# Work Plan for Vehicle-Grid Integration Working Group

The proposal below is from the following companies: American Honda Motors, BMW of North America, EPRI,[[1]](#footnote-1) Fiat Chrysler Automobiles, Ford Motor Company, Honda R&D Americas Inc., Nissan Technical Center North America, Pacific Gas & Electric Company, Sacramento Municipal Utility District, Southern California Edison Company, Tesla Motors, and Toyota Motor North America. See appendix E for list of representatives from each company. This proposal is based on the original draft workplan from the staff at the CPUC, CEC, CARB and CAISO, discussions at the first two VGI working group meetings and the agencies’ straw proposal.

# Background and Summary:

Per feedback gathered in advance of and during the April 24 Launch Meeting of the VGI Communications Protocol Working Group (“Working Group”, WG), the interagency staff has revised the structure of the Straw Proposal. Major revisions to the approach are multi-fold:

1. To avoid attempting to address issues less germane or tangential to the agencies’ jurisdictional authorities within the limited timeframe.
2. To focus and segment the scope of work to answer the:
	1. CPUC’s questions relating to engineering design and functionalities of charging infrastructure equipment proposed for ratepayer funding under the investor-owned utilities’ SB 350 applications.
	2. Broader policy, valuation, and business-model considerations potentially barring VGI market and policy development
3. To map the agencies’ Straw Proposal questions to the State’s existing statements for developing VGI policy and technology
4. To propose a more precisely defined trajectory of Working Group meetings to enable more efficient discussions considering travel, efficacy of online conferences, and deliverables from active participants and interests.

**Objective**:

Enabling economical Plug-In Vehicle Grid Integration (VGI) will help achieve California’s greenhouse gas and air pollution reduction goals by promoting EV adoption with improved value propositions and by optimizing EV charging resources.

The California Public Utilities Commission, California Energy Commission, and other State agencies, with broad stakeholder input, will assess the current barriers to VGI solutions and the potential remedies including technical implementation and markets.

The Working Group will assess how and whether the adoption of a communications protocol or protocols is necessary to enable VGI resources to more economically participate in electricity markets at scale, will evaluate the grid and consumer value of non-wholesale market alternatives (e.g., distribution infrastructure services and customer facing services), and will make recommendations to achieve high priority VGI solutions to provide grid and EV driver benefits.

**Strategy**:

Form a working group to identify and assess opportunities in which VGI can create value from multiple participants’ perspectives, solutions needed to deliver that value, and concepts for how utilities, automakers, electric vehicle service providers, aggregators, and others can develop pathways to implement VGI resources and benefits (e.g., wholesale market services, distribution infrastructure services, and customer-facing services). The working group will allow participants to review, understand, and discuss in two key Workstreams:

* *Use Case Definition/Categorization, Requirements, Technology and Standards Evaluation*
* *VGI Terminology, Guiding Principles/Criteria, Value/Cost Assessment, and Enabling Policy*

After developing priority VGI solutions and use cases for market and non-market solutions, the working group will evaluate them to recommend high priority actions. The recommendations of the working group will be considered and incorporated in CPUC’s Rulemaking 13-11-007 (and/or the SB 350 Transportation Electrification applications A.17-01-020, A.17-01-021 and A.17-01-022) and the Energy Commission’s Integrated Energy Policy Report (IEPR) proceeding for future policy decisions

# Required Reading and Supporting Documentation: (See Appendix C for full list)

* + CPUC Energy Division, Vehicle-Grid Integration: A Vision for Zero-Emission Transportation Interconnected throughout California’s Electricity System, 2013. (“[VGI Whitepaper](http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/EE_and_Energy_Savings_Assist/CPUCEnergyDivisionVehicleGridIntegrationZEVSummit.pdf)”)
	+ CAISO et al., California Vehicle-Grid Integration Roadmap: Enabling vehicle-based grid services, 2014. (“[VGI Roadmap](http://www.caiso.com/documents/vehicle-gridintegrationroadmap.pdf)”)
	+ CPUC, Appendix B to the Assigned Commissioner Ruling Regarding the Filing of Transportation Electrification Applications Pursuant to Senate Bill 350, 2016 (“[Appendix B](http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M167/K099/167099725.PDF)”)
	+ CEC and CPUC Joint Workshop, Vehicle-Grid Integration Communications Standards – [Interagency Presentation](http://docketpublic.energy.ca.gov/PublicDocuments/16-TRAN-01/TN214649_20161207T080617_VehicleGrid_Integration_Communications_Standards.pdf), [2016](http://www.energy.ca.gov/altfuels/2016-TRAN-01/documents/index.html#12072016)
	+ CEC, Annual Multi-Agency Update on Vehicle-Grid Integration Research, [2014](http://www.energy.ca.gov/research/notices/#11192014), [2015](http://www.energy.ca.gov/research/notices/#12142015), [2016](http://www.energy.ca.gov/research/notices/#12122016)
	+ SMUD - various presentations and studies on VGI benefits and costs ( see appendix)
	+ Vehicle-Grid Integration Communications Protocol Working Group, CPUC and CEC Staff Straw Proposal, 2017 (“[Straw Proposal](http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442453060)”)
	+ EPRI presentation, Dec 2016 at interagency workshop (e.g., lists 24 guiding principles expanding on Appendix B)
	+ CPUC submetering effort (see Appendix for full list)
	+ ElaadNL, EV Related Protocol Study, 2017 (“[Protocol Study](https://www.elaad.nl/uploads/files/EV_related_protocol_study_v1.1.pdf)”) – for European architecture and protocol reference purposes only.
	+ IEC / ISO Standards (see Appendix for full list)
	+ SAE Standards / Technical Information Reports / Recommended Practices (See Appendix for full list)
	+ OpenADR 2.0b, IEEE 2030.5, NIST IR 7628, and other NIST/SGIP standards (See appendix for full list)
	+ California Smart Inverter Working Group and California Smart Inverter Profile documents and recommendations
	+ EPRI public documents on Open Vehicle-Grid Integration Platform
	+ RMI Battery Storage Economics report

**Key Terms and Definitions and draft Frameworks early DRAFT (See Appendix D for complete list)**

* VGI benefit groupings (Option 1) or value category
	+ **Wholesale market services**:  1) frequency regulation, 2) spinning, non-spinning and supplemental reserve, 3) load following / ramping support for renewables 4) capacity markets 5) Demand Response Auction Mechanism 6) real-time and day-ahead energy markets
	+ **Distribution infrastructure benefits**:  1) distribution upgrade deferral 2) voltage and/or reactive power support 3) local distributed generation support 4) peak load shedding
	+ **Customer facing benefits:** 1) retail energy time shift, 2) demand leveling, 3) power quality, 4) power reliability, 5) monetizing of GHG and air pollution reduction benefits, 6) maximizing customer use of renewable generation
* VGI Beneficiary groupings (2)
	+ Site host benefits - TBD
	+ EV driver benefits - TBD
	+ All utility customer benefits – TBD
	+ ISO wholesale market benefits - TBD
* VGI grouping (3)
	+ Wholesale market solutions: ISO-oriented VGI benefits
	+ Non-market solutions: VGI benefits that can be secured without interacting with the ISO
* VGI benefit grouping (4) value category
	+ Reducing energy generation cost
	+ Reducing site hosts and EV driver’s electric bills
	+ Deferring distribution upgrades
	+ Improving reliability
	+ Aligning EV load with renewable integration
	+ Measuring fuel switching – gasoline to EV (required by Low Carbon Fuel Standard for non-residential charging)
* VGI types
	+ Charging level incentives
		- Tools include rebates for lower level charging, modifying current allowance policy, demand charge design
	+ Managed Charging
		- Tools include TOU rate design, TOU rate adoption, DR programs at the charging station, EV management system or building management system
	+ V1G wholesale market services provided by unidirectional power flow enabling vehicles to charge including varying the charge rate
	+ V2G wholesale market services provided by bidirectional power flow to and from the grid and the EV
* Technical solutions: EV grid solutions that need a communication protocol.
* Non-Technical solutions: EV grid solutions that do not need a communication protocol (e.g. rates, charging station rebates, allowances, fuel switching measurement)
* Use case: Defines a grid problem that can be solved with one or more solutions (technical and/or non-technical) and describes the solutions
* Others *(The Terminology and Definitions subgroup is currently working on a much longer list that should be added later)*

**Expectations for Active Participants Contributing to Products/Deliverables:**

* The Working Group expects that subgroups will form to assist in the development of material needed to answer the questions identified below and use the foundational documents to avoid duplication of prior work. The Facilitator will assist these subgroups in establishing a reasonable and timely review process to determine the level of agreement among stakeholders for delivered products.

# Stakeholder Viewpoints to be Examined

1. EV user (driver/rider)
2. Electric Vehicle (EV) Original Equipment Manufacturer (OEM)
3. Distribution System Operator (DSO or Utility) and Independent System Operator (ISO)
4. Site Host (for Charging Stations)
5. Charging Station Operator
6. Charging Station Manufacturer
7. VGI Resource Aggregator
8. Non-Participating Ratepayer or Society

**Workplan Tasks and Deliverables**

**Workstream Summary**: The VGI Working Group is to be divided into two Workstreams (W):

**Workstream 1** Use Case Definition/Categorization, Requirements, Technology and Standards Evaluation is focused on defining and categorizing the recommended use cases covering VGI benefit groupings (e.g., wholesale market benefits, distribution infrastructure benefits, and site host/driver facing benefits) from the working group members, determining the use case requirements, determining use case solutions (technical and non-technical) and evaluating VGI applied standard protocols that facilitate the use case objectives and functionality. Use Case technical requirements will define the basis for the design of the VGI architecture and assessment of applied standard communications protocols.

**Workstream 2** VGI Terminology, Guiding Principles/Criteria, Value/Cost Assessment, and Enabling Policy will define the VGI terminology and definitions, qualify VGI guiding principles and criteria for determining the use case categories, and provide methodology/criteria for determining the value and prioritization of the use cases. Will provide an opportunity cost assessment of the prioritized use cases to support recommendations for pilot implementation and demonstration.

 **Workstreams 1 and 2** will work in parallel and will provide cross input and coordination for application of VGI terminology, criteria, value assessment, and prioritization of VGI applicable use cases.

**Workplan Summary:** The working group purpose is to define, evaluate, and prioritize use cases addressing grid issues/problems, and solutions through application of Vehicle Grid Integration (VGI) services, benefits and functionality. See the next three pages for detailed workplan, deliverables (D) and timeline. The summary of major tasks follows:

* Use Case Definitions – what are we trying to solve
	+ Define the VGI terminology and definitions (W2D1)
	+ Define the problems (use cases) to be solved (W1D1)
	+ Define the evaluation criteria (guiding principles) (W2D2)
	+ Prioritize the problems (use cases) (W2D2 & W1D1)
* Use Case Solutions – identification and evaluations of problem solutions
	+ Create architecture diagram of participant interactions (W1D2)
	+ Develop sub-groups to address technical/non-technical solutions to the problems (W1D2)
	+ Evaluate the solutions – technical/non-technical, standards, cost, policy, etc. (W1D3 & W2D3)
	+ Understand the trade-offs and linkages between technical and non-technical solutions (W1D2 & W2D3)
	+ Prioritize the solutions (W1D4 & W2D4)
* Recommend Actions – base recommendations on most viable cost effective solutions
	+ Develop Market or Policy action recommendations (e.g., rates, incentives, communication protocols for demand response or ancillary services) (W1D4 & W2D5)
		- Recommend actions where the agencies have authority
* Develop Pilot / Field Demo recommendations (W1D4)
* Final Report (W2D6)

# Workstream 1: Use Case Definition/Categorization, Requirements, Technology and Standards Evaluation

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# Deliverable 1: Use Case Definition/Categorization

# Develop use cases with defined grid or charging infrastructure problem /need to be addressed and include solutions on what needs to be done (technical and non-technical).

# Define use cases that cover grid problems/needs at site, distribution system, and wholesale market levels that provide EV driver benefits, distribution upgrade deferral, ancillary services, and other VGI benefits.  Consider other classification schemes. For example, define use cases for major charging market segments: single family homes (attached and detached), large multi-unit dwellings, fleets, workplaces, away-from-home charging plazas, and for major charging levels.

# Organize the use cases into categories based on the described problem/need.

# Determine in scope/out of scope categories, and use cases within each category, per the VGI guiding principles and prioritization criteria established in Workstream 2.

# Deliverable 2: Use Case Requirements Definition

# Develop sub groups based on use case categories. Each sub group will:

# Further define the individual use case solutions, both technical (e.g. communication protocols for wholesale market services) and non-technical (e.g., rates, charging station rebates, allowances, submetering)

# Define the solutions requirements for implementation, including communications interface/integration/interactions, data exchange/communications flows, functionality, measurement & verification, and performance

# Identify and summarize tradeoffs and interactions between technical and non-technical solutions

# Determine the VGI network system architecture design based on the use case technical requirements, and identify overlaps and/or variability of architecture designs between use case categories for determining overarching VGI ecosystem architecture.

# Deliverable 3: VGI Standards Application Evaluation

# Each sub group, based on the results of the solution and requirements definition process, will identify and apply appropriate standard communications protocols, as necessary, to assess the capability to meet the use case objectives and functional requirements.

# Each sub group will develop a criteria methodology in coordination from Workstream 2 for qualifying each applied standard protocol for its level of effectiveness and compatibility for meeting the use case requirements and evaluate the standard or protocol.

# Each sub group will develop a criteria methodology in coordination with Workstream 2 for qualifying non-protocol related solutions (e.g. rates or policy) for its level of effectiveness and compatibility for meeting the use case requirements and evaluate the solutions.

# Deliverable 4: VGI Standards and Pilot Recommendations

# Develop consolidated sub group use case and standards evaluation summaries.

#  Determine pilot recommendations for selected priority VGI use cases with standards based technical solutions.

# Determine pilot recommendations for VGI use cases with non-technical solutions.

# Summarize the architecture and technical requirements for defining an implementation plan for the recommended use cases.

# Workstream 2: VGI Terminology, Guiding Principles/Criteria, Value/Cost Assessment, and Enabling Policy

**Deliverable 1: Develop Glossary of VGI Terminology**

1. Develop a glossary of VGI specific terminology and definitions to establish consistency and uniformity of understanding and applicability in the working group documentation, dialogue and resulting use case definitions and requirements.

**Deliverable 2: Develop VGI Guiding Principles/Analytical Framework /Use Case Valuation**

1. Develop guiding principles for establishing criteria for evaluating and determining recommended use case categories and use case applicability for VGI grid services or benefits (Use Appendix A as a starting point for discussions).
2. Determine the analytical framework for categorization of use cases based on providing the technical and non-technical solutions to address wholesale market, distribution infrastructure, and EV driver needs and, if appropriate, the charging market segment (e.g., attached and detached single family homes, fleets, workplaces, multi-unit dwellings, charging station plazas),and charging level.
3. Conduct monetary and non-monetary value assessment on use case categories.
4. Determine and apply criteria for prioritization of VGI benefit groupings and then in coordination with Workstream 1 prioritize the use cases within the groupings for VGI application.
5. In coordination with Workstream 1, determine in scope/out of scope categories, and use cases within each category.

**Deliverable 3: Analyze Opportunity Costs, Business Case and Trade-offs from Stakeholders’ Perspectives** for Technical and Non-Technical Solutions

1. Determine if stakeholders have a recommendation whether the CPUC should require the utilities to specify a standard in their ratepayer-subsidized infrastructure, is there a consensus recommendation on the specification. Apply the standard protocol evaluation summary for determination of applicable standards.
2. Quantify the transitional and the opportunity costs associated with the adoption or absence of the standard; and if specific cost assumptions are unavailable, develop a framework for analysis. Analyze opportunity costs and business cases from categories of stakeholder viewpoints:
	1. EV user (driver/rider)
	2. Electric Vehicle (EV) Original Equipment Manufacturer (OEM)
	3. Distribution System Operator (DSO or Utility) and Independent System Operator (ISO)
	4. Site Host (for Charging Stations)
	5. Charging Station Operator
	6. Charging Station Manufacturer
	7. VGI Resource Aggregator
	8. Non-Participating Ratepayer or Society.
3. Quantify the transitional and the opportunity costs associated the non-technical use cases. If specific cost assumptions are unavailable, develop a framework for analysis. Analyze opportunity costs from the categories of stakeholder viewpoints listed earlier.

**Deliverable 4: Provide Answers to the Questions in Appendix B**

1. Understand the trade-offs (e.g., customer vs central control, charging levels, making vs saving money) and linkages between/within technical and non-technical solutions. Determine if there are other barriers (market or policy impediments) to realizing VGI benefits. Compare analysis with Workstream 1 effort in this area and resolve conflicts, if any.
2. Provide answers to the questions above and in appendix B, or make recommendations if next steps are needed to fully answer the questions.

**Deliverable 5: Market and Policy Actions/Recommendations**

1. Determine stakeholder’s prioritized recommendations for market or policy actions to more appropriately value, procure, or put into operation VGI resources and use cases. Include recommendations for removing barriers or improving business cases. Highlight actions where the sponsoring agencies have authority to influence or require outcomes.
2. Develop scope / requirements, timeline, deliverables and budget for prioritized field demonstration of high value use cases based on Workstream 1 priority recommendations. Include recommendations for removing barriers or improving business cases.
3. Updated roadmap for yet-to-be completed work on VGI including technical and non-technical solutions.

 **Deliverable 6: Final Report for Both Workstreams**

**Timeline**

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# Meeting Trajectory

To assist working group participants’ ability to schedule their participation and in consideration of the technical and multi-disciplinary nature of this task, the interagency staff propose that the working group meetings generally follow the following sequence:

1. Exposition of issue and proposals to solve problem, identification of preparatory items for in-person working session
2. In-Person workshop, alternating between San Francisco and Sacramento, stakeholder presentations, discussions and working sessions
	1. Follow-up in deliverable-specific subgroup break-outs working teams
3. Report-Out from Subgroups and Submission of Documents for Review.
4. Feedback and Discussion, Resolution of Issues

**Appendix A**

**Guiding Principles for Vehicle Grid Integration Working Group**

These Guiding Principles/ Criteria summarize the Appendix B guiding principles from the CPUC Assigned Commissioner Ruling, Sept 2016 as well as comments expressed by parties at the Dec 7 multi-agency workshop on VGI, and the April 24, 2017 VGI Working Group launch meeting to organize the wide range of concerns into a handful of high-level categories of criteria that the Working Group can align around for evaluating Market and Non-Market VGI Solutions.

**Meet EV Drivers’ Needs & Preferences**

* A driver’s mobility, need for simplicity, and privacy is preeminent (ACR 1)[[2]](#footnote-2)
* A vehicle’s charging behaviors is consistent with the battery management system and mobility requirements are not externally curtailed by an entity without consulting the driver (ACR 2)

**Reduce and Balance Costs of Achieving Greenhouse Gas and Air Pollution Reductions with TE**

* Guarantee and hasten opportunities for the return of ratepayer investments in research and development (R&D) (ACR 11)
* Reduce up front and end use costs to site hosts and end customers (includes network fees)
* Reduce costs to all utility ratepayers
* The standard is adaptive to automakers’ design and manufacturing requirements which are, ultimately, global in nature. Regulations incorporating standards should strive to recognize existing progress and avoid duplication (ACR 8)

**Enable Grid Value that is Safe, Reliable, & Scalable**

* Functions enabled through the standard’s implementation are fully scalable: a) In electrical system terms, from an individual vehicle, to an array of EVSE, to facility circuity, to a campus/microgrid, to distribution, and to regional transmission systems, and b) In magnitude to accommodate millions of vehicles of different makes and models (ACR 3)
* Reliability and functional requirements meet those of the California Public Utilities Commission’s adoption of Utility Electric Rules, Federal Energy Regulatory Commission as implemented by the CAISO, or the best practices of the North American Electric Reliability Corporation (NERC) (ACR 4)
* Functional and Safety Requirements for integrating EVs as a BTM DER asset

**Enable the Future Development of the VGI Ecosystem**

* Technologies and equipment deployed through the standard’s implementation are resilient to evolving use cases in the automotive, electricity, and communications industries including: high-power charging, wireless charging, vehicle-to-grid, autonomous, connected, electric and shared (ACES) vehicles, higher-speed wireless and wire-based communications (ACR 5)
* Technologies and equipment deployed prior to the standard’s implementation can voluntarily be re-equipped to increase functionality and compatibility to the adopted standard to the cost-effective extents possible (ACR 6)
* Transportation Network-specific use cases and services will be leveraged and account for Geospatial Information System (GIS) data including charging infrastructure utilization, road infrastructure utilization, route navigation, demand sequencing and queueing, traffic flow, and trip dispatch (ACR 7)
* Resolution of primacy of control conflicts and alignment of customer objectives
* Flexibility to address dynamic data exchange and functional requirements from multiple stakeholders/actors - Between and amongst primary and secondary actors
* Extensibility toward future VGI technologies (i.e. V2G, V2B, V2H, DER, ZNE, Connected Cars), while Safeguarding against technology obsolescence and stranded assets
* Coexistence and interoperability for variety of services and technologies in the VGI ecosystem
* Ability to foster 3rd party innovation, customer choice and competitive marketplace (e.g., open standards/protocols)

**Coordinate Across Policy Stakeholders and Related Technologies**

* Synchronize the timing of public and private investments in developing vehicle, infrastructure, and network or data management products with timelines established in California policy and regulations to efficiently meet climate change mitigation and adaptation goals. (ACR 9)
* Leverage the technical capability of the State agencies, and the research and interests of the national labs of the U.S. Department of Energy and independent research institutions and standards making organizations (ACR 10)
* Consistency with Rule 21 SIWG DER Integration Principles, avoiding new silos for PEVs as DERs
* IOU-side uniformity and unanimity with other approaches to aggregated & distribution system level grid management
* Consistency across Medium and Heavy Duty Vehicle Segments re: High Power Charging

**Provide for Cyber Security and Flexible Data Exchange**

* Conformance to NISTIR 7628 Cybersecurity Guidelines for Smart Grid communications protocols
* EPRI defining VGI architecture requirements for cyber security implementation and verification

**Appendix B**

**Questions to be answered and detailed tasks**

# Review research that has been conducted in California and globally by utilities, automakers, charging companies, and others related to VGI. What lessons learned from the research are relevant to working group activities? Develop new terms to minimize miscommunication and develop a glossary of terms to use.

# Review existing and identify any additional potential VGI use cases/ solutions for wholesale market services, distribution infrastructure services, and customer facing services. How can customers, third parties, and utilities extract value from these use cases?

# Review the current technical and economic barriers to implementing VGI use cases. Identify any market barriers that may be addressed by state action.

# Understand the business requirements /grid values (e.g., reducing generation costs, improving reliability, demand leveling, renewables alignment, mitigating local distribution infrastructure and measuring fuel switching environmental benefit) to help determine and prioritize the various use cases/ solutions for wholesale market services, distribution infrastructure services and customer facing services.

# What are the additional solutions outside of a market application (e.g. TOU and demand charge rates, buying low level charging stations)? For market resource VGI, are there inherent advantages to this type of VGI solutions compared to other market resources (e.g. stationary batteries or compressed air)? If not, how big is the market, and who are the competitors to VGI market resources?

# Understand the needs of the various actors (e.g., carmaker, driver, utility customer, charging station operator, market aggregator)

# What are the criteria/objectives that should be used to prioritize the VGI use cases in both market and non-market applications (e.g., avoiding costs to all ratepayers, reducing cost of charging or charging infrastructure)? Are some criteria more important than others? For different charging market segments (e.g. home, workplace, fleet) where EVs are parked for a long-time, develop basic use cases focused on EV drivers saving money, and advanced use cases focused on wholesale market services. Determine if high level charging (home or away-from-home) should receive additional focus. Determine which complex use cases, if any, should be in scope (e.g. principle agent challenge or multiple actors)

# What frameworks, outcomes, or criteria have prior studies employed to analyze the functionalities, costs, efficiency, interoperability, (or other factors) of VGI communications protocols?

# What is the EV driver interest in the value from grid services (market and non-market)?

# Determine what information flow is needed

# Evaluate future state visions (e.g. 2040) for charging station impact on the grid to provide bounding cases on costs and benefits to all utility customers especially for distribution infrastructure services and customer facing services (e.g., different mixes of short-and long-range BEVs and PHEVs, different mixes of home and away-from-home charging, different base levels of charging in the various segments)

# Can selecting an open-source network architecture enable the market to test, implement, and continually improve multiple protocols while maintaining simplicity for drivers? What are the implications of architecture design for market participants manufacturing devices?

# How do proposed protocols fit within the larger context of communications between vehicles, EVSE, the grid, utilities, automakers, EVSPs, and other distributed energy resources?

1. How do automakers, charging providers, and IOUs measure the value of the proposed protocols and whether implementation will be cost-effective? How could market participants measure cost-effectiveness?

# How do the selected end-to-end use cases for wholesale market services (communication protocol(s)/ architecture(s)) compare based on the selected criteria (discussed above)? How will large scale adoption of non-market solutions impact the viability of market solutions? Are there particular use cases that are best suited for VGI market services (e.g. fleets)?

# Develop and Analyze VGI Solutions that Don’t involve Communication Protocols

# Recommend possible ways to improve residential and commercial rates for EVs, and encourage charging stations that have less impact on the electric grid in order to encourage VGI and meet the other, agreed-upon criteria

# Assuming non-market VGI solutions will exist, recommend for wholesale market services communication protocol(s) / architecture(s) for the priority use cases studied if any are needed, and next steps for yet-to-be-studied uses cases or grid services.

**Appendix C**

# Required Reading and Supporting Documentation:

* + CPUC Energy Division, Vehicle-Grid Integration: A Vision for Zero-Emission Transportation Interconnected throughout California’s Electricity System, 2013. (“[VGI Whitepaper](http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/EE_and_Energy_Savings_Assist/CPUCEnergyDivisionVehicleGridIntegrationZEVSummit.pdf)”)
	+ CAISO et al., California Vehicle-Grid Integration Roadmap: Enabling vehicle-based grid services, 2014. (“[VGI Roadmap](http://www.caiso.com/documents/vehicle-gridintegrationroadmap.pdf)”)
	+ CPUC, Appendix B to the Assigned Commissioner Ruling Regarding the Filing of Transportation Electrification Applications Pursuant to Senate Bill 350, 2016 (“[Appendix B](http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M167/K099/167099725.PDF)”)
	+ CEC and CPUC Joint Workshop, Vehicle-Grid Integration Communications Standards – [Interagency Presentation](http://docketpublic.energy.ca.gov/PublicDocuments/16-TRAN-01/TN214649_20161207T080617_VehicleGrid_Integration_Communications_Standards.pdf), [2016](http://www.energy.ca.gov/altfuels/2016-TRAN-01/documents/index.html#12072016)
	+ CEC, Annual Multi-Agency Update on Vehicle-Grid Integration Research, [2014](http://www.energy.ca.gov/research/notices/#11192014), [2015](http://www.energy.ca.gov/research/notices/#12142015), [2016](http://www.energy.ca.gov/research/notices/#12122016)
	+ SMUD - various presentations and studies on VGI benefits and costs ( see appendix)
		- SAE 2014-01-0344:  Electric Grid Integration Costs for Plug-in Electric Vehicles:  Jeff Berkheimer, Jeff Tang, Bill Boyce, Deepak Aswani, SAE International Journal of Alternative Power, 3(1), 2014, doi: 10.4271/2014-01-0344
		- EVS29 EPRI’s ‘Hotspotter’ Tool:  Identifying Potential Utility System Overloads in a Growing EV Market:  Jamie Dunkley, Deepak Aswani, Arindam Maitra, Jason Taylor, Rajesh Radhakirishnan, Dwight MacCurdy.
		- Bill Boyce Presentation on April 18, 2016 to the CEC’s IEPR / IRP workshop
	+ Vehicle-Grid Integration Communications Protocol Working Group, CPUC and CEC Staff Straw Proposal, 2017 (“[Straw Proposal](http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442453060)”)
	+ EPRI presentation, Dec 2016 at interagency workshop (e.g., lists 24 guiding principles expanding on Appendix B)
	+ CPUC submetering effort
	+ DOE-EPRI Battery Storage Guidelines
	+ Rocky Mountain Institute, The Economics of Battery Energy Storage, 2015
	+ ElaadNL, EV Related Protocol Study, 2017 (“[Protocol Study](https://www.elaad.nl/uploads/files/EV_related_protocol_study_v1.1.pdf)”) – for European architecture and protocol reference purposes only.
	+ IEC / ISO Standards
	+ SAE Standards / Technical Information Reports / Recommended Practices
		- J2836/1 Use Cases for Communication Between Plug-in Vehicles and the Utility Grid
		- J2847/1 Communication between Plug-in Vehicles and the Utility Grid
		- J2836/2Use Cases for [**Communication Between Plug-In Vehicles and Off-Board DC Chargers**](http://standards.sae.org/j2847/2_201504/)
		- J2847/2 [**Communication Between Plug-In Vehicles and Off-Board DC Chargers**](http://standards.sae.org/j2847/2_201504/)
		- J2836/3 Use Cases for Plug-In Vehicle Communication as a Distributed Energy Resource
		- J2847/3 Plug-In Vehicle Communication as a Distributed Energy Resource J2931/1 Digital Communications for Plug-in Electric Vehicles
		- J2931/4 Broadband PLC Communication for Plug-in Electric Vehicles
		- J3072 Interconnection Requirements for Onboard, Utility-Interactive Inverter Systems

<http://www.sae.org/search/?qt=j2836%2F1&sort=relevance&sort-dir=desc&display=list&content-type=%28%22STD%22%29>

* + IEEE 2030.5 IEEE Adoption of Smart Energy Profile 2.0 Application Protocol Standard - https://standards.ieee.org/findstds/standard/2030.5-2013.html
	+ OpenADR 2.0b Specifications - https://standards.ieee.org/findstds/standard/2030.5-2013.html
	+ NIST IR 7628, volumes 1, 2 and 3 - http://csrc.nist.gov/publications/nistir/ir7628/nistir-7628\_vol2.pdf
	+ California Smart Inverter Working Group (SIWG) and California Smart Inverter Profile (CSIP) documents and recommendations California Smart Inverter Profile of IEEE 2030.5- [http://sunspec.org/ieee-2030-5-common-california-iou-rule-21-implementation-guide-smart-inverters/](https://urldefense.proofpoint.com/v2/url?u=http-3A__sunspec.org_ieee-2D2030-2D5-2Dcommon-2Dcalifornia-2Diou-2Drule-2D21-2Dimplementation-2Dguide-2Dsmart-2Dinverters_&d=DwMGaQ&c=YFYuafCCopBdR2aI1UDiwKbQTSrP7gdpddSkt1TYoDc&r=68DZSAKoPAzLeehQ-8-yKQ&m=VR_cFfLu25zghK-bCxBD83bDZ1W7ay0mpROHyq1FWI0&s=ivraSZD2rMcG3F64gEo8BfJD79shffMxZboe-qxafco&e=)
	+ EPRI Public Documents:
		- Open Vehicle-Grid Integration Platform: General Overview Product ID 3002008705
		- Open Vehicle-Grid Integration Platform: Systems Approach to Standards and Interoperability Product ID: 3002008866,
		- Open Vehicle-Grid Integration Platform – Unified Approach to Grid / Vehicle Integration: Definition of Use Case Requirements Product ID: 3002005994

https://www.epri.com/#/search/Open%20Vehicle-Grid%20Integration%20Platform:%20General%20Overview/?to=1483020750731&from=1310345249268

* + NIST/SGIP Catalog of Standards - [http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/SGIPCoSStandardsInformationLibrary](https://urldefense.proofpoint.com/v2/url?u=http-3A__collaborate.nist.gov_twiki-2Dsggrid_bin_view_SmartGrid_SGIPCoSStandardsInformationLibrary&d=DwMGaQ&c=YFYuafCCopBdR2aI1UDiwKbQTSrP7gdpddSkt1TYoDc&r=68DZSAKoPAzLeehQ-8-yKQ&m=VR_cFfLu25zghK-bCxBD83bDZ1W7ay0mpROHyq1FWI0&s=u9aUfC70ufZ9JpX41yc7RZYJ-EVnw6G2F37OiTt_1OI&e=)
	+ *Others to be added later*

**Appendix D**

**Glossary** - *To be added later by the Terminology and Definitions subgroup* (for some definitions and terms see the workplan above)

**Appendix E**

**List of companies and their representatives who drafted this proposal**

**American Honda Motors**, Jeremey Whaling

**BMW of North America**, Adam Langton

**EPRI**, Dan Bowermaster, Sunil Chhaya, George Bellino

**Fiat Chrysler Automobiles**, Rich Scholer

**Ford Motor Company**, Dave McCreadie

**Honda R&D Americas Inc**., Robert Uyeki

**Nissan Technical Center North America**, Lance Atkins

**Pacific Gas & Electric Company**, Abigail Tinker

**Sacramento Municipal Utility District**, Bill Boyce

**Southern California Edison Company**, Dean Taylor, Jordan Smith, Josh McDonald

**Tesla Motors**, Beau Whiteman

**Toyota Motor North America**, Dan Mikat

1. EPRI has no position on policies adopted as a result of this working group [↑](#footnote-ref-1)
2. ACR X denotes the criteria was listed as “Exemplary Criteria” in Appendix B of the September 14, 2016 ACR on SB 350 TE applications (pg. B5-B6) [↑](#footnote-ref-2)