Transportation Electrification Workstream Report

EPIC POLICY + INNOVATION COORDINATION GROUP

FEBRUARY 2021

This report was completed by The Accelerate Group, a consultant to the California Public Utilities Commission and the Project Coordinator for the EPIC Policy + Innovation Coordination Group. The information herein was collected and summarized by the Project Coordinator, with input from members of the EPIC Policy + Innovation Coordination Group, and does not reflect an official position of the California Public Utilities Commission.

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EXECUTIVE SUMMARY

The overall goal of the EPIC Policy + Innovation Coordination Group's Transportation Electrification Workstream was to work with EPIC RD&D projects and other stakeholders to address questions raised by the interagency Vehicle-Grid Integration (VGI) Working Group and the California Public Utilities Commission's Transportation Electrification Framework on technology, regulatory, and market challenges to transportation electrification development, and gain an understanding of the cost-effectiveness of different approaches. Stakeholders can also use the lessons learned from the Transportation Electrification Workstream in opportunities for comments and workshop participation, including during the implementation of CPUC Decision 20-12-029, concerning Low Carbon Fuel Standard holdback revenue utilization, which the CPUC approved on December 17, 2020.

More than 180 different individuals participated in the three 90-minute workstream meetings from September – November 2020, including California Public Utilities Commission and California Energy Commission staff and Commissioners; research, development, and deployment (RD&D) project leaders; utilities, technology solution providers; vehicle manufacturers; and researchers.

Key Learnings

Learning #1: Software solutions can reduce grid infrastructure upgrades costs in installing EV infrastructure.

EPIC projects participating in the workstream identified that software-based energy management systems, which can limit the maximum charging level of a fleet of electric vehicles (EVs) on the customer side of the service, have strong potential to avoid the need for additional and costly service upgrades and/or customer side electrical capacity upgrades.

Learning #2: Leveraging automated load management as a solution to reduce grid upgrade costs can be accomplished by sharing more grid infrastructure data, or by establishing managed charging standards.

To implement managed charging as a way to avoid infrastructure costs at a significant scale in the market, participants said a consistent, simple, and replicable approach will be needed, rather than the ad hoc approach used today.

Learning #3: Understanding the challenges of managed charging for Medium- and Heavy-Duty vehicle customers is key to increasing adoption.

If California wants to leverage the capability of managing electric vehicle load to address energy and power system needs, it needs to ensure that the systems being deployed today can adapt to the needs of the future.

Learning #4: V1G – demand management and load shifting – is the low-hanging fruit that can provide benefits now.

Workstream presenters noted that while much attention has been focused on the development of technology solutions and rules around Vehicle-to-Grid (V2G) solutions, there is a significant need already today around managed or controlled charging (V1G) services that electric vehicles can be providing, where customers shift charging behavior in response to grid needs.

Learning #5: Addressing market entrance barriers will enable vehicles to provide frequency regulation and some demand response services.

Leveraging electric vehicles to provide demand response and frequency regulation can support grid needs, including resource adequacy, frequency regulation, and renewable energy integration. Yet, current market rules around demand response participation and wholesale market access limit the ability of standalone charging infrastructure from providing those services.

Learning #6: There is a clear path for V2G with DC-based charging systems with smart inverters.

Buses coming off the line with CHAdeMO (DC fast charge ports) are V2G capable. As the charging infrastructure acts as an inverter, converting AC to DC and vice-versa, it simply needs to be Rule 21-certified (interconnection standard for inverters) in order to connect to and provide services to the grid.

Learning #7: Consistent standards will support development of V2G with AC-based charging systems.

In contrast to DC fast charge systems, the future of V2G with AC-connected infrastructure (Level 1 and Level 2 AC Electric Vehicle Supply Equipment) is more uncertain because the inverter is on the vehicle itself. Consistent standards will be helpful in avoiding a patchwork of approaches to vehicle communication and control technologies, reducing the risk of stranded assets, and streamlining processes such as interconnection.

Learning #8: V2H electric vehicle systems, paired with stationary storage and rooftop solar, can provide significant resiliency benefits during high-stress periods.

Maria Sanz, of PG&E, presented the results of PG&E's "Vehicle to Home Demonstration," documenting that their electric vehicle system, paired with rooftop solar and stationary storage, was able to achieve 31.2 days of resiliency during a summer power outage simulation.

Learning #9: Workplace charging has potential benefits for supporting the grid and can be the easiest to incorporate into managed charging.

Policymakers have focused extensively on ways to shift electric vehicle charging load in the middle of the workday to align solar generation, providing load when it is most beneficial for the grid.

Learning #10: Compiling large, anonymized EV datasets for the research community, utilities, solution providers, and policymakers can help plan for and optimize electric vehicle charging.

Understanding when, where, and how electric vehicle owners are charging their vehicles can drive more effective analysis, incentives, rate design, and other policies to optimize charging behavior and achieve greater consumer benefits, according to workstream panelists.

Learning #11: Optimized charging can significantly reduce peak impacts and reduce customer demand charges.

Projects have demonstrated their ability to reduce peak loads due to EV charging in public settings by about half, and shift the ultimate peak load hour of workplace customers from 9 am to 12 pm, in greater alignment with solar output.

Learning #12: Individual customer incentives for managing EV load are relatively small and are short-lived drivers of EV charging behavior change.

Projects that focused on incentivizing customers to shift load for each event had difficulty retaining customers. Other incentives may be more effective.

Key Opportunities for Coordination and Collaboration

- The CPUC should consider establishing a working group process, comprised of technology solution providers, SCE, PG&E, and SDG&E, to develop a consistent application and approval process for companies to use automated load management as a means to offset upfront infrastructure costs. In D.20-12-029, the CPUC directed that any future tariff or rule for service line and/or distribution line upgrades to support transportation electrification shall provide an option for customer-side Automated Load Management where beneficial to ratepayers while meeting transportation electrification charging needs.
- Policymakers, technology solution providers, distribution system operations, and CAISO can come together to address market barriers to vehicles participating in grid services, including frequency regulation, voltage support, and grid support functions enabled by smart inverters. Barriers identified by the workstream include minimum size requirements, metering requirements, the ability of certain resources to participate in wholesale market services, and settlement.
- Stakeholders should continue work with automakers to support the development of consistent standards for communication between vehicles and AC-based charging systems to enable Vehicle-to-Grid services, where the inverter technology is located on the vehicle itself.
- Researchers and stakeholders should work together to develop a standardized schema for sharing charging location behavior data from multiple electric vehicle and electric vehicle supply equipment vendors. A clearinghouse for storing those datasets will provide researchers, companies, and policymakers with real-world behavior data that can be used to measure the costs and benefits of optimizing charging behavior through incentives, rates, and infrastructure planning.
- Workstream participants found that there needs to be additional work to identify ways to motivate customer behavior for sustained periods of time. One option panelists discussed was developing policy-focused testbeds, rather than just technology-focused testbeds, where researchers can test variable pricing, incentives, and rewards and evaluate customer behavior.

BACKGROUND

What is the Policy + Innovation Coordination Group?

The California Public Utilities Commission (CPUC) oversees and monitors the implementation of the ratepayer funded Electric Program Investment Charge (EPIC) research, development, and deployment program. For current EPIC funds from investment periods 1, 2, and 3, there are four program administrators: the California Energy Commission (CEC), Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E).

In Decision 18-10-052, the CPUC established the Policy + Innovation Coordination Group (PICG)—comprised of a Project Coordinator, the four Administrators, and the CPUC—to increase the alignment and coordination of EPIC investments and program execution with CPUC and California energy policy needs.

Selection of the Workstreams

In August 2020, the California Public Utilities Commission (CPUC) launched four Partnership Areas where RD&D projects funded through the CPUC's EPIC Program could accelerate innovation, and create a positive feedback loop between the State's electricity RD&D efforts and emerging energy policy challenges: equity, transportation electrification, wildfire mitigation, and public safety power shutoffs. The Partnership Areas were identified as critical and timely for decision-making for 2020.

To facilitate productive input, the Policy + Innovation Coordination Group established workstreams for each Partnership Area to allow RD&D project leaders and stakeholders to share their direct experiences in RD&D projects, identify policy obstacles to new and emerging technology adoption, help inform ongoing and upcoming Commission proceedings and other policy deliberations, and create new collaborations to accelerate energy innovation.

Workstream Goals

The overall goal of the Transportation Electrification Workstream is to address questions raised by the California Joint Agencies Vehicle-Grid Integration (VGI) Working Group and the CPUC's Transportation Electrification Framework on technology, regulatory, and market challenges to transportation electrification development, and gain an understanding of the cost-effectiveness of different approaches. Stakeholders can also use the lessons learned from the Transportation Electrification Workstream in opportunities for comments and workshop participation, including during the implementation of CPUC Decision 20-12-029, concerning Low Carbon Fuel Standard holdback revenue utilization, which the Commission approved on December 17, 2020.

The topics and core questions of the workstream meetings were designed to target recommendations where the CPUC Energy Division signaled a need to answer open questions, and where information from EPIC projects that are active or completed could provide worthwhile insights.

Workstream Schedule

Transportation Electrification Workstream Meeting #1:
Energy management
September 30, 2020
Transportation Electrification Meeting #1 focused on EPIC projects that can provide insights on Energy Management Systems as offsetting the need for a utility service connection upgrade.

Transportation Electrification Workstream Meeting #2:
Vehicles providing backup power and grid services
October 22, 2020
Transportation Electrification Meeting #2 focused on EPIC projects that can provide insights on the use of electric vehicles for backup generation, as part of microgrids, and to provide grid services.

Transportation Electrification Workstream Meeting #3:
Customer engagement in VGI, and infrastructure planning
November 19, 2020

Transportation Electrification Meeting #3 focused on EPIC projects that can provide insights on marketing, education, and outreach to gain customer participation in vehicle-grid integration efforts, and on planning and optimizing charging infrastructure deployment to avoid distribution system impacts.

Presentations & Panelists

Presenter / Panelist	Organization
Andrew Barbeau	EPIC Policy + Innovation Coordination Group
Ed Pike	CPUC
Zachary Lee	PowerFlex Systems
Hitesh Soneji	Olivine, Inc.
Thomas Ashley	Greenlots
Jordan Smith	SCE
Lydia Krefta	PG&E
Seunil Chhaya	EPRIA
Kelsey Johnson	Nuvve
Timothy Lipman	UC Berkeley
Maria Sanz	PG&E
Gustavo Vianna Cezar	SLAC National Accelerator Laboratory
Douglas Black	Lawrence Berkeley National Laboratory
George DeShazo	UCLA
Stephen Wong	UC Berkeley

TRANSPORTATION ELECTRIFICATION MEETING #1

Transportation Electrification Meeting #1 was held virtually on September 30, 2020 from 10:00 am – 11:30 am Pacific Standard Time. The meeting focused on EPIC projects that can provide insights on Energy Management Systems as offsetting the need for a utility service connection upgrade.

Presenters at the first workstream meeting were asked to address some, or all, of the following core questions:

- How can utilities/customers incorporate an electric vehicle energy management system when determining the need for a utility service connection upgrade?
- Which barriers would prevent customers from adopting energy management systems as a non-wires alternative to physical upgrades?
- What information is needed to evaluate the potential to use electric vehicle energy management systems to manage concentrated loads, such as Medium-Duty/Heavy-Duty loads, to avoid a utility distribution system transformer or feeder upgrade?

Panelists

- **Introductions, Goals, What to Expect**
  Andrew Barbeau, PICG Project Coordinator
- **Transportation Electrification Policy Background and Context**
  Ed Pike, California Public Utilities Commission
- **Demonstration of Vehicle-Grid Integration under Non-Residential Scenarios (CEC EPC-17-020)**
  Zach Lee, PowerFlex Systems
- **California E-Bus to Grid Integration Project (CEC EPC-16-065)**
  Hitesh Soneji, Olivine, Inc.
- **Improving Commercial Viability of Fast Charging by Providing Renewable Integration and Grid Services with Integrated Multiple DC Fast Chargers (CEC EPC-16-055)**
  Thomas Ashley, Greenlots

- **Distributed PEV Charging Resources: Fast Charging Stations (SCE EPIC 3 – Project 8)**
  Jordan Smith, SCE

- **Demonstrate Subtractive Billing With Submetering for EVs to Increase Customer Billing Flexibility; Multi-Purpose Meter (EPIC 1 – Project 22, EPIC 3-Project 27)**
  Lydia Krefta, PG&E

Attendees

There were 135 attendees at the first Transportation Electrification Workstream meeting, representing government entities, utilities, Community Choice Aggregators, transportation electrification technology companies, non-governmental organizations, and researchers. Twelve members of CPUC staff, 16 members of California Energy Commission staff, and representatives from the California Air Resources Board participated.

Learning #1: Software solutions can reduce grid infrastructure upgrades costs in installing EV infrastructure.

As electric vehicle charging infrastructure is deployed, the power requirements of medium- and heavy-duty and fleet vehicle charging infrastructure (and in some cases non-fleet passenger vehicle charging) will often exceed the existing electrical service capabilities of a customer. Most applications could require significant and costly upgrades, such as a new electrical panel upgrade, a main electrical room upgrade and an upgraded electrical service, a transformer upgrade, and some may require additional upgrades on the feeder of the electric distribution system. Currently, the additional infrastructure needed to support electric vehicle charging is based on the nameplate capacity of the charging equipment, assuming all vehicles are charging at their peak charging rate at the same time.

EPIC projects participating in the workstream identified that software-based energy management systems, which can limit the maximum charging level of a fleet of vehicles on the customer side of the service, have strong potential to avoid the need for additional and costly service upgrades and/or customer side electrical capacity upgrades. This managed charging would ensure that connected load does not exceed the rated capacity of the line serving it.

Southern California Edison identified that it is working to develop an intake process that would allow the utility to take into account managed charging as an offset to grid infrastructure upgrades, and that their work with PowerFlex was the first example where a company worked with the utility to do so.

- PowerFlex identified that an energy management system allowed them to deploy far more charging ports in their project for the same cost. It was able to deploy 168 charging stations at a cost of $3,000/port, significantly less than comparable deployments at $10,000 - $15,000/port.

- Greenlots identified that the software side of electric vehicle infrastructure costs that includes an energy management system is about 1% of total infrastructure costs, and thus cost savings on the infrastructure side far outweigh any software expense.

Learning #2: Leveraging automated load management as a solution to reduce grid upgrade costs can be accomplished by sharing more grid infrastructure data, or by establishing managed charging standards.

Southern California Edison underwent an extensive evaluation process to add PowerFlex's technology to their "Approved Package List" in their Charge Ready program, the first for energy management systems that are designed to limit charge rates under the line rating (the maximum power under which a distribution segment can safely operate). SCE believes that was the first evaluation procedure for an electric vehicle energy management system that was effectively put into practice.

To ensure an energy management system is able to limit the current and power use at its facility, the utilities are most concerned with ensuring that the systems are able to maintain power use at the defined level in normal operating conditions, and that if the system does fail, that it fails in a safe manner so that lines are not overloaded.

To accomplish this type of effort at scale, participants said a consistent, simple, and replicable approach will be needed. The load-serving entities are exploring the role of energy management systems themselves and have approached each implementation on a case-by-case basis.

Companies working in this space on early projects state that one approach that could enable projects to be done more easily at scale would be to securely share more grid infrastructure data, including:

- Aggregated feeder load
- Real-time measurements to understand typical electrical use on the line
- Transformer and line ratings to understand the total capacity of the line

With this information, the companies said, they can perform the analysis needed to establish a maximum load level that would reduce the need for significant new infrastructure supporting the site and have that approved by a distribution system operator. Alternatively, getting “safe operating envelopes” from the utility themselves (maximum load levels that the distribution infrastructure can support) would serve the same purpose.

Alternatively, panelists discussed that standards could be developed to implement energy management systems as a means to reduce infrastructure upgrade costs. There are some standards that are emerging, such as UL 916, and CSA 22.2 EVEMS, but panelists commented that more work needs to be done on those standards before they are ready.

Learning #3: Understanding the challenges of managed charging for Medium- and Heavy-Duty vehicle customers is key to increasing adoption.

The adoption of energy management systems and smart charging systems in the medium- and heavy-duty vehicle sector is very low today, and the existing electric vehicle infrastructure and control systems that have been deployed have not been built to be VGI active. If California wants to leverage the capability of managing electric vehicle load to address energy and power system needs, it needs to ensure that the systems being deployed today can adapt to future needs.

For many medium- and heavy-duty fleet owners, the challenge of electrification is so great, according to panelist Hitesh Soneji of Olivine, Inc., that long-term management of energy use is typically not considered during the development of the project. The greatest concern for these customers, according to Olivine, is getting their systems built and functioning and coordinating charging operations.

Further, fleet operators may believe their fleet schedules may not be conducive to managed charging, as often fleet charging is very time constrained. A fleet owner’s perceived need for emergency charging may also lead companies to oversize their charging systems, believing they must ensure they can rapidly charge if needed.

Where energy management systems have been adopted by light-, medium- and heavy-duty fleets to date, they have not been used to offset upfront costs on the electrical infrastructure serving their facility, and have been primarily used to reduce ongoing costs, such as demand charges, and to earn revenue from market participation in demand response programs. Managing electric load for Medium- and Heavy-Duty vehicles is essential to avoid costly and time-consuming electrical capacity upgrades that would otherwise be a major barrier to installing charging infrastructure.

Summary of Opportunities for Coordination and Collaboration

- The CPUC should consider establishing a working group process, comprised of technology solution providers, SCE, PG&E, and SDG&E, to develop a consistent application and approval process for companies to use automated load management as a means to offset upfront infrastructure costs. This working group should gain lessons learned from the work utilities have conducted so far to authorize company automated load mnagement software as part of transportation electrification installations, as well as data from other real-world examples, to gain up-front grid and customer cost reductions, and ongoing benefits, from managed charging. In D.20-12-029, the CPUC directed that any future tariff or rule for service line and/or distribution line upgrades to support transportation electrification shall provide an option for customer-side automated load management where beneficial to ratepayers while meeting transportation electrification charging needs.

- While public and residential grid impact is largely dependent on consumer behavior, fleet vehicle impact is driven by operations. SCE is looking at data coming from its Charge Ready Transport program, which will be valuable to understand this impact and resultant energy management potential which could be used to avoid or reduce infrastructure costs.

TRANSPORTATION ELECTRIFICATION MEETING #2

Transportation Electrification Meeting #2 focused on EPIC projects that can provide insights on the use of electric vehicles for backup generation, as part of microgrids, and to provide grid services, such as demand response and frequency regulation.

Presenters were asked to share insights and lessons learned from their project and related work on the following areas:

- The feasibility of EVs for backup generation when not as part of a Microgrid (Recommendation 5.02 of the VGI Working Group final report), and when part of a multi-customer Microgrid (Recommendation 6.07 of the VGI Working Group final report).
- The ability of Electric Vehicle Supply Equipment (EVSE) vendors to provide grid services (Recommendation 2.21 of the VGI Working Group final report).
- The costs of hardware and software technology solutions for transportation electrification.

Panelists

- **Introductions, Recap of First Meeting, What to Expect**
  Andrew Barbeau, PICG Project Coordinator

- **Open Vehicle to Building/Microgrid Integration Enabling Zero Net Energy and Improved Distribution Grid Services (CEC EPC-16-054, CEC EPC-14-086)**
  Sunil Chhaya, EPRI

- **Intelligent Electric Vehicle Integration (INVENT) (CEC EPC-16-061)**
  Kelsey Johnson, Nuvve

- **Service Center of the Future & Smart Cities (SCE EPIC 3 – Project 12)**
  Jordan Smith, SCE

- **Open-Source, Open-Architecture Software Platform for Plug-In Electric Vehicle Smart Charging in California (CEC EPC-15-013)**
  Tim Lipman, UC Berkeley

- **Test Smart Inverter Enhanced Capabilities - Vehicle to Home; BMW Charge Forward (PGE EPIC 2 – Project 3 B, BMW Charge Forward)**
  Maria Sanz Moreno, PG&E

Attendees

There were 91 attendees at the second Transportation Electrification Workstream meeting representing government entities, utilities, Community Choice Aggregators, transportation electrification technology companies, vehicle manufacturers, non-governmental organizations, and researchers. Eleven members of CPUC staff, 15 members of California Energy Commission staff, and representatives from the California Air Resources Board participated.

Learnings

Learning #4: V1G – demand management and load shifting – is the low-hanging fruit that can provide benefits now.

Workstream presenters noted that while much attention has been focused on the development of technology solutions and rules around Vehicle-to-Grid (V2G) solutions, that there is a significant need already around managed or controlled charging (V1G) services that electric vehicles can provide, where customers shift charging behavior in response to grid needs.

Kelsey Johnson, of Nuvve, stated that these V1G services, operating behind the meter, are the low-hanging fruit that can happen today. Nuvve's project to manage charging at a parking garage with a number of vehicles was able to demonstrate $385/month of demand charge savings (9% of the garage's overall monthly bill). That represents a potential for around $4,600 in annual savings for a typical parking garage (with a demand of under 100kW) in SDG&E territory.

Jordan Smith, of Southern California Edison, noted that near-term adoption should focus on simple systems that are easily implemented, such as embedding certain settings and configurations, like following Time-of-Use Rate signals, as a more effective approach compared to active vehicle management.

Tim Lipman, of UC Berkeley, noted that in his research, using telematics to integrate charge management with existing vehicle charging infrastructure and vehicles can be a cost-effective approach to V1G. At scale, Tim Lipman argued that managing EV charging load to align with periods of oversupply can reduce curtailment of solar production by 1.5 - 2 terawatt-hours annually in California by 2030, assuming a range of 2.6 - 3 million Electric Vehicles in the state by that time. That would be a reduction of 15-20% of expected curtailment by 2030, providing up to $50 million per year in grid cost savings and abiding the need for natural gas generation in ramp hours. To achieve this, a greater focus on workplace charging (and associated incentives) is needed, in order to gain capacity to charge during the day. Evaluating incentive and infrastructure costs to gain workplace charging adoption would need to be evaluated against the total benefit achieved.

Maria Sanz, of PG&E, noted that load shifting in response to Time-of-Use Rates and other price signals are near-term opportunities, but do face enrollment challenges to gain participation. In PG&E's Charge Forward Pilot, in partnership with BMW, she noted that PG&E and BMW identified that customers were willing to change their charging behavior when given the right incentives and messaging. During Earth Week, with more social messaging to participants and additional financial incentives, 73% of people charged in the middle of the day (during times of high solar penetration), more than double the typical amount. She recommended that program leaders also develop leaner customer enrollment processes to help increase participation.

Learning #5: Addressing market entrance barriers will enable vehicles to provide frequency regulation and some demand response services.

Leveraging electric vehicles to provide demand response and frequency regulation can support grid needs, including resource adequacy, frequency regulation, and renewable energy integration, and generate more than $10,000/MW/month in revenue for V2G providers.

Presenter Kelsey Johnson, with Nuuve, described the Intelligent Electric Vehicle Integration (INVENT) (CEC EPC-16-061) project that Nuvve worked on, in coordination with UC San Diego, to demonstrate the ability and value of a set of vehicle-grid integration solutions. She documented that they were able to piggy-back onto UCSD's existing demand response market participation to demonstrate 4.6 MW of additional demand response in August 2020, earning close to $50,000 for the month. Further, they were able to demonstrate the technical ability to provide a “Regulation Up” and “Regulation Down” service for the Frequency Regulation market.

Yet, current market rules around demand response participation and wholesale market access limit the ability of standalone charging infrastructure from providing those services.

For demand response, there is a minimum offering limit within commercial customer demand response participation of 100 kW, according to Maria Sanz with PG&E. That minimum bar would exclude most level 2 AC electric vehicle charging station deployments of less than 20 ports on one premise, even at higher charging levels. Maria Sanz noted that it is typically not possible to aggregate that much capacity for customers working exclusively with electric vehicles, due to the number of charging stations that would have to be installed at a location to reach the minimum offering level. Further, program requirements create additional barriers: DR programs’ required hours of availability for load reduction may not align with the times when charging typically happens at a location, and baseline calculation methods (demand response performance is calculated against a baseline of typical and recent load levels) have been developed for more traditional loads, and are not well-defined for electric vehicle charging loads.

For frequency regulation, Kelsey Johnson pointed to the inability of electric vehicles to participate in wholesale frequency regulation services with CAISO. While their systems and performance were technically feasible, they had no ability to directly participate in the market as a resource behind a retail meter, due to CAISO rules on market participation. Together, participants cautioned that without this ability, there was no viable business model for customers looking to use VGI to participate in wholesale market service. Tim Lipman, of UC Berkeley, noted that, based on deployment observations in other markets, the need for Frequency Regulation will saturate quickly, and it is likely that other technologies, such as large-scale battery energy storage systems, will fill the need in the market before vehicles have an opportunity to participate.

Within both markets, Maria Sanz noted another barrier, that the markets are designed for stationary storage, and that the fact that a vehicle moves from premise to premise (home to workplace, for example) creates uncertainty on where and when that capacity will be available. Tim Lipman, however, noted that shifting across time and space could provide opportunities to serve grid constraints in ways that stationary storage cannot.

Learning #6: There is a clear path for V2G with DC-based charging systems with smart inverters.

Kelsey Johnson of Nuvve noted that buses coming off the line with CHAdeMO (DC fast charge ports) are V2G capable. DC charging that relies on an off-board inverter that converts utility AC power to DC power to charge the vehicle can be interconnected so long as it meets requirements described in Rule 21 to connect and provide services to the grid. However, she also commented that ISO-15118, a standard for the V2G communication interface between a vehicle and the electric vehicle supply equipment, needs more work to enable this function. Southern California Edison agreed, commenting that there is a clear path for V2G interconnections on the DC side.

Kelsey Johnson further commented that Nuvve is very involved with V2G school buses, which will be hitting the road in 2021, and consider them a gamechanger, with the ability to provide voltage control and frequency regulation. Kelsey Johnson commented that the typical installation cost for V2G for medium- and heavy-duty vehicles was around $1/Watt for the EVSE and other infrastructure, with a typical medium-duty/heavy-duty infrastructure installation requiring around 60 kW. The 60 kW charging level is typical for school bus charging, but other medium- and heavy-duty vehicles may charge at a different level.

Learning #7: Consistent standards will support development of V2G with AC-based charging systems.

Consistent standards will be helpful in avoiding a patchwork of approaches to vehicle communication and control technologies. According to Sunil Chhaya, standards are important in reducing the risk of stranded assets, and for streamlining processes such as interconnection. This is particularly true when accommodating public and workplace charging, where the pairing of vehicles and electric vehicle supply equipment is not a consistent arrangement.

In contrast to DC fast charge systems, the future of V2G with AC-connected infrastructure (Level 2 AC Electric Vehicle Supply Equipment), is more uncertain. With AC-connected electric vehicle supply equipment, the inverter that converts the electricity supply from AC to DC (and vice versa in a V2G environment) is actually located on the vehicle itself. Partnerships with automakers are required to design systems that control the charge and discharge of the vehicle battery systems in alignment with grid services. Maria Sanz noted that without participation from manufacturers, many V2G and V2H (vehicle to home) strategies could threaten the warranty of vehicle batteries, under either AC-based or DC-based charging systems. There is currently work in this area with the development of a Vehicle-Grid Integration Council (which includes vehicle manufacturers).

Learning #8: V2H electric vehicle systems, paired with stationary storage and rooftop solar, can provide significant reliability benefits during high-stress periods.

Maria Sanz, of PG&E, presented the results of PG&E's EPIC 2.03b project, "Vehicle to Home Demonstration," documenting that their system of an electric vehicle providing backup power support to a home, and paired with rooftop solar and stationary storage, achieved 31.2 days of reliability during a summer power outage simulation. For communities experiencing the impact of natural disasters and Public Safety Power Shutoff events, this balancing of behind-the-meter resources could provide significant energy assurance for customers looking to manage power uncertainty.

The laboratory setup included an electric vehicle battery of 60 kWh, with a discharge capability of 5 kW, as well as a 5 kW rooftop solar array, and a 5 kW/8.6 kWh stationary storage system. The scenario assumed a summer outage, with no extreme weather conditions, and an average residential load profile generated through Snapshot Efficiency, a tool designed to assist early-stage policy research. Without the stationary storage and including just the EV battery and the rooftop solar array, the system was able to provide 13.3 days of reliability. When the system relied on just the rooftop solar and the stationary storage system, and not the EV battery, the system was able to provide 5.3 days of reliability.

Summary of Opportunities for Coordination and Collaboration

- Policymakers, technology solution providers, distribution system operations, and CAISO can come together to address market barriers to vehicles participating in grid services, including frequency regulation, voltage support, and grid support functions enabled by smart inverters. Barriers identified by the workstream include minimum size requirements, metering requirements, the ability of certain resources to participate in wholesale market services, and settlement.
- Stakeholders should continue to work with automakers, standards organizations, certification organizations, companies, and utilities to support the development of consistent standards for communication between vehicles and AC-based charging systems to enable Vehicle-to-Grid services, where the inverter technology is located on the vehicle itself.

TRANSPORTATION ELECTRIFICATION MEETING #3

Transportation Electrification Meeting #3 focused on EPIC projects that can provide insights on marketing, education, and outreach to gain customer participation in vehicle-grid integration efforts, and on planning and optimizing charging infrastructure deployment to avoid distribution system impacts.

Presenters were asked to share insights and lessons learned from their projects and related work on the following areas:

- What are insights and lessons learned we can gain to inform marketing, education, and outreach efforts to enable customer engagement around Vehicle-Grid Integration (VGI Working Group Recommendation 9.03)?
- What can be done to better plan and optimize charging infrastructure deployment to avoid distribution system impacts?
- Discussion of opportunities for coordination and collaboration among transportation electrification RD&D efforts.

Panelists

- **Introductions, Recap of Second Meeting, What to Expect**
  Andrew Barbeau, EPIC Policy + Innovation Coordination Group Project Coordinator

- **Development of Smart Charging Infrastructure Planning Tool (SCRIPT) (CEC EPC-16-057)**
  Gustavo Vianna Cezar, SLAC National Accelerator Laboratory

- **Smart Charging of Plug-in Vehicles with Driver Engagement for Demand Management and Participation in Electricity Markets (CEC EPC-14-057)**
  Doug Black, Lawrence Berkeley National Laboratory

- **Identifying Effective Demand Response Program Designs to Increase Residential Customer Participation (CEC EPC-15-073)**
  J.P. DeShazo, UCLA

- **Challenges and strategies in customer engagement in VGI**
  Stephen Wong, University of California, Berkeley

Attendees

There were 97 attendees at the third Transportation Electrification Workstream meeting representing government entities, utilities, Community Choice Aggregators, transportation electrification technology companies, vehicle manufacturers, non-governmental organizations, and researchers. Fourteen members of CPUC staff, 12 members of California Energy Commission staff, and representatives from the California Air Resources Board participated.

Learnings

Learning #9: Workplace charging has potential benefits for supporting the grid and can be the easiest to incorporate into managed charging.

Policymakers have focused extensively on ways to shift electric vehicle charging load to the middle of the day to align with solar generation and provide load when it is most beneficial for the grid. A focus on increasing, and managing, workplace charging can provide an easy pathway to aligning that load, according to Gustavo Cezar, with SLAC. Managing load through a cluster of level 2 charging ports, during a long period of flexibility, can provide a greater load shift potential than relying on individual residential or fast charge behavior.

The strategy for optimizing charging should focus on the problem needing to be solved, argued JR DeShazo of UCLA, noting that demand response activities and reducing load during critical peak periods tend to be very limited in frequency. But solving for the duck curve is quite a different problem, and a different type of optimization may make more sense.

The panelists identified that there will be a need to work together to encourage workplace charging that can be a flexible resource. J.R. DeShazo noted that the vast majority of vehicles do not charge during the day, and the move toward longer-range vehicles are reducing the propensity to connect at the workplace.

Learning #10: Compiling large, anonymized EV datasets for the research community, utilities, solution providers, and policymakers can help plan for and optimize electric vehicle charging.

Understanding when, where, and how electric vehicle owners are actually charging their vehicles can drive more effective analysis, incentives, rate design, and other policies to optimize that charging behavior and achieve greater consumer benefits, according to workstream panelists. Location data, charging start times, charging end times, and location departure times, can all provide valuable insights into the ability of EV drivers to be flexible in charge times and charging capacity.

These datasets must ensure that customer data is anonymized and privacy is preserved, but that can be done by providing anonymized data on a large scale. Gustavo Cezar said that SLAC's research, which analyzes a large dataset with 119,000 unique drivers from 6 million charging sessions over four years, has led to the creation of a powerful set of analytical tools that allow them to model managed charging, build forecast tools, and assess costs and benefits from different stakeholder perspectives. Yet, even that dataset was incomplete, and could not be easily integrated with different datasets from different manufacturers.

Doug Black noted that his team learned in their project that fleet operation logistics are more complicated in reality than in planning and simulation, given the operational needs of fleets and in situations where the number of EVs is greater than the number of electric vehicle supply equipment ports.

Creating a standardized schema for sharing charging location behavior data from multiple EV and EVSE vendors, and a clearinghouse for storing those datasets, will provide researchers, companies, and policymakers with real-world behavior data that can be used to measure the costs and benefits of optimizing charging behavior through incentives, rates, and infrastructure planning.

Learning #11: Optimized charging can significantly reduce peak impacts and reduce customer demand charges.

Panelist Doug Black described that on their project managing charging in an Alameda County parking garage, optimizing the charging at 36 Level 2 charging ports, and one DC Fast Charge port, reduced the monthly peak load of the garage from ~44kW to ~23 kW, with the same volume of charging and no impact on serving customer needs, by managing EV charging load within customer parameters.

Further, the project shifted the ultimate peak load hour of the garage from 9 am to 12 pm, in greater alignment with solar output, and was able to mitigate the demand spikes from the DC fast charge station by coordinating with the fleet as a whole.

The project provided charging customers with a simple phone application that asked for customers' departure time when they first parked and plugged in, and also asked how much charge they needed. The software then coordinated the charging of the vehicles to spread out charging demand over the period the vehicles were connected. While the participation in the application decreased over time, the capability of charge management proved effective with active customer participation.

Learning #12: Individual customer incentives for managing EV load are relatively small and are short-lived drivers of EV charging behavior change.

Panelists agreed that in their experience with incentivizing customers to shift load, customer interest waned quickly due to the small incentive amount per charging event. Panelist Doug Black mentioned that even with their app that provided a convenient way to manage the charge of vehicles, including with incentives and gamification, that participation rates faded after just three months. Doug noted similar results in other projects. Panelists noted that for an estimated $10/month in incentives, for example, a driver may not park in different, and possibly inconvenient locations due to the opportunity cost of walking an extra three blocks.

Panelist J.R. DeShazo agreed that gamification can be a short-lived motivator of individual action. In J.R. DeShazo' s residential demand response programs, they focused on gamification that tried to motivate longer and more sustained engagement, and looked at the motivations for different customer types. In the end, J.R. DeShazo concluded that automation is a superior strategy, because it doesn't rely on cooperative behavior.

Panelists discussed that automation and well-known Time of Use rates, in contrast to incentive-based structures, were far more effective at achieving load shifting outcomes when drivers have discretion about when to charge. The customer experience is far simpler, involving setting a schedule for charging in the car or on an app. For larger vehicles, such as buses, the capacity of load shifting is significant in the middle of the day and overnight. J.R. DeShazo agreed that the same opportunity is also likely true for Transportation Network Companies. Further, Stephen Wong, of UC Berkeley, who worked on a pilot project with 34 Honda vehicles, found that more than compensation drives customer behavior, and that non-monetary levers could have a similar effect.

In the second workstream meeting, Maria Sanz, of PG&E, noted that using Time-of-Use Rates and other price signals present near-term opportunities, but still face enrollment challenges to gain participation themselves. In PG&E's Charge Forward Pilot, in partnership with BMW, she noted that they were able to drive behavior for a week with incentives and messaging, but that was a short-term period.

Panelists discussed developing policy-focused testbeds, rather than just technology-focused testbeds, where researchers can change costs and rewards for what customers receive and evaluate the response.

Learning #13: Requiring ISO 15118 in deployed electric vehicle supply equipment and sharing smart charging information is one option to enabling cost-effective vehicle grid integration.

During the group discussion, Noel Crisostomo, of the California Energy Commission, said they are seeing the same conclusions from every pilot, both EPIC-funded and otherwise, that optimizing electric vehicle charging time and capacity could be done by requiring the implementation of ISO standard 15118. That would enable electric vehicles to communicate with charging equipment and systems about the vehicle's state of charge. The CPUC's Vehicle Grid Integration Communications Protocol Working Group, however, has identified multiple potential communications pathways, including ISO 15118.

Noel identified that relying on customer behavioral studies or customer input to guess states of charge, in order to optimize how vehicle charging could be managed, is not effective today and will likely be less so with more mandated electric vehicle purchasers. Gustavo Cezar noted that within their large datasets of 6 million charging sessions, they have not been able to gather information on the state of charge of a vehicle, how many miles they need to travel, and thus how much energy a driver actually needs for their commute. Within their interactions, Gustavo said that most individuals select the default option for charging each time, and one of their research questions going forward is whether people connect the dots between how many miles they need and what is the state of charge of their vehicle. Gustavo Cezar noted they don’t know how to get that information without tapping into the vehicle directly.

Summary of Opportunities for Coordination and Collaboration

- Create a working group to develop a standardized schema for sharing charging location behavior data from multiple electric vehicle and electric vehicle supply equipment vendors. A clearinghouse for storing those datasets will provide researchers, companies, and policymakers with real-world behavior data that can be used to measure the costs and benefits of optimizing charging behavior through incentives, rates, and infrastructure planning. The working group could also consider the proper home and management of such a clearinghouse.
- Workstream participants found that there needs to be additional work to identify ways to motivate customer behavior for sustained periods of time. One option panelists discussed was developing policy-focused testbeds, rather than just technology-focused testbeds, where researchers can test variable pricing, incentives, and rewards and evaluate customer behavior.
- Participants should provide feedback into the ongoing proceedings around the CPUC’s Draft Transportation Electrification Framework to provide their thoughts on whether ISO-15118, a standard for communication of data between vehicles and electric vehicle supply equipment, should be integrated into the utilities’ electric vehicle programs.

APPENDICES

Transportation Electrification Workstream Meeting 1:

Video Recording:
https://vimeo.com/463947588

Transcript:
https://epicpartnership.org/resources/Transcript_Transportation_Electrification_Workstream_Meeting_1_09_30_2020.pdf

Spanish Translation:
https://epicpartnership.org/resources/Spanish_Translation_Transportation_Electrification_Workstream_Meeting_1_09_30_2020.pdf

Zachary Lee (PowerFlex Systems) Presentation:
https://epicpartnership.org/resources/Lee_PICG_Transportation_Workstream_1.pdf

Hitesh Soneji (Olivine, Inc) Presentation:
https://epicpartnership.org/resources/Soneji_PICG_Transportation_Workstream_1.pdf

Thomas Ashley (Greenlots) Presentation:
https://epicpartnership.org/resources/Ashley_PICG_Transportation_Workstream_1.pdf

Jordan Smith (SCE) Presentation:
https://epicpartnership.org/resources/Smith_PICG_Transportation_Workstream_1.pdf

Lydia Krefta (PG&E) Presentation:
https://epicpartnership.org/resources/Krefta_PICG_Transportation_Workstream_1.pdf

Transportation Electrification Workstream Meeting 2:

Video Recording:
https://vimeo.com/471439188

Transcript:
https://epicpartnership.org/resources/Transportation_Electrification_Workstream_2_English_Transcript.pdf

Spanish Translation:
https://epicpartnership.org/resources/Transportation_Electrification_Workstream_2_Spanish_Transcript_v2.pdf

Sunil Chhaya (EPRI) Presentation:
https://epicpartnership.org/resources/Chhaya_PICG_Transportation_Workstream_2.pdf

Kelsey Johnson (Nuvve) Presentation:
https://epicpartnership.org/resources/Johnson_PICG_Transportation_Workstream_2.pdf

Jordan Smith (SCE) Presentation:
https://epicpartnership.org/resources/Smith_PICG_Transportation_Workstream_2.pdf

Timothy Lipman (UC Berkeley) Presentation:
https://epicpartnership.org/resources/Lipman_PICG_Transportation_Workstream_2.pdf

Maria Sanz Moreno (PG&E) Presentation:
https://epicpartnership.org/resources/Sanz_PICG_Transportation_Workstream_2.pdf

Transportation Electrification Workstream Meeting 3:

Video Recording:
https://vimeo.com/481790406

Transcript:
https://epicpartnership.org/resources/Transportation_Electrification_Workstream_Meeting_3_English_Transcript.pdf

Spanish Translation:
https://epicpartnership.org/resources/Transportation_Electrification_Workstream_Meeting_3_Spanish_Transcript_v2.pdf

Gustavo Vianna Cezar (SLAC National Accelerator Laboratory) Presentation:
https://epicpartnership.org/resources/Cezar_PICG_Transportation_Workstream_3.pdf

Douglas Black (LBNL) Presentation:
https://epicpartnership.org/resources/Black_PICG_Transportation_Workstream_3.pdf

George DeShazo (UCLA) Presentation:
https://epicpartnership.org/resources/DeShazo_PICG_Transportation_Workstream_3.pdf