

VGI Communication Protocol Working Group Energy Division Staff Report

**Energy Division
California Public Utilities Commission
October 2018**

This report reflects the CPUC Energy Division Staff's recommendations following a collaborative effort involving many staff across multiple agencies and informed by stakeholder participation in numerous meetings, webinars, workshops, and work products over the course of a year. Such efforts and engagements have been essential to the formation of content and recommendations contained within.

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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 investigate 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 overarching goal is to reduce emissions both by incentivizing the switch from fossil fuel vehicles to zero-emission vehicles (ZEVs) 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 Energy Division staff recommendations 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. However, Energy Division does provide certain hardware performance recommendations intended to enable the market to trial and potentially converge on a protocol in the future.**

The Working Group identified a large number of potentially valuable VGI use cases but did not have enough information to develop a comparison or ranking of the use cases based on the relative value – to drivers, ratepayers, automakers, utilities, the grid operator, and other stakeholders. While the State Agencies’ original Work Plan¹ included a deliverable to assess the costs and benefits associated with each use case, the Working Group did not have the information available to assess the value of various VGI use cases. The Working Group amended the Work Plan to allow progress to continue without assessing the relative value of the VGI use cases.

Further evaluation of 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 Roadmap² and conducting ongoing research through its administration of Electric Program Investment Charge³ 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 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 for enabling VGI. This approach ensures future usability of the EVSE in most, if not all, future charging scenarios, while providing certainty that manufacturers need to identify a business case associated with developing and producing VGI-enabled products.

Energy Division staff believes the CPUC should consider applying the recommendations to all relevant future IOU applications. We recognize there may be additional costs associated with meeting the recommendations, and that in some use cases, the communication facilitated by the recommended hardware and software may not be necessary upon initial deployment. Meeting the requirements, however, will ensure ratepayer-funded EVSE will have the inherent ability to communicate real-time grid conditions.

This report summarizes the information and analysis completed by the full Working Group from April to December of 2017, and includes some additional information supplied by Working Group participants as comments and reply comments to the draft Staff Report that was issued on February 23, 2018.⁴

¹ The Working Group’s initial work plan was based on the state agencies’ straw proposal, available at <http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442456400>.

² The CEC’s docket for the 2018 VGI Roadmap update is available at <https://www.energy.ca.gov/transportation/vehicle-grid-integration/>

³ More information about the EPIC program is available at <http://www.cpuc.ca.gov/energyrdd/>

⁴ The draft Staff Report and the comments/reply comments are all available at www.cpuc.ca.gov/vgi.

The Working Group's efforts will contribute to other ongoing state agencies efforts to support VGI, including the CEC's 2018 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

This section details the regulatory history of the state's VGI policy efforts and the evolving process and scope of the Working Group. The Working Group launched as an effort in support of the VGI Roadmap's direction to establish consistent requirements for EVSE⁵. The Working Group did not prioritize which use cases should be implemented. The Working Group participants presented divergent opinions regarding whether a regulatory mandate of a specific protocol for IOU investments in EVSE is necessary in order to grow the VGI market at this time.

While the Working Group did not come to a consensus on communication protocols as anticipated, the process escalated the conversation among all stakeholders and identified the data and information gaps that need to be closed before VGI use cases can be implemented economically and at scale.

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 the state install the infrastructure to support 1 million ZEVs by 2020, and include electric vehicle charging that "will be integrated into the electricity grid." This order and the subsequent 2013 Zero-Emission Vehicle Action Plan⁶ 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 adversely impact the electric grid, particularly if charging is not managed. In an effort to mitigate 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 customer's home or commercial 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 utilities' distribution upgrade and maintenance investments, and/or mitigate wholesale energy prices.⁷

Two related documents have led California's policy development in VGI: the 2014 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 on Vehicle-Grid Integration included in the Alternative-Fueled Vehicles rulemaking, R.13-11-007.

⁵ Vehicle Grid Integration Roadmap, page 5 <http://www.caiso.com/Documents/Vehicle-GridIntegrationRoadmap.pdf>

⁶ The ZEV Action Plan was updated in 2016. https://www.gov.ca.gov/docs/2016_ZEV_Action_Plan.pdf.

⁷ Several examples of pilot programs that attempted to demonstrate the potential value of VGI through managed charging are available through the VGI and ZEV Infrastructure pilot survey conducted by the CPUC in 2018. The survey results are available as a downloadable and sortable Excel database at www.cpuc.ca.gov/zev/#Resources.

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."⁸ In particular, it notes how existing communication standards will be required to send messages between the VGI resource, aggregators, and utilities.⁹

In September 2016, the Assigned Commissioner's Ruling in R.13-11-007¹⁰ stated an intention to overcome barriers to effective VGI, particularly as the utilities were ordered to prepare applications to accelerate widespread transportation electrification pursuant to Senate Bill 350. In an attached whitepaper on VGI, CPUC Energy Division staff considered options for the adoption of a VGI communication standard in order to achieve technology development and system reliability objectives, and initially recommended the use of the International Organization for Standardization and International Electrotechnical 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 various means of vehicle-to-grid communication including charging or home area networks, an Open Vehicle-Grid Integration Platform,¹¹ and vehicle telematics, and the different communication protocols that support the different communication pathways. There was no consensus among stakeholders on which, if any, specific communication protocol or pathway 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 this working group to continue discussions with stakeholders.

⁸ VGI Roadmap at 11.

⁹ VGI Whitepaper at 30 and 34

<http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M080/K775/80775679.pdf>.

¹⁰ Assigned Commissioner's Ruling in R.13-11-007 is available at

<http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M167/K099/167099725.PDF>

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, meet greenhouse gas reduction goals, and increase access to electric vehicles across the state. In compliance with this requirement, in September 2016, the CPUC directed the state's six investor-owned utilities¹² to file applications proposing programs to accelerate transportation electrification. The CPUC in 2018 authorized nearly \$750 million in IOU transportation electrification infrastructure programs and is currently reviewing eight proposals for another nearly \$1 billion in additional investment programs.¹³

In some of the proposed projects, the IOUs would directly purchase and own the EVSE, while in other proposals the IOUs would qualify specific EVSE models that customers may purchase and install. 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 740.12. 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 funded through the Electric Program Investment Charge (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,¹⁴ 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 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.

¹² There are six electric IOUs in the state: San Diego Gas & Electric, Southern California Edison, Pacific Gas and Electric, PacifiCorp, Liberty, and Bear Valley.

¹³ Information about the SB 350 IOU transportation electrification programs authorized in 2018 is available at www.cpuc.ca.gov/sb350te.

¹⁴ <http://www.energy.ca.gov/energypolicy/>.

The CEC will leverage the Working Group to ensure that its research leads to VGI functionality that benefits ratepayers and that electricity demand forecasts associated with EV-related load mediate overall system impacts. The information gathered will ensure future demonstration projects build upon past research results to improve VGI technology to support the development and deployment of widespread advanced infrastructure.

California Air Resources Board: The Electric Vehicle Charging Stations Open Access Act¹⁵ (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 kWh and have the ability to opt in or out of price changes by choosing whether or not to participate in a managed charging program or other VGI use case. 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 through video/telephone conference. Additionally, as detailed in Section 3 of this report, four sub-working groups formed to allow smaller groups of technical experts additional time for in-depth discussions on specific topics. 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 by attending most meetings and providing documentation and analysis that were key to developing the Working Group’s deliverables. 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.

Table 1. 2017 VGI Working Group Meeting Schedule

Date	Discussion Topics
April 24, 2017	Introduction to Working Group, Discussion of Work Plan Proposal
May 15, 2017	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, 2017	Presentation and Discussion of Use Case and Definitions Sub-Working Group progress

¹⁵ SB 454, Corbett, 2013, available at: http://leginfo.legislature.ca.gov/faces/billPdf.xhtml?bill_id=201320140SB454&version=20130SB45492CHP.

June 12, 2017	Overview of and Discussion on Terms and Definitions and Use Cases, Use Case Exercise Demonstration and Discussion on Use Case Evaluation Methodologies
June 26, 2017	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, 2017	Presentation of Deliverable 1 Outline, Development of Mapping Sub-Working Group
July 24, 2017	Presentation on Work Plan Updates, Discussion on Terms and Definitions Sub-Working Group progress, Status Update from Requirements Sub-Working Group
August 7, 2017	Requirements Sub-Working Group Presentation, Discussion on Requirements Deliverables, Kickoff Deliverable 2 with Presentations on VGI value
August 21, 2017	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, 2017	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, 2017	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, 2017	Presentation of Draft Proposal for Hardware Requirements, Discussion on Proposal and Working Group Next Steps
November 14, 2017	Discussion on Hardware Proposal, Review of Stakeholder Comments, Discussion on Potential Deliverable 2 Process and Next Steps
December 1, 2017	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, 2017	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
February 23, 2018	The Assigned Commissioner's Ruling on the draft Vehicle-Grid Integration Communication Protocol Working Group Energy Division Staff Report was issued seeking comments from parties
March 21, 2018	Comments on the draft Energy Division Staff Report were filed
April 4, 2018	Reply Comments on the draft Energy Division Staff Report were filed

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 consideration. The initial Work Plan released in May 2017 outlined three deliverables for the Working Group to complete: (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 value¹⁶ 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, and discussion was limited to the versions of protocols that had already been ratified by a national or international standards organization.

The initial Work Plan envisioned focusing on the VGI communication programmed within the EVSE, because CPUC has jurisdiction over IOU 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),¹⁷ 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 encouraged the implementation of additional, large-scale pilots to identify the business case for enabling VGI as a resource. Other stakeholders suggested implementation of specific protocols to enable the immediate implementation of high-level communications between EVSE and PEV.

3. Working Group Process and Results

a. Glossary Sub-Working Group

The Working Group was comprised of participants from a variety of sectors 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.

¹⁶ 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.aiso.com/Documents/Vehicle-GridIntegrationRoadmap.pdf>.

¹⁷ The Working Group defined PFE as an offsite entity that is requesting or mandating VGI activities from other actors downstream.

The 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

The glossary is a living document that can be modified and updated as VGI technology evolves.

b. Use Case Sub-Working Group

To help examine the full suite of potential VGI use cases and communication pathways, a second sub-working group was formed to vet the technical feasibility of use cases and categorize them for future consideration.

All Working Group participants were encouraged to submit 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 provides the potential to deliver value to actor(s) 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 the use cases they individually submitted with relevant tags as described below. Some of these categorizations may be mutually exclusive, as identified in the VGI Roadmap:

1. V1G: charge only flows into the vehicle.
2. V2G: allow charge into the electric vehicle battery system as well as discharge of electricity from the electric vehicle battery system.
3. Aggregated: 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: an entity manages only one load.
5. Fragmented: actors involved have different objectives.
6. Unified: actors involved have the same objective.
7. Other: do not fit into any of the above categories.

Members of the sub-working group assessed the accuracy and viability of each use case. 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 identified 47 use cases.

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’ and more detailed information about each individual use case submission is contained within the ‘Meeting Files’ 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 by encouraging customers to charge during off-peak times.
- Direct Current Flow: These use cases focus on 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 (e.g., demand response or load management programs) 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.

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 and categorized them. Some use cases fit into more than one category.

c. Requirements Sub-working Group

After the Use Case sub-working group created the final list of use cases, the use case submitters identified what information various actors must communicate to actuate the use cases. The Requirements sub-working group was then created to identify which requirements were needed for that information to travel between actors.

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)
<i>Examples of common names used in use-case descriptions:</i>							
<ul style="list-style-type: none"> • Driver • End User • Owner • Fleet transportation operator 	<ul style="list-style-type: none"> • Aggregator • Utility • EV Service Provider • Energy Service Co. • Alt. Energy Supplier • Energy Portal • Clearing House 	<ul style="list-style-type: none"> • Site Host • Ratepayer • Bill Payer • Home Owner 	<ul style="list-style-type: none"> • Electric Vehicle • EV • BEV • PHEV • PEV 	<ul style="list-style-type: none"> • Inverter • Rectifier • Bi-directional inverter 	<ul style="list-style-type: none"> • Electric Vehicle Supply Equipment • Charger • Level 2 EVSE • Level 1 EVSE 	<ul style="list-style-type: none"> • End-user meter device (EUMD) • Site meter • Sub meter 	<ul style="list-style-type: none"> • 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 actor:

1. EV Driver (EVD) – 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 (UCR) – 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 connects the AC electricity grid at a site to the EV.
7. Energy Meter (EM) – 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 in part 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 the primary Functional Requirement category associated with each of the 47 use cases is available at www.cpuc.ca.gov/vgi as 'Use Case Summaries Spreadsheet' under the Deliverables Heading.

Completing most use cases require only a subset of the functional requirements and involve communication between some 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 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 'Final VGI Requirements Consolidated Spreadsheet under the Deliverables heading.

The Functional Requirements Matrix ultimately included 11 communication pathways:¹⁸

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.

¹⁸ Appendix B offers diagrams of the different communications pathways identified by the Requirement Sub-Working Group.

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 communication protocols that were in scope for the Working Group. The Working Group considered only the most recent, fully approved version of a protocol; protocols or updates to protocols that were in progress were out of scope. Stakeholders proposed 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 Engineers¹⁹ (IEEE) 2030.5
2. Open Automated Demand Response (OpenADR)²⁰ v2.0b
3. International Organization for Standardization (ISO)²¹ 15118 v1
4. CHAdeMO²² (IEEE 2030.1.1)
5. SAE²³ J3072, J2847, J2931, J1772
6. Open Charge Point Protocol (OCPP)²⁴ v1.6
7. Telematics²⁵
8. Charging Network Management Protocol (CNMP)²⁶ IEEE 2690

¹⁹ 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/>.

²⁰ 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/>.

²¹ 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>.

²² 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/>.

²³ SAE International is a global association of engineers and technical experts in the aerospace, automotive and commercial-vehicle industries.

²⁴ 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. Version 2.0 is currently being finalized. More information is available at <http://www.openchargealliance.org/>.

²⁵ Each automaker has its own method of implementing telematics, either using proprietary communication protocols or IEEE 2030.5.

²⁶ 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

While the Mapping sub-working group discussed CNMP/IEEE 2690, it was not included in the mapping exercise because it is still under development, and so it is outside the scope of the assessment.

The Working Group identified six viable protocols that are currently available in addition to telematics, 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 six of the protocols considered by the Working Group and their 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 could be repurposed to achieve a functional requirement not originally addressed by individual protocols. Several combinations of protocols 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. Given the lack of consensus on a clearly superior protocol, Energy Division staff recommends no one protocol or combination of protocols 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**.

parameters of charging sessions. More information is available at <https://standards.ieee.org/develop/project/2690.html>

Table 2. Protocols included in participating automakers’ 10-year time horizon, 2017

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 v2
Ford	Telematics & ISO 15118 (future)	ISO 15118 (HomePlug Green PHY)	ISO 15118 v2
GM	No High Level Communication	DIN Spec, no timeframe for ISO/IEC	WiFi and Telematics
Honda	TBD High Level Communication, Vehicle to Grid	DIN Spec / ISO 15118, Vehicle to Grid	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 they are currently developing hardware capable of supporting the high level communications protocols considered by the Working Group. However, few commercially available EVSE is fully-compliant in support of high-level communication protocols.

Both auto manufacturers and EVSPs are operating in a rapidly evolving field. Table 2 above reflects product plans presented by industry stakeholders during their participation in the working group as of 2017. These business plans represent are reflective of or may change due to market factors including the costs of alternatives, consumer demand, and functionality. Not adopting an individual high-level communication protocol requirement at this time allows for flexibility according to these market factors.

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, the Working Group proceeded to discuss 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 categorically, 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 charging service providers identified certain protocols that will be deployed regardless of the outcome of the Working Group and suggested that utilities immediately support these within their investments in charging equipment. Other automakers expressed a need to better understand the value of some VGI use cases to create a business case for implementing the hardware and software necessary to enable VGI at scale.

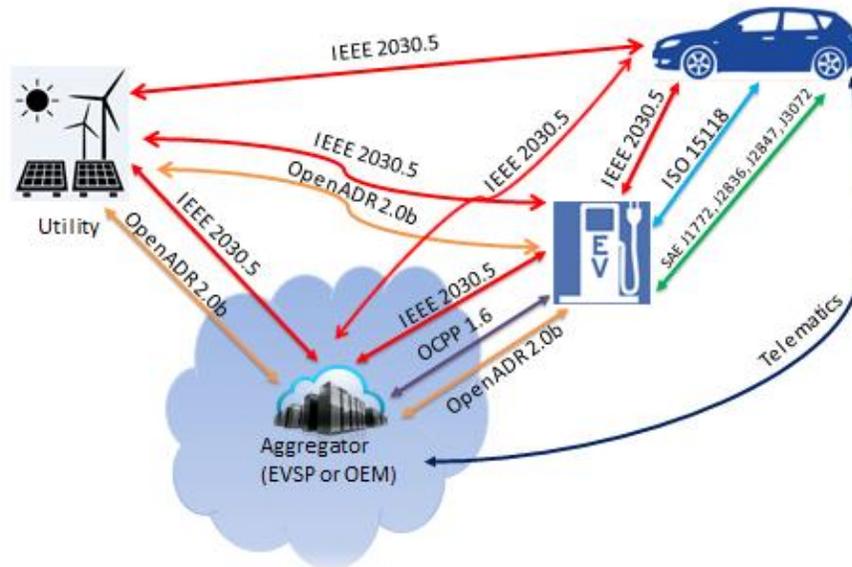
Most Working Group participants were open to large-scale pilots to test implementation of different communication protocols. Participants also expressed willingness to help identify the costs and benefits associated with each use case, which could feed into a broader assessment of VGI value in the future. Some stakeholders suggested large-scale pilots (i.e., ~2,000 vehicles) to test different use cases using communication protocols that 1) go directly from the PFE to the EV and/or 2) are translated by the EVSE between the PFE and the EV. These types of pilots could be incorporated in future state-sponsored research projects, but Energy Division staff encourages Working Group participants to 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 or have the potential to 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 suggests that IEEE 2030.5 supports most of the use cases identified by stakeholders and enables end-to-end communication from PFE to EV without the need for an additional protocol. However, stakeholders were unable to reach consensus in support of 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 for AC Conductive Charging²⁷



The costs and benefits of the different communication protocols, or combinations of protocols, are unclear at this time. Also, some communication paths bypass the EVSE to go from the PFE to the EV, while other paths go through the EVSE. The Working Group did not have the information needed to evaluate whether one business model should be favored over another at this time.

Finally, VGI functionality and potential use cases are expanding and changing rapidly. The working group was divided regarding whether understanding the value of these use cases was a prerequisite to specifying high level communication protocols for EVSE. Therefore, per Working Group feedback, at this time the state agency staff leading the working group determined it would not be prudent to require certain capabilities of ratepayer-funded EVSE because doing so could preference an individual communication pathway. The decision not to mandate a specific protocol or combination of protocols was made in full awareness of the risk associated with not adopting uniform requirements at this time, which many Working Group participants raised as a key concern.²⁸

²⁷ The line “through” the EVSE for IEEE 2030.5 is intended to show the EVSE acting as a bridge for IEEE 2030.5. Messages can pass between the EV and the PFM using IEEE 2030.5 without any translation, encryption, or decryption from the EVSE.

²⁸ See, for example, comments submitted by Siemens, Greenlots, Oxygen Initiative, and Kitu Systems that recommended the CPUC adopt a standard communication protocol to send a clearer signal to the EVSE market and auto manufacturers.

Table 3. Mapping Sub-Working Group Summary Table²⁹

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. Hardware Performance Functionalities

Based on the Working Group results, the State Agencies developed a recommendation for the IOUs’ infrastructure investments. The recommendation was intended to set 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.

It became clear through discussions and analysis that many VGI communication protocols require similar hardware platforms, but the Working Group did not come to a consensus on any specific hardware requirements. Energy Division staff recognize that while hardware can support VGI functionalities, no specific hardware is necessary to facilitate the VGI use cases discussed during the working group that do not require high-level communication (HLC).³⁰

Given the similarities identified in hardware platforms, however, Energy Division staff recommend the Commission consider adopting hardware functionality requirements that allow EVSEs to accommodate the multiple high-level communication protocols that may be used to enable VGI. The goal of this

²⁹ The 2018 update to IEEE 2030.5 will enable it to meet the two specific requirements in the “miscellaneous” category: (1) Ability to send GPS information on charging station location; and (2) Ability to send the accurate information to charge when renewable energy is available (cleaner than grid mix). Joint Parties’ Comments on draft Energy Division Staff Report at 5. For the Smart Charging row, the versions of OpenADR and OCPP that were evaluated by the working group did not support Smart Charging but Working Group participants suggested that updates to those communication protocols are currently underway that could enable them to support Smart Charging in combination with other protocols once future versions are adopted.

³⁰ “High Level Communication” (HLC) refers to driver authentication, communication of transaction details, and smart charging coordination information parameters. Select HLC parameters are described in the Functional Requirements Matrix.

recommendation is to identify the necessary EVSE hardware functionality that will enable the high-level communication needed to achieve many of the VGI use cases that stakeholders identified through the Working Group process. The recommendations are designed to prevent the need for costly upgrades to ratepayer-funded infrastructure if use cases that require HLC are found to be the most economic.

Utilities and other Working Group participants expressed concerns about requiring a single, specific technology, due to concerns about interoperability across different platforms.³¹ Rather than set specific hardware requirements, Energy Division staff worked with ARB, CEC, CAISO, and GO-Biz to identify the minimum hardware performance functions that should be included in EVSE supported by the IOU's relevant infrastructure investments.

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 recommendations by choosing their preferred communication pathways and associated protocols. Sites may choose to include additional hardware functionalities within the EVSE beyond these minimum recommended requirements.

Based on Working Group discussions and the limited data provided by EVSE manufacturers and services providers and automakers, we expect the incremental hardware costs of meeting the hardware performance requirements recommended below to be relatively small.

a. Scope of Recommended Hardware Performance Requirements

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

- Level 2, AC:
 - 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 should not discourage 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:

³¹ One example frequently cited during the Working Group was the ongoing interoperability issues associated with the utilities' initial deployment of advanced metering infrastructure (AMI) based on Zigbee, which was reliant on a specific protocol. The Zigbee-based products had interoperability limitations that complicated the utilities' AMI rollout.

- 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.
- 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 PFE 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.
- While the requirements listed below should be considered mandatory for all ratepayer-funded investment programs, for single-user EVSEs in locations with restricted use – such as single-family residences– the additional hardware may provide minimal additional benefits and may not be worth the additional costs. IOU programs supporting these types of users should be evaluated on a case-by-case basis.³²

Table 4. Hardware Functionalities Recommended by Energy Division for Level 2, AC, conductive, EVSEs to support the protocols necessary to enable VGI

<i>Functionality Description</i>	<i>EVSE Hardware /Physical Layer Description</i>
Provide interoperability with widely applied and implemented physical layer network connectivity	Interoperable with IEEE 802.11n for high bandwidth wireless networking OR Interoperable with IEEE 802.3 for Ethernet connectivity for Local Area Network and Wide Area Network applications
Mitigate need for hardware modifications and on-site software upgrades	Remote update capability that allows the EVSE software to be upgraded without site visits
Support real-time protocol translation/encryption/decryption to allow flexibility in implementation of standard communication protocols	Processor and Internet Protocol stack must accommodate multiple communication protocols

³² “[D]ue to the long charging times associated with [private and/or single-user] EVSE, there is certainly potential for grid benefits by enabling VGI functionality. Accumulatively, home charging will account for a significant load on the grid, particularly in the evenings and overnight.” OEMS Final Comments on VGI Working Group draft Staff Report at 2.

Modify EVSE functionalities without changes needed to installed hardware	EVSE functionalities should be software-based to avoid the need for on-site upgrades to the hardware and allow for functionalities to be added or modified remotely
Support the use of internet protocols for management and networking of EVSE	Compliance with Transmission Control Protocol/Internet Protocol ³³ and Internet Protocol v6, or its successor version(s) ³⁴
Provide the physical layer when needed to allow for high-level communications between the EVSE and the EV ³⁵	Where necessary to allow for HLC, incorporate power line carrier communications module compliant with HomePlug GreenPHY specifications

The Working Group found that existing load management functionalities and technological standards can immediately be used to capture some VGI value. For example, PFE to EVSE communication using Internet Protocol to enable remote management and flash capabilities will allow for updates to each of the EVSEs when and where they are deployed if market forces dictate the change. The hardware supported by utility TE infrastructure programs should enable these communication protocol updates to occur without any site visits or changes to the hardware platform (field upgradable).

The recommended EVSE Hardware /Physical Layer functionality requirements listed above will ensure the equipment can transfer HLC to an EV. EVSE that meet the requirements detailed above will include flash capabilities that allow updates to the equipment without requiring a site visit and allow load management functionalities to be conducted remotely.

Some stakeholders discussed an alternative to including all hardware requirements on each EVSE: an external protocol converter³⁶ can be used to control multiple EVSEs. In this case, the external protocol converter must meet all 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. If this architecture is deployed, not every individual EVSE would need to meet the network connectivity and upgradability

³³ TCP and IP are the foundational protocols within the Internet Protocol Suite, the conceptual model and set of communications protocols used on the Internet and similar computer networks.

³⁴ IPv6 is in 2018 the most recent version of the Internet Protocol (IP); the communications protocol that provides an identification and location system for computers on networks and routes traffic across the Internet.

³⁵ Working group participants raised concerns that including a requirement for power line communication modules would significantly increase the cost of EVSE (Siemens reply comments on the draft Energy Division Staff Report at 5.) This functionality recommendation only applies to sites that will be using protocols that must be translated through the EVSE to facilitate VGI use cases and should be considered on a case-by-case basis to avoid adding unnecessary cost to the charging stations deployed using public funds.

³⁶ An external protocol converter can be connected to more than one EVSE and perform any communication requirements for all the EVSEs connected to it. This centralized, external protocol converter can reduce the cost of individual EVSEs by lowering the amount of hardware and software needed in each individual EVSE.

hardware requirements described above. The EVSEs would still need the physical layer needed for high-level communication to the EV.

The Working Group explored different metering requirements and cybersecurity requirements for the EVSE, which are two important components to fully enable VGI. However, as of the December 2017 conclusion of the Working Group, Energy Division staff do not have enough information to identify requirements in these areas and will focus on metering and cybersecurity in future discussions and VGI work. Further investigation on the vulnerabilities associated with encryption, decryption, and translation of VGI messages is needed to ensure VGI use case implementation does not create a cybersecurity risk.

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 of compliance could include certification sheets, parts lists, or item data sheets.

b. Recommended Protocols to Enable VGI

Energy Division staff acknowledges that hardware alone is insufficient to enable VGI and that communication protocols are also necessary. In addition to hardware and communication protocols, new market opportunities, clarity across wholesale and retail rate structures, performance measurement, load management and demand response programs, 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, State Agency staff identified the leading communication protocols that are currently available to support various communication domains.

Some of the protocols currently available can bypass the EVSE and go directly from the PFE to the EV, while some fully-functional protocols go through the EVSE. Each option can enable different business models for EV charging services. The Working Group did not provide any basis at this juncture for favoring one business model over another.³⁷

As described in the summary and throughout this report, Energy Division 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 EVSE supported by the utilities' investment programs support one or more of the currently available protocols documented in

Table 5, with no ranking or order.

³⁷ Joint Parties comments on the draft Energy Division Staff Report at 7.

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

Domain of Communication	Communication Protocols Currently Recognized and 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 OEM 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 P2690³⁸ and IEC 63110³⁹ were identified by 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 identified the potential to use telematics for communicating information between the vehicle automaker or PFE and the EV using either automaker proprietary protocols or IEEE 2030.5 or J2847/J2936.

We acknowledge that developments in communication protocols are ongoing but are unable to assess them using the information gathered during the Working Group, so we do not address them in this recommendation.

For example, Working Group participants suggested some homogenization of functionality is occurring among the protocols listed above. Newer versions of OCPP have expanded functions that support ISO 15118, and SAE’s suite of software support ISO 15118 to communicate between the EV and the vehicle OEM in DC charging implementations.

It is unknown at the time of this report how exactly these efforts to better align the various communication protocols will improve how ISO 15118 can interface with the OCPP protocol and SAE protocols. However, both the OCPP and SAE efforts appear to better accept the functionalities

³⁸ This IEEE standard, if finalized and adopted, would define communication between EVSE systems and a device, services, and network management system typically based “in 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>

³⁹ 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:125,5,20,100390.

associated with the implementation of ISO 15118 if modifications to better align the existing protocols are incorporated in the next versions approved by their applicable standards bodies. The implementation of these protocols may still support implementation using other protocols such as IEEE 2030.5. The newer versions of the protocols and their potential for capturing the value of VGI will be evaluated through the State Agencies' next steps as described in Section 6.

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 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:

- Prioritizing use cases based on current and potential future value
- Deploying multiple large-scale pilots and assessing the value, including costs and benefits, of various communication protocols and VGI services
- Identifying funding sources or consultants to help guide a statewide analysis of VGI issues
- Coordinating with other CPUC distributed energy resource programs that address nascent or new markets to support emerging grid resources, such as Storage Multi-Use Applications⁴⁰ and Distribution Resource Plans
- Focusing on a seamless experience for drivers and measuring rates of driver participation in VGI programs
- Using big data analytics, where available, to audit performance, enable billing/settlement, and attribute value to the appropriate actor(s)
- Identifying load management strategies that avoid overloading circuits at the neighborhood level, or at the beginning of a time-of-use off-peak period
- Studying the nature of wholesale price volatility, in collaboration with CAISO, to identify use cases that maximize the value of VGI resources
- Studying utility distribution costs, in collaboration with the utilities, to identify opportunities for deferral of distribution upgrades

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 EVSEs. Therefore, Working Group participants suggested that the

⁴⁰ The CPUC in January 2018 adopted D.18-01-003 on Multiple-Use Applications for Storage.

recommendation may only apply to one of the current SB 350 standard review⁴¹ proposals SDG&E, SCE, and PG&E included in A.17-01-020, et al., SDG&E’s Residential Charging Infrastructure program. Additionally, the standard review programs of Bear Valley, Liberty Utilities, and PacifiCorp authorized in D.18-09-034 do not fall within the scope of the recommendation.⁴²

During the final Working Group meeting, PG&E and SDG&E discussed each of their light-duty charging infrastructure proposals.

PG&E’s light-duty Fast Charge program, authorized in D.18-05-040,⁴³ will install DC Fast Charging stations, so the recommendations associated with L2 charging infrastructure would not apply. 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.

SDG&E stated that for their Residential Charging Infrastructure program,⁴⁴ they are proposing to qualify Level 2 EVSE that are Wi-Fi 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. While Energy Division staff believe the hardware performance requirements could be applicable to SDG&E’s program, staff are concerned there may not be commercially available EVSE options that meet the performance requirements. To avoid delays in implementation of SDG&E’s program, it is up to the utility’s discretion whether to require the detailed hardware performance requirements in their Residential Charging Infrastructure program.

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	Yes	The value of residential VGI use cases may be better captured using high-level communications
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

⁴¹ 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.

⁴² <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M231/K030/231030113.PDF>

⁴³ <http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442457637>

⁴⁴ SDG&E’s Residential Charging Infrastructure Program was modified and approved as a rebate program for the installation of residential L2 charging stations in D.18-05-040.

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 functionalities recommended in this report should apply to a utility proposal. The Commission should also consider whether any aspects of the hardware requirements could to be modified to better futureproof the infrastructure supported by a specific utility project.

Staff also suggests the Commission consider calling for the six utilities to work together to identify a standard communication protocol that should be implemented in all ratepayer funded EV charging infrastructure. This effort should align with ongoing interagency staff efforts to accelerate the identification and deployment of priority VGI use cases that will bring the most value to ratepayers, EV drivers, and the grid.

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,⁴⁵ the Distributed Energy Resources Action Plan,⁴⁶ and the Integrated Resource Plan.⁴⁷

b. VGI Roadmap 2018 Update

The CEC's Fuels and Transportation Division and Research and Development Division are leading an update of the VGI Roadmap,⁴⁸ 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

⁴⁵ 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.

⁴⁶ R.14-10-003. Documents available at [http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Commissioners/Michael_J._Picker/DER%20Action%20Plan%20\(5-3-17\)%20CLEAN.pdf](http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Commissioners/Michael_J._Picker/DER%20Action%20Plan%20(5-3-17)%20CLEAN.pdf).

⁴⁷ 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.

⁴⁸ 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/. The docket for and information about the VGI Roadmap update process is available at <https://www.energy.ca.gov/transportation/vehicle-grid-integration/>

to VGI within its Integrated Energy Policy Report⁴⁹ that will be addressed as part of the Roadmap update.

CEC's Integrated Energy Policy Report process identified "the needs to use open standards, to return the value of [vehicle-grid] integration to stakeholders, and to commercialize prior investments in research and maintain leadership in advanced technology development."

CEC anticipates the Roadmap update will coordinate with recent and ongoing staff reports and findings regarding charging demand modeling and infrastructure deployment strategies. Energy Commission staff plans to host public workshops to scope the issues to be covered in the VGI Roadmap, which may include those identified by stakeholders listed above as needing future state consideration and action. These will be organized into four topic areas that Energy Commission staff will propose as the structure for the roadmap update: Policy and Planning Initiatives, Economic Potential, Technical Needs, and Customer Experience.

CEC staff is also developing a Transportation Electrification Research Roadmap,⁵⁰ independent from 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.

c. Other State Agency VGI Work

CARB will continue coordinating with ongoing VGI work as it implements SB 454 the Electric Vehicle Charging Station Open Access Act⁵¹. CARB held the first public workshop on SB 454 implementation on May 30, 2018 and work to implement the legislation is ongoing as of the publication of this report.⁵²

CAISO continues to work on demand response and storage enhancements through the Energy Storage and Distributed Energy Resources Initiative (ESDER)⁵³ Stakeholder Initiative, which aims to identify and lower the barriers currently limiting energy storage and distribution system level resources from participating in the CAISO markets. Currently in Phase 3, the ESDER initiative aims to expand opportunities for energy storage and distributed resources to serve as generation resources and load consumption/demand response resources. ESDER Phase 3 includes a proposal to enable EVSE sub-metering and extend the current Meter Generator Output(MGO) performance method for EVSE market participation independent of, or in combination with, its host customer. 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

⁴⁹ CEC's current 2017 Integrated Energy Policy Report docket can be found at http://www.energy.ca.gov/2017_energypolicy/.

⁵⁰ 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/.

⁵¹ <https://ww2.arb.ca.gov/our-work/programs/electric-vehicle-charging-stations-open-access-senate-bill-454>

⁵² Contact Stephanie Palmer at stephanie.palmer@arb.ca.gov to join the list of quarterly call participants

⁵³ More information about CAISO's ESDER 3 Stakeholder initiative is available at https://www.caiso.com/informed/Pages/StakeholderProcesses/EnergyStorage_DistributedEnergyResources.aspx

within a Distributed Energy Resource Provider (DERP) aggregation to provide wholesale and ancillary services. The most recent CAISO stakeholder policy paper on the ESDER 3 initiative can be found on the CAISO Stakeholder website under ‘Stay Informed.’

CAISO 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 is partnered with the CPUC on developing a recommendation on a multi-use framework for DER storage resources under CPUC Rulemaking (R.)15-03-011⁵⁴; Decision (D.)18-01-003.

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 2030.⁵⁵

The California Department of Food & Agriculture’s Division of Measurement Standards is developing a regulation to ensure electricity dispensed as a motor vehicle fuel is accurately measured and sold according to approved units of measure.⁵⁶ The draft regulation references a section of the National Institute of Standards and Technology’s Handbook 44 “*Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices*,” Section 3.40. Electric Vehicle Fueling Systems.⁵⁷ 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 adopted by the Department of Food and Agriculture via rulemaking.⁵⁸ However, if an IOU also owns, maintains and operates the EVSE, CDFR regulatory requirements do 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.

⁵⁴ More information about R.15-03-011 is available at <http://www.cpuc.ca.gov/General.aspx?id=3462>

⁵⁵ 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/>.

⁵⁶ Assembly Bill 808, Ridley-Thomas, Chapter 591, Statutes of 2015.

⁵⁷ 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>.

⁵⁸ 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=\(sc.Default\)](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, 2017 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 Response⁵⁹, 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 resource⁶⁰ 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.
 - 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,⁶¹ and of electricity consumption necessary to enroll with EV-specific charging electricity tariffs enabled through the CPUC development of the Submetering Protocol.⁶²

⁵⁹ https://www.caiso.com/Documents/IssuePaper_FrequencyResponsePhase2.pdf

⁶⁰ Resources may be heterogeneous including non-EV facility load or an aggregation of EVs.

⁶¹ https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/110617presentation.pdf

⁶² <http://www.cpuc.ca.gov/general.aspx?id=5938>

- 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.⁶³
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.⁶⁴
 - The EVSE must have the capability seamlessly facilitate the driver’s ability to authenticate their identity, vehicle, and account preferences securely to 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.

⁶³ 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.

⁶⁴ 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/>

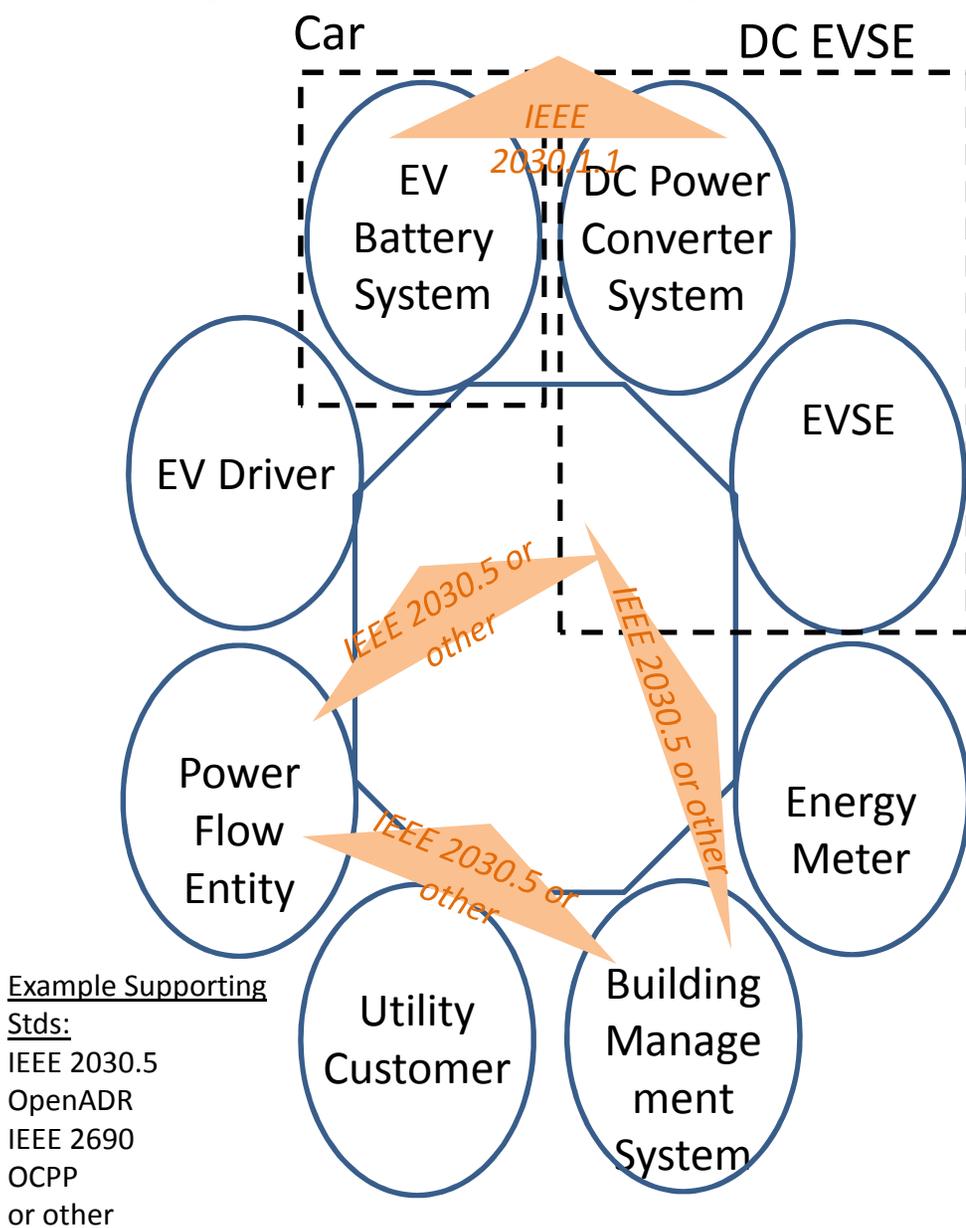
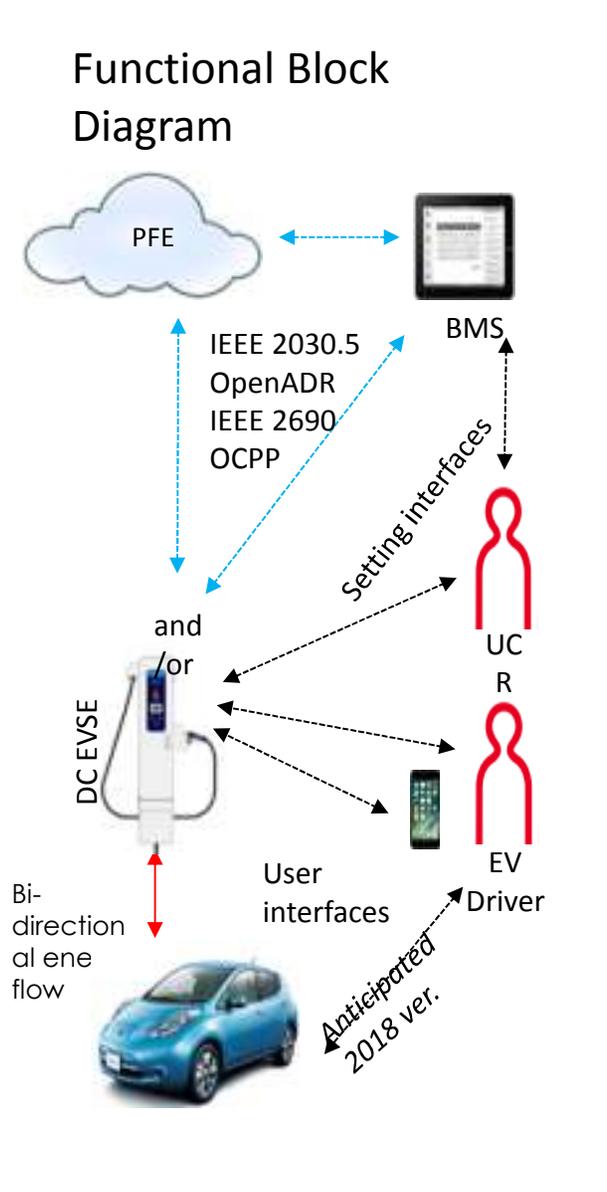
Appendix B: Architectures and Pathways of Communication Protocols Considered by the VGI Working Group

CHAdeMO (IEEE 2030.1.1)

- Developed for DC Fast Charging
- Most communications and settings occur at the DCPC
- Flexible protocol that can be used in conjunction with many others to communicate from PFE to EV

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/>

Likely End-to-End Architecture CHAdEMO (IEEE 2030.1.1)



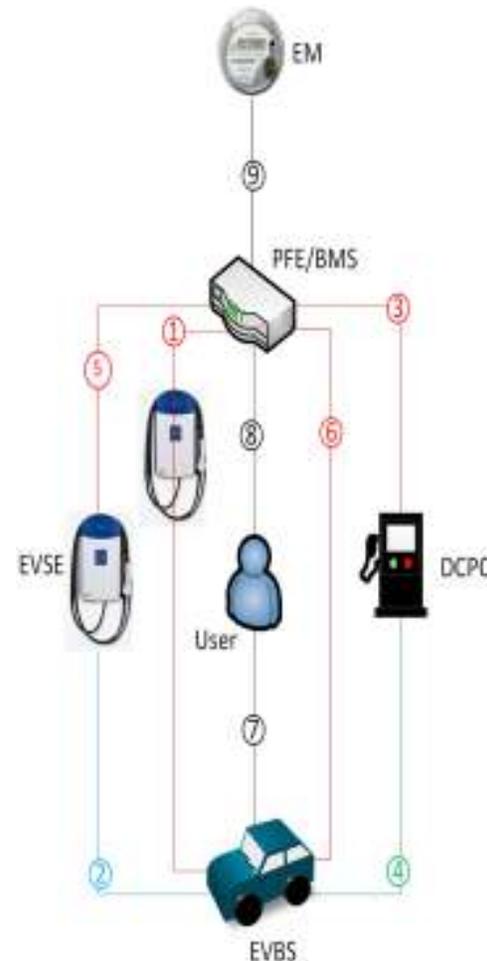
IEEE 2030.5

- Can be used in both AC and DC applications
- Current revision will add new capabilities that better allow EVs to serve as demand response resources
- Can be used in conjunction with EV telematics to communicate between PFE and EV

The Institute of Electrical and Electronic Engineers (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/>

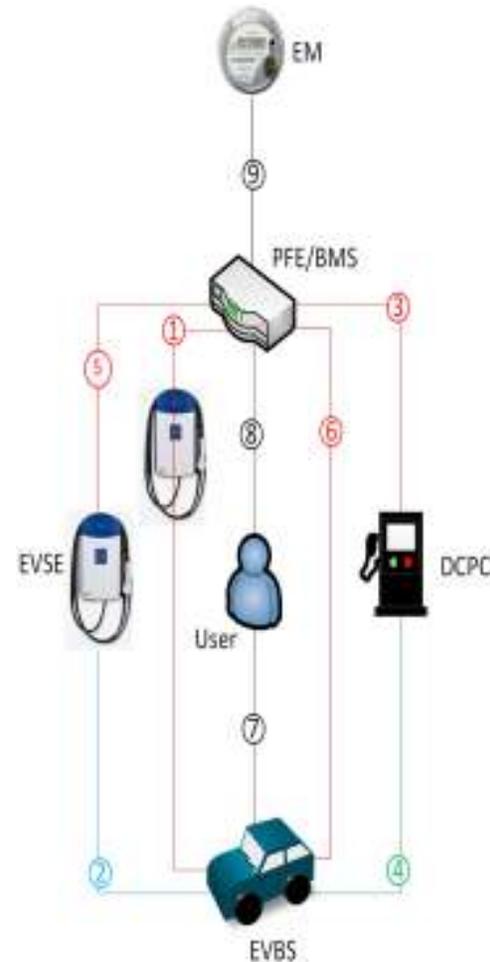
IEEE 2030.5 - AC Charging

- 1- PFE/BMS to EV (Bridged through EVSE)
- 2- Not Needed
- 3- Not Applicable
- 4- Not Applicable
- 5- May be used for DR to communicate between PFE/BMS and EVSE
- 6- Communications between PFE and EVBS possible if IEEE 2030.5 is run over Telematics
- 7- *BMS/EVSE to User (Secondary)*
- 8- *EV/Telematics to User (Secondary)*
- 9- *Energy Meter to PFE/BMS (Secondary)*



IEEE 2030.5 - DC Charging

- 1- Not Needed
- 2- Not Needed
- 3- IEEE 2030.5 communicates between PFE/BMS and DCPC
- 4- Not Applicable
- 5- Not Applicable
- 6- Not Applicable
- 7- *BMS/EVSE to User (Secondary)*
- 8- *EV/Telematics to User (Secondary)*
- 9- *Energy Meter to PFE/BMS (Secondary)*



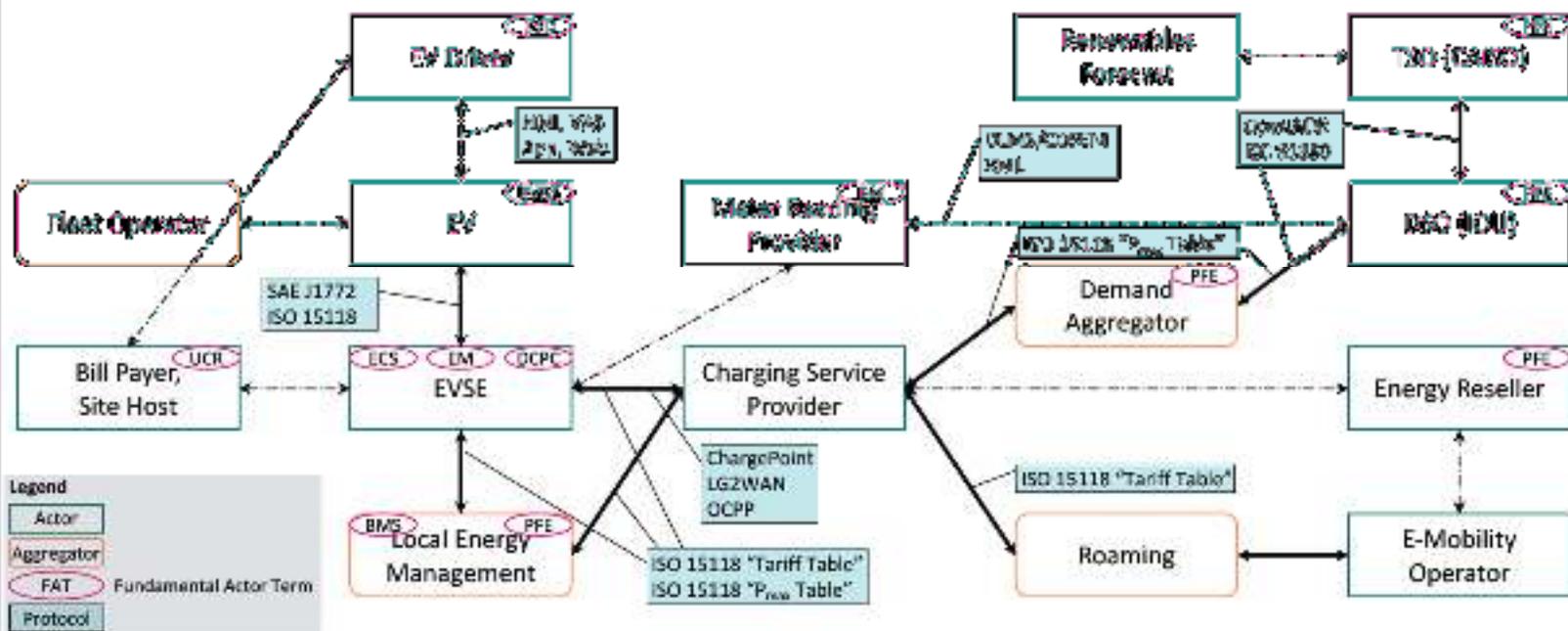
ISO 15118

- Communicates between the EV and the EVSE
- Signals between the PFE and EV can be transported using other protocols and translated by the EVSE

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>

ISO 15118 relevant communication links

— with "Fundamental Actor Terms" & protocols

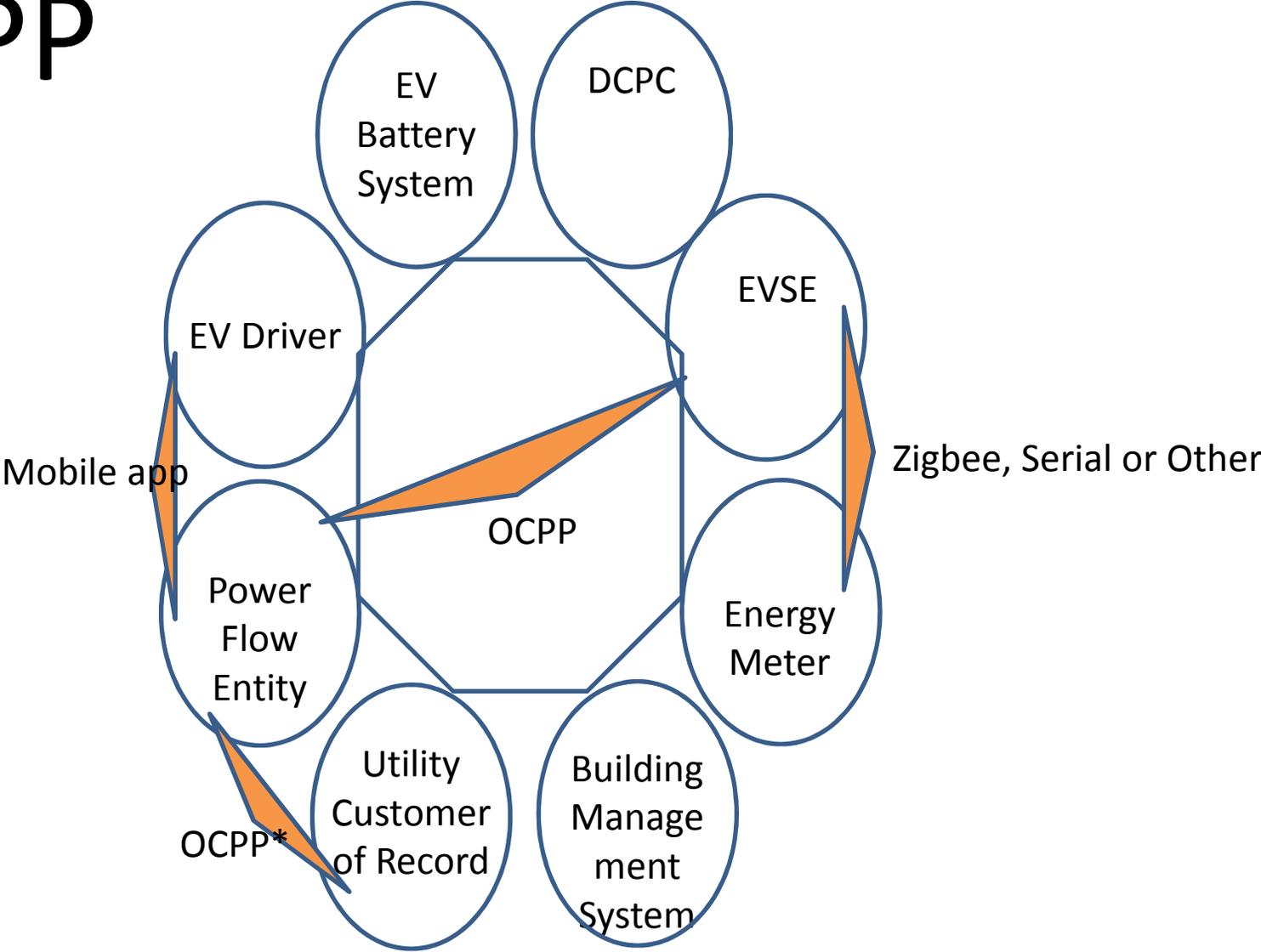


OCPP

- Enables communications between a central server/back office and the EVSE
- Communications forwarded to EV via a mobile app or other software
- Typically implemented with other open protocols, especially OpenADR

Open Charge Point Protocol (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. Version 2.0 is currently being finalized. More information is available at <http://www.openchargealliance.org/>

OCPP

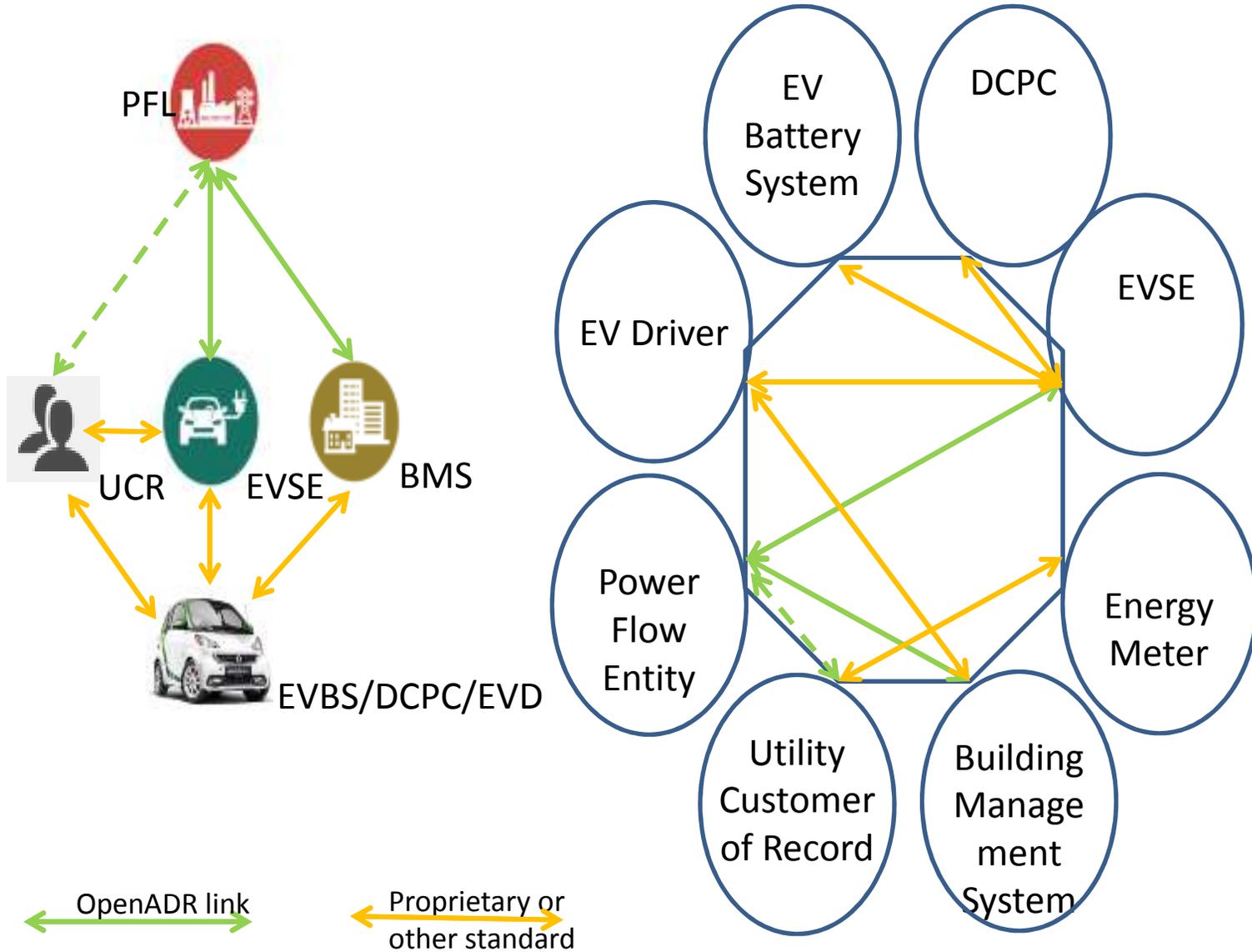


OpenADR 2.0b

- Sends information from the PFE about grid conditions to a BMS or EVSE
- Other protocols are needed to translate the OpenADR signal into an action/response
- BMS or EVSE can communicate the EV's action/response back to PFE

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/>

OpenADR 2.0b



SAE Suite

- SAE's standards are designed for use with other protocols, largely IEEE 2030.5
- There are different SAE standards for AC and DC applications
- The communications functionality of ISO 15118 is expected to be added to the next version of SAE 2047.2, which sends direct messages between the DCPC and the EV

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

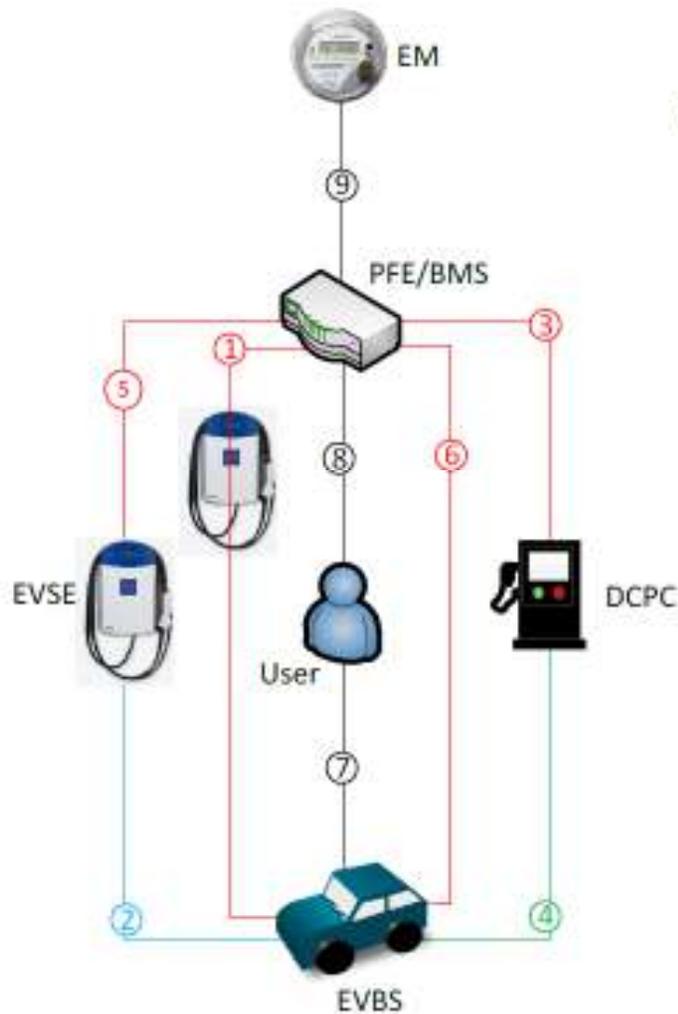
SAE Suite

AC Charging : J2836/1,
J2847/1, IEEE 2030.5

DC Charging (SAE/DIN)
J2836/2, J2847/2

Note: SAE is working to harmonize J2847/2 with ISO 15118 but it is not clear if it will incorporate the existing standard or develop its own that mirrors it

V2I end-to-end Application Interfaces



	Charging		DER	
	AC	DC	AC	DC
1- PFE/BMS to EV (Bridged through EVSE)	X		X	
2 (+5)- EVSE to EVBS (Needs 5 for end to end)			X	
3- PFE/BMS to DCPC				X
4 (+3)- EVBS to DCPC		X		X
5- Direct to EVSE (Interface 2 protocol or J1772 PWM to EV)	X		X	X
6- Telematics direct to EV	X		X	X
7- BMS/EVSE to User (Secondary)	X		X	X
8- EV/Telematics to User (Secondary)			X	X
9- Energy Meter to PFE/BMS (Secondary)				