a full Working Group call, the Facilitator asked participants to identify existing protocols that were in scope for the Working Group. Stakeholders identified eight existing communication protocols to map to the use case functional requirements as identified by the requirements sub-working group:

1. Institute of Electrical and Electronic Engineers[20] (IEEE) 2030.5
2. Telematics[21]
3. Open Automated Demand Response (OpenADR)[22] v2.0b
4. International Organization for Standardization (ISO)[23] 15118 v1
5. CHAdeMO[24] (IEEE 2030-1-1)
6. Charging Network Management Protocol (CNMP)[25] IEEE 2690
7. SAE[26] J3072, J2847, J2931, J1772
8. Open Charge Point Protocol (OCPP)[27] v1.6

---

[20] IEEE is an organization that develops standards through consensus building aimed at advancing technologies by identifying specific functionality, capability, and interoperability standards. More information is available at http://standards.ieee.org/.

[21] Each automaker has its own method of implementing telematics, either using proprietary communication protocols or IEEE 2030.5.

[22] OpenADR is sponsored by the OpenADR Alliance, which was formed in 2010 by industry stakeholders to standardize and automate utility demand response programs using an open software platform. More information is available at http://www.openadr.org/.

[23] The ISO is a non-governmental organization made up of 162 national standards bodies that develops voluntary, consensus-based standards to support technology innovation. More information is available at https://www.iso.org/home.html.

[24] CHAdeMO, an abbreviation of Charge de Move, is the trade name for a protocol for fast charging EV batteries. Available at: https://www.chademo.com/about-us/what-is-chademo/.

[25] This IEEE standard, if finalized and adopted, would define communication between Electric Vehicle Charging Systems and a device or network services system to allow for monitoring, controlling, and communicating parameters of charging sessions. More information is available at https://standards.ieee.org/develop/project/2690.html

[26] SAE International is a global association of engineers and technical experts in the aerospace, automotive and commercial-vehicle industries.

[27] OCPP is sponsored by the Open Charge Alliance, and offers a uniform method of communication between a charge point and a network operator or utility system.

Footnote continued on next page

While the Mapping Sub-Working Group discussed CNMP/IEEE 2690, it was ultimately not considered because it is still under development, and so it is outside the scope of this Working Group.

The Working Group identified seven viable protocols that are currently available, and a subject-matter expert (SME) for each developed a diagram demonstrating which of the functional requirements each protocol is able to support via various communication pathways. The SMEs created diagrams to show how each protocol supports communication between various actors and completed a revised version of the Functional Requirements Matrix to indicate whether each protocol can support the requirement by itself, in combination with another protocol, or not at all.

The separate diagrams and matrices are available at www.cpuc.ca.gov/vgi within the Mapping Sub-Working Group Zipped Files under the Deliverables heading.

A document with all of the protocols considered by the Working Group and their various associated communication pathways is available at www.cpuc.ca.gov/vgi as 'Mapping Diagrams Summary' under the Deliverables heading.

During this mapping process, it became clear that many communication protocols could support most, but not all, of the functional requirements. To achieve communication between the PFE and the EV, multiple pathways are available, including using combinations of currently available communication protocols that are specialized for different purposes. In several instances, data structures and/or function sets could be repurposed to achieve a functional requirement not originally addressed by individual protocols. There are a variety of combinations of protocols that can meet most or all of the requirements and communicate a message between the PFE and the EV or vice versa. Through the course of the Working Group, it became clear there is not one best path to communicate between the PFE and the EV that should be required at this time. During the Working Group's stakeholder meetings, and in individual follow-up conversations, the participating automakers provided an indication of what protocols they are likely to implement over the next ten years. Their responses are included in **Table 2.**

Version 2.0 is currently being finalized. More information is available at http://www.openchargealliance.org/.

Table 2. Protocols included in participating automakers' 10-year time horizon

Automaker	AC Conductive	DC Conductive	Wireless Inductive
BMW	ISO 15118 (HomePlug Green PHY)	ISO 15118 (HomePlug Green PHY)	ISO 15118
Fiat Chrysler	IEEE 2030.5	ISO 15118 (HomePlug Green PHY)	WiFi, ISO 15118 Ed.2
Ford	Telematics & ISO 15118 (future)	ISO 15118 (HomePlug Green PHY)	ISO 15118 Ed. 2
GM	No High Level Communication	DIN Spec, no timeframe for ISO/IEC	WiFi and Telematics
Honda	TBD High Level Communication, V2G	DIN Spec / ISO 15118, V2G	Premium product
Lucid	ISO 15118 (HomePlug Green PHY)	ISO 15118 (HomePlug Green PHY)	
Mercedes Benz	ISO 15118 (HomePlug Green PHY)	ISO 15118 (HomePlug Green PHY)	J2954/ ISO 15118
Nissan	Telematics	ChaDeMo	In development
Porsche/Audi/Volkswagen	ISO 15118 (HomePlug Green PHY)	ISO 15118 (HomePlug Green PHY)	ISO 15118 (in development - 2018)

Many EVSPs stated that currently available hardware is more likely to be capable of supporting ISO 15118 than other protocols considered by the Working Group, but that options for hardware that supports other protocols or multiple protocols are in development.

More details from these discussions with automakers and EVSPs are included in the **Meeting Notes from the October 30, 2017, meeting available at www.cpuc.ca.gov/vgi under the Meeting Materials heading**.

e. Assessing Costs and Benefits

While the Mapping Sub-Working Group process was ongoing, another Sub-Working group formed to consider the costs and benefits associated with each use case, and whether the implementation of specific protocols affects those costs and/or benefits. The goal of this exercise was to assess whether a communication protocol, a combination of protocols, or an alternative to a protocol, could generate the greatest benefits for the set of use cases as a whole.

The State Agencies planned to identify costs and benefits broadly, without assigning specific numerical values, given that costs associated with protocols and benefits associated with use cases are going to evolve over time. Even with

that precaution, only a limited number of Working Group participants shared cost data with the group. This was due to competitive and anti-trust concerns and/or lack of data availability.

The Working Group found more time is needed to evaluate which VGI solutions will best accelerate EV adoption. Some automakers and service providers identified certain protocols that will be deployed regardless of the outcome of the Working Group, but others expressed a need for better understanding of the value of some VGI use cases to create a business case for implementing the hardware and software necessary to enable VGI at scale. Working Group participants suggested large-scale pilots could test implementation of different communication protocols and help to identify the costs and benefits associated with each use case, which could feed into a broader assessment of VGI value in the future. This could be incorporated in future state-sponsored research projects, but Working Group participants should also identify additional funding to undertake these large-scale pilots.

4. Assessment of Communication Protocols' Abilities to meet Requirements

Based on Working Group results, Energy Division staff determined it is too early to require the IOUs to implement a single existing protocol or combination of protocols to best enable widespread, economic VGI. Markets, protocols, and technology are rapidly developing, and at this time we do not want to preclude any protocols or use cases that can deliver VGI value. While there are some use cases that do not require any high-level communication protocols and other use cases that can be enabled with a single protocol, others are possible only with a combination of protocols.

The Working Group's documentation suggest that IEEE 2030.5 supports most of the use cases identified by stakeholders and can complete the communication end-to-end from PFE to EV without the need for an additional communication protocol. However, stakeholders were unable to reach consensus to support selecting IEEE 2030.5 as a required protocol for several reasons. First, other protocols have been developed to communicate specialized information between specific actors. For example, a utility could use OpenADR to communicate real-time pricing to a network service provider, which then uses OCPP to communicate a price schedule to the EVSE, which uses ISO 15118 to conform a charge rate that is consistent with a driver's preferences, which were communicated to the EVSE by the EVBS. Second, vehicle telematics may also be capable of supporting communication between a PFE and EVBS without using the IEEE 2030.5 protocol.

Figure 2. Diagram of Communication Pathways

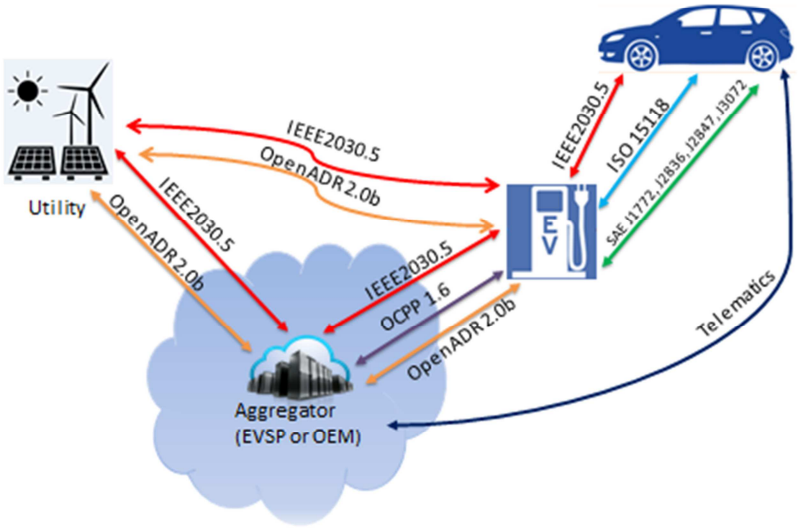

Table 3. Mapping Sub-Working Group Summary Table

Functional Requirements Category	OpenADR	IEEE 2030.5	OCPP	Telematics	SAE Suite	IEEE 2030.1.1	ISO 15118
Rule 21	Not Supported	Supported	Not Supported	Supported in Combination	Supported in Combination	Supported in Combination	Not Supported
Pricing	Supported	Supported	Not Supported	Supported in Combination	Supported in Combination	Supported in Combination	Supported in Combination
Load Control	Supported	Supported	Supported in Combination	Supported in Combination	Supported in Combination	Supported in Combination	Supported in Combination
Smart Charging	Supported in combination/ Not Supported	Supported	Not Supported / Supported in	Supported in Combination	Supported in Combination	Supported in Combination	Supported in Combination
Monitoring	Supported in Combination	Supported	Supported in Combination	Supported in Combination	Supported in Combination	Supported in Combination	Supported in Combination
Restart	Supported	Supported	Not Supported	Supported in Combination	Supported in Combination	Supported in Combination	Supported in Combination
Miscellaneous	Not Supported	Not Supported	Not Supported	Supported in Combination	Not Supported	Supported in Combination	Not Supported

5. Discussion of Hardware Requirements

Based on the Working Group results, staff from CPUC, CARB, CEC, CAISO, and GO-Biz developed a recommendation for the IOUs' infrastructure investments. These are intended to be minimum requirements to enable EVSE to accommodate various protocols that may be needed upon installation or at a future time to participate in VGI programs and services.

While the Working Group did not come to a consensus on a specific communication protocol or protocols to require for the IOU infrastructure investments, it became clear through discussions and analysis that many of the protocols require similar hardware platforms.
Given our finding that it is premature to select a single protocol, or combination of protocols, at this time, and the similarities identified in hardware platforms, we recommend hardware performance requirements that allow EVSEs to accommodate the multiple communication protocols that may be used to enable VGI. The goal of this recommendation is to identify the necessary EVSE hardware functionality that will enable the VGI use cases that stakeholders identified through the working group process.
Rather than set specific hardware requirements, Energy Division staff worked with ARB, CEC, CAISO, and GO-Biz to identify the minimum hardware performance requirements that should be included in the IOU's relevant infrastructure investments. Utilities and other Working Group participants expressed concerns about requiring a single, specific technology, based on the lessons learned from the IOUs' installations of Zigbee-based advanced metering infrastructure.
Each installation of charging infrastructure will be site-specific, and the site hosts and network service providers will ultimately customize the implementation of these hardware requirements by choosing their preferred communication pathways and associated protocols. Sites may choose to include additional hardware within the EVSE beyond these minimum requirements.
This approach combines the flexibility to ensure future usability with the certainty that manufacturers of charging stations need to invest in producing products. Based on Working Group discussions and limited data provided by EVSE manufacturers and services providers and automakers, we expect the incremental hardware costs of meeting the hardware performance requirements to be relatively small.

a. Scope of Hardware Performance Requirements

The scope of these requirements is limited to Level 2, alternating current (AC), conductive, multi-user EVSEs due to the following:

- Level 2, AC justifications
    - Level 1 EVSEs are unlikely to have a duty cycle that justifies the expense of enabling VGI in the EVSE hardware, because drivers will likely need to receive full power for their entire charging session to be fully charged.
    - There is currently more opportunity for VGI in long dwell time scenarios typically associated with L2 AC charging and not with DC fast charging.

  - The Working Group did not have enough time to fully evaluate what hardware may be required for best managing DC Fast Charging.
  - This proposal does not prohibit investments in DC charging technologies that can be designed or controlled to provide grid-integration functions. The working group did not assess DC slow charging, nor are there any IOU proposals for DC slow charging pending CPUC approval.
- Conductive charging justifications
  - The IOUs transportation electrification applications before the CPUC include proposals for conductive charging infrastructure. None have proposed inductive (i.e. wireless) charging.
  - Inductive charging is a technology that is rapidly developing, but not widely commercially available; therefore the Working Group did not consider this technology in its discussions.
- Multi-user justifications
  - For single-user EVSEs in locations with restricted use – such as single-family residences– the additional hardware may provide minimal additional benefits, any may not be worth the additional costs. Projects supporting these types of users should be evaluated on a case-by-case basis.
  - Public/multi-user EVSEs have less predictable use patterns than residential and private workplace EVSE and can benefit from additional high-level communication.
  - Public/multi-user EVSEs must be capable of providing pricing information and receiving charging instructions from multiple users.
- This recommendation does not apply to the design of an electric vehicle; therefore it does not restrict, limit, or determine the use of vehicle-based technologies (e.g. telematics) in providing grid integration functions between the Utility and EV.
- This recommendation is intended to represent the minimum requirements necessary for infrastructure supported by the IOUs with ratepayer investments. Site hosts can choose additional hardware beyond these requirements depending on their specific needs.
- Cybersecurity, metering, and software development costs may be additional to any hardware costs incurred to meet these functionality requirements.

Table 4. Minimum Hardware Functionality Requirements for Level 2, AC, conductive, multi-user EVSEs to support the protocols necessary to enable VGI

Domain of Communication	Hardware Functionality/Physical Layer	Description
Power Flow Entity to EVSE	Either IEEE 802.11n interoperability OR IEEE 802.3 interoperability	Hardware should include wireless networking transmission capability with multiple antennae to increase

		data exchange speeds, and meet or be interoperable with IEEE 802.11n requirements. Ethernet connection should meet or be interoperable with IEEE 802.3, and can include Local Area Network and Wide Area Network applications.
	Field upgradable	Ensures utility or network service provider can provide software updates remotely, without hardware modifications or site visits
	Sufficient processor power to perform real time protocol translation and encryption/decryption, supporting IP stack	Processor must be able to accommodate multiple communication protocols to allow for flexibility in implementation
	Interface that provides hardware extensibility	Ensures the installed hardware would not be affected, or would only be minimally affected, if new or modified functionality is added
	Form factor that supports extensibility via Internet Protocol version 6	Use of IPv6 will allow for third party management of EVSE
EVSE to EV	HomePlug Green PHY for conductive EVSE	The physical layers that support the protocols the working group identified

We have identified hardware requirements between the EVSE and the PFE, and between the EVSE and EV. There is still opportunity for growth in each area and we understand that protocols specialized in each segment are necessary to enable a broader set of VGI controls by working in concert with the others.

PFE to EVSE requirements are important because the agencies would like to avoid stranded assets and enable load management functionalities immediately. PFE to EVSE communication should use Internet Protocol to enable remote management and flash capabilities that allow for updates to each of the EVSEs when they are deployed (field upgradable) and if market forces dictate the change. The hardware should enable these communication protocol updates to occur without any site visits or changes to the hardware platform.

The EVSE to EV requirements ensure vehicles are charged to meet drivers' needs by enabling the transfer of high-level communication.[28]

The Working Group also discussed an alternative to including all hardware requirements on each EVSE: an external protocol converter can be used to control multiple EVSEs. In this case, the external protocol converter must meet all of the hardware requirements identified in Table 4. Under this architecture, each EVSE does not directly communicate to the third party, rather, the EVSE is part of a networked group that communicates an individual EVSE's connection to the external protocol converter. Under this architecture, each EVSE communicates to the external protocol converter, which then communicates to a third party such as an electric vehicle service provider (EVSP), aggregator, or PFE.

The Working Group explored different metering requirements and cybersecurity requirements for the EVSE, which are two important components to fully enable VGI. However, Energy Division staff do not have enough information at this time to identify requirements in these areas and will focus on metering and cybersecurity in future discussions and VGI work.

As applicable to their specific pilots and programs, the utilities should work with their Program Advisory Councils or Advisory Boards to determine what kind of documentation is necessary to demonstrate that an EVSE meets the required hardware functionality and develop a clear and streamlined process for ensuring that EVSE they support with ratepayer funding contains this hardware functionality. Documentation could include certification sheets, parts list, or item data sheet.

[28] "High Level Communication" (HLC) refers to driver authentication, clearing, and smart charging coordination information parameters. Select HLC parameters are described in the Functional Requirements.

b. Recommended Protocols to Enable VGI

We acknowledge that hardware alone is not sufficient to enable VGI and that communication protocols will also be necessary. In addition to hardware and communication protocols, new market opportunities, clarity across wholesale and retail rate structures, performance measurement, tariffs, and policies will be necessary to enable some VGI use cases.

Based on Working Group discussions with communication protocols subject matter experts, automakers, and EVSPs, staff from CPUC, CARB, CEC, CAISO, and GO-Biz identified the leading communication protocols that are currently available to support various communication domains.

Staff does not think it is appropriate to mandate specific communication protocols at this time. To enable VGI through different domains of communication in the near-term, however, staff recommends the currently available protocols documented in Table 5, with no particular ranking or order.

Table 5. Recommended Protocols to Enable VGI High Level Communication for Level 2, AC, conductive, multi-user EVSEs

Domain of Communication	Recommended Protocols Currently Available*
PFE to EVSE	One or a combination of the following: 1. OpenADR 2.0b 2. IEEE 2030.5 3. OCPP 1.6
EVSE to EV	One or a combination of the following: 1. ISO 15118 v1 2. IEEE 2030.5
Vehicle OEM to EV	Telematics (using proprietary protocols or IEEE 2030.5)

* The current versions of these protocols, as listed here, serve as a minimum threshold. Future versions of the protocols are expected to also meet use case requirements. This table assumes that all EVSEs have J1772 pulse width modulation capabilities for low-level communication. Other PFE to EVSE protocols, including IEEE P2690[29] and IEC 63110[30] were identified by

[29] This IEEE, if finalized and adopted, would define communication between EVSE systems and a device, services, and network management system typically based "in

Footnote continued on next page

stakeholders, but were not discussed in detail during the Working Group because they are still under development.

In addition, while not germane to EVSE communication, some stakeholders have identified the potential to use telematics for communicating information between the vehicle automaker and the EV using either automaker proprietary protocols or IEEE 2030.5.

Working Group participants have suggested some homogenization of functionality is occurring among the protocols listed above, such as increased conformance between many communication functionality elements of the ISO 15118 Edition 2,[31] OCPP 2.0[32] (which is under review after a round of public comments), and SAE's suite of software to communicate between the EV and the vehicle OEM. It is unknown at the time of this report how exactly these efforts will improve how ISO 15118 can interface with the OCPP protocol and SAE protocols. However, both appear to better accept the functionalities associated with the implementation of ISO 15118 if such modifications are incorporated in the next versions approved by their applicable standards bodies.

6. Next Steps

The state agencies aim to build upon the momentum established in this Working Group to continue discussions and analysis that will inform future policy decisions going forward. Each of the agencies will consider the outcomes of this Working Group as applicable to their jurisdiction and regulatory processes, but

---

the cloud" but potentially interfaced with site-specific components (e.g. BMS). More information is available at https://standards.ieee.org/develop/project/2690.html

[30] This IEC standard, if finalized and adopted, would define communication for management of Electric Vehicle charging and discharging infrastructures. More information is available at http://www.iec.ch/dyn/www/f?p=103:38:32661914925202::::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:1255,20,100390.

[31] ISO 15118 is currently under review. More information is available at https://www.iso.org/standard/69113.html.

[32] The most recent draft of OCPP 2.0 is available at http://www.openchargealliance.org/protocols/ocpp/ocpp-20/.

will coordinate efforts to further evaluate the value of VGI and identify policies that help it scale where feasible.
Many stakeholders identified issues or recommendations that arose during the Working Group process that need additional action from State Agencies through future VGI efforts. These include:

- Identifying the most prominent use cases
- Deploying large-scale pilots to test implementation of various communication protocols and identifying required funding Assessing the value, including costs and benefits, of different use cases in providing VGI services to different markets and at various charging locations
- Identifying funding sources or consultants to help guide a statewide analysis of VGI issues
- Coordinating with other CPUC distributed energy resource efforts, such as Storage Multi-Use Applications and Distribution Resource Plans. Each of these efforts, along with the VGI efforts, seek to identify nascent or new markets to support emerging grid resources.
- Focusing on a seamless experience for drivers and measuring rates of driver participation in VGI programs
- Looking at big data analytics, understand what data is public versus private, and identify ways to use such analytics to audit performance, enable billing/settlement, and attribute value to the appropriate actor(s)
- Addressing load management at the neighborhood level, or at the beginning of a time-of-use off-peak period
- In collaboration with the CAISO, studying the nature of wholesale price volatility
- In collaboration with utilities, study utility distribution costs and opportunities

a. Incorporation into CPUC Proceedings

Energy Division staff participated in this Working Group to determine how a recommendation could apply to IOU proposals before the Commission.
The scope of the hardware requirement included in this final report is limited to Level 2, alternating current (AC), conductive, multi-user EVSEs. Therefore, Working Group participants suggested that the recommendation does not apply to any of the current SB 350 standard review[33] proposals SDG&E, SCE, and PG&E included in A.17-01-020, et al. During the final Working Group meeting, SDG&E and PG&E specifically discussed each of their light-duty charging

[33] In A.17-01-020, the three large utilities proposed programs with smaller scopes and budgets that were reviewed on an expedited, "priority review," basis and some were approved in D.18-01-024. The utilities' other, larger-scale proposals are currently under review through the CPUC's "standard review" process.

infrastructure proposals. SDG&E stated that for their proposed Residential Charging Infrastructure proposal, they are proposing Level 2 EVSE that are wifi enabled and support field upgrading of software. SDG&E also stated that it would likely require the most recent versions of OCPP and OpenADR on the EVSE.

Working Group participants generally agreed that for PG&E's DC Fast Charge Infrastructure proposal, which would support both CHAdeMO and J1772 CCS connectors, the CHAdeMO and J1772 communication are sufficient for any use cases that would occur at these DCFC sites, and no additional hardware or software requirements would be necessary.

Additionally, the standard review proposals of Bear Valley, Liberty Utilities, and PacifiCorp included in A.17-06-031, et al. do not fall within the scope of the recommendation. As further described in Table 6 staff agrees that the recommendation based on the Working Group results should not apply to the current SB 350 standard review proposals.

Table 6. Applicability of Recommendation to Current SB 350 Standard Review Proposals

Utility	Standard Review Proposal	Does Hardware Requirement Apply?	Explanation
SDG&E	Residential Charging Infrastructure	No	Single-user residential applications are out of scope
SDG&E	Commercial & Residential Grid Integration Rates	No	Rate design only; does not include infrastructure
SCE	MD/HD Charging Infrastructure	No	Medium- and Heavy-duty sectors are out of scope
SCE	Commercial EV Rate Design	No	Rate design only; does not include infrastructure
PG&E	FleetReady Make-Ready Infrastructure	No	Medium- and Heavy-duty sectors are out of scope
PG&E	Fast Charge Infrastructure	No	DC fast charging is out of scope
Bear Valley	EV TOU Rate Pilot	No	Not providing or qualifying EVSE

Liberty Utilities	EV Bus Infrastructure Program	No	Medium- and Heavy-duty sectors are out of scope

Future Applications

Staff suggests that for any future utility applications for transportation electrification the Commission receives, the Commission consider in each respective proceeding whether the hardware requirement contained in this report should apply to a utility proposal. The Commission should also consider whether any aspects of the hardware requirement need to be modified for a specific utility project.

The Commission may decide, at a later time, to revise the hardware requirements contained in this report based on new information or market developments.

Working group participants encouraged the CPUC to align its VGI efforts across all proceedings that are focused on identifying the IOUs' future resource portfolio, including the California Energy Storage Roadmap[34] and the Integrated Resource Plan.[35]

b. VGI Roadmap 2018 Update

The CEC's Fuels and Transportation and Research and Development Divisions are leading an update of the VGI Roadmap,[36] in coordination with the other state agencies, and preliminarily anticipate completion of a revised roadmap before the end of 2018. The CEC discussed a variety of issues related to VGI within its

[34] R.15-03-011. Documents available at https://apps.cpuc.ca.gov/apex/f?p=401:56:0::NO:RP,57,RIR:P5_PROCEEDING_SELECT:R1503011.

[35] R.16-02-007. Documents available at https://apps.cpuc.ca.gov/apex/f?p=401:56:0::NO:RP,57,RIR:P5_PROCEEDING_SELECT:R1602007.

[36] Stakeholders interested in participating in the VGI Roadmap update process can subscribe to CEC Service List 'VGI Communications.' Go to www.energy.ca.gov/listservers/.

Integrated Energy Policy Report[37] that will be addressed as part of the Roadmap update.
CEC's Integrated Energy Policy Report process identified several areas of interest including:

1. Technical
    a. Cybersecurity
    b. Dispatchability
    c. Operations of programs
    d. Battery standards
2. Economic
    a. Infrastructure modeling
    b. Value assessment and return to customers
    c. Demonstrations
    d. Commoditization of equipment
    e. Unbundling of services
3. Policy
    a. Interactions between CEC, CARB, and CPUC regulations
    b. Fleet procurement
4. Customer-Focused
    a. User interactions and interfaces
    b. Needs
    c. Behavior
    d. Disadvantaged community impacts

CEC anticipates the Roadmap update will coordinate with recent and ongoing staff reports and findings regarding charging demand modeling and infrastructure deployment strategies.
CEC staff is also developing a Transportation Electrification Research Roadmap,[38] independent but complimentary to the VGI Roadmap, to identify and prioritize which advanced technologies identified during VGI research reviews and market assessments will lead to accelerated adoption of electric vehicles and VGI services.

---

[37] CEC's current 2017 Integrated Energy Policy Report docket can be found at http://www.energy.ca.gov/2017_energypolicy/.

[38] Stakeholders interested in funding opportunities supported by EPIC and ARFVTP can subscribe to the CEC Service Lists 'Research,' 'Epic,' and 'Altfuels.' Go to www.energy.ca.gov/listservers/.

c. Other State Agency VGI Work

CARB will continue coordinating with ongoing VGI work as it develops its charging station interoperability standards, as required by SB 454. CARB has also offered to hold voluntary, quarterly meetings regarding value, with each meeting's topic coordinated with the CEC-led VGI Roadmap update. CARB currently expects the first meeting to be in March 2018.[39]

CAISO continues to work on demand response and storage enhancements through the Energy Storage and Distributed Energy Resources Initiative (ESDER)[40] Stakeholder Initiative, which aims to identify and lower the barriers currently limiting energy storage and distributed resources from participating in the CAISO markets. It is currently in Phase 3, which aims to expand opportunities for energy storage and distributed resources to serve as generation resources and load consumption/demand response resources. Aggregators who are able to take advantage of hardware and communication protocol standards should be able to further build and improve a business case for electric vehicle participation in the wholesale markets. Today, EV resources are included in wholesale demand response aggregations and have the ability to become a resource within an ISO to provide wholesale and ancillary services. The CAISO is planning to release a policy paper on the ESDER 3 initiative in March 2018. CAISO also continues to work with utilities to help establish a utility interconnection path for aggregated distributed energy resources to participate in the CAISO market through the DERP framework, and collaborating with the CPUC on a multi-use framework for DER.

GO-Biz will continue its interagency coordination to facilitate the expansion of charging infrastructure needed to meet the Governor's aggressive target of 5 million zero-emissions vehicles on California roads by 2030.[41]

---

[39] Contact Stephanie Palmer at stephanie.palmer@arb.ca.gov to join the list of quarterly call participants

[40] More information about CAISO's ESDER 3 Stakeholder initiative is available at https://www.caiso.com/informed/Pages/StakeholderProcesses/EnergyStorage_DistributedEnergyResources.aspx

[41] Executive Order B-48-18 raised the state's ZEV mandate from 1.5 million cars by 2025 to 5 million by 2030. Available at: https://www.gov.ca.gov/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/.

The California Department of Food & Agriculture's Division of Measurement Standards is developing a regulation to ensure electricity dispensed as a fuel is accurately measured.[42] The draft regulation references a section of the National Institute of Standards and Technology's Handbook 44.[43] If the IOU infrastructure investments are supporting EVSE that is owned and operated by a third party and commercially selling electricity, those EVSE would need to meet the requirements set out in Handbook 44.[44] However, if an IOU also owns the EVSE, the Handbook 44 requirements would not apply. The CPUC will continue working with other state agencies and industry stakeholders to determine whether any specific metering requirements should be established for IOU investments not covered by DMS regulations: IOU-owned EVSE, or where there is IOU support for charging infrastructure but no commercial sale of electricity. The CPUC, CEC, CARB, CAISO, and GO-Biz will also continue to investigate cybersecurity issues to identify best practices for maintaining customer privacy and providing information security. Working Group participants suggested any cybersecurity standard would be national or global, and that the state should seek further information from subject matter experts rather than conduct these discussions on a California-specific basis.

[42] Assembly Bill 808, Ridley-Thomas, Chapter 591, Statutes of 2015.

[43] NIST is a division of the US Department of Commerce. Handbook 44 is available at https://www.nist.gov/pml/weights-and-measures/nist-handbook-44-2018-current-edition.

[44] California Code of Regulations, Title 4, Division 9, Article 2.2. Available at https://govt.westlaw.com/calregs/Browse/Home/California/CaliforniaCodeofRegulations?guid=I86947E30D45911DEA95CA4428EC25FA0&originationContext=documenttoc&transitionType=Default&contextData=(sc.Default).

Appendix A: California Energy Commission recommended EVSE Performance Attributes

CEC actively participated in the interagency staff discussions related to the development and refinement of the above-required hardware functionalities and recommended communication protocols. CEC staff stated their concerns, however, that EVSE designed only with the list of hardware functionalities identified –and if not implemented with select communication protocols at the outset of an investment consistently across all charging location segments— will likely forego the immediate opportunity to achieve maximum possible VGI benefits needed to support EV adoption. During the December 18, 2018 Working Group meeting, CEC staff presented recommendations that any EVSE requirements considered should operationalize three performance attributes further detailed below. CEC considers these attributes essential within EVSE to remain highly-functional and resilient to changes in grid operational conditions at the transmission and distribution levels, and technologies used in the automotive and charging sectors.

1. Speed – EVSE, as part of PFE to EV communication, must be capable of meeting requirements for participating in CAISO ancillary services market for Frequency Regulation (i.e. Regulation Up and Regulation Down) and Frequency Response[45], consistent with CAISO's existing business practices, identified below, and localized voltage fluctuations and transformer loading conditions on distribution systems affected by the clustering of EV adoption, high penetrations of photovoltaic generation and Zero-Net Energy policies.
    - Frequency Regulation: Through its EVSE, an EV responds to PFE or Scheduling Coordinator-based load control signals following automatic generation control (AGC) set-points that change at 4-second intervals. The CAISO transmits AGC set-points to its certified resource[46] via a Scheduling Coordinator to a DER Provider responsible for dispatching commands to its EVSE and EV sub-resources to match the CAISO's AGC set-points.

[45] https://www.caiso.com/Documents/IssuePaper_FrequencyResponsePhase2.pdf

[46] Resources may be heterogeneous including non-EV facility load or an aggregation of EVs.

- Frequency Response: The EVSE/EV must provide a rapid (low latency) response to stabilize the interconnection frequency following the sudden loss of generation or load, per the FERC Order 794 reliability standard.

2. Measurement – EVSE must have metering equipment to enable the measurement and verification of Electric Vehicle credits pursuant to the CARB Low Carbon Fuel Standard,[47] and of electricity consumption necessary to enroll with EV-specific charging electricity tariffs enabled through the CPUC development of the Submetering Protocol.[48]
    - The EVSE must have accuracy compliance to NIST Handbook 44 – Section 3.40 Electric Vehicle Fueling System, sections S.8. Minimum Measured Quantity, N.5.2. Accuracy Testing, and S.3.1. Metrological Components.[49]
3. Customer Simplicity – To avoid having incompatible charging interfaces become a barrier to mass adoption and reduce the potential for EV driver attrition from grid integration programs, vehicles must be able to connect to EVSE capable of high level communication that maintains Customer Requirements *regardless* of the location of the EVSE (public, work, and home), the service provider network, or the utility territory.
    - The EVSE should be able to communicate directly, or conform its operation based on information sent to a PFE, including: driver opt-outs, energy and operational mode preferences, customer responses to charging status or event pricing, customers' willingness to pay for immediate charging (or conversely, receive free charging in exchange for curtailment), and/or information gathered by the EVBS.[50]
    - The EVSE must have the capability seamlessly facilitate the driver's ability to authenticate their identity, vehicle, and account preferences securely to

[47] https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/110617presentation.pdf

[48] http://www.cpuc.ca.gov/general.aspx?id=5938

[49] During Working Group discussions, Handbook 44 - 3.40 Table S.3.3 Categories of Device and Methods of Sealing and the business process requirements to establish audit trails were identified as a potential cost barrier. However, meter accuracy requirements listed above were generally identified as a feasible for commercially-available EVSE.

[50] As defined, but not limited to those listed by the Requirements subgroup as C 3.01, C 3.02, C 3.03, C 3.04, and C 3.05 at http://cpuc.ca.gov/vgi/.

initiate charging regardless of the location of the charger in order to avoid negatively affecting the charging site host.

CEC identified that these performance attributes will enable continuous learning of customer preferences and flexibility potential from chargers that are deployed on the widespread scale necessary to support adoption. The CEC values continued participation with the agencies and the industry participants to support VGI-capable charging and vehicle technologies to maximize benefits for customers.

(END OF ATTACHMENT)