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Open Vehicle-Grid Integration Platform: Unified Approach to Grid/Vehicle Integration

Phase 2 Final Update

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Technical Update, April 2020

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ABSTRACT

EPRI is involved with leading global automotive manufacturers and the utility industry in a collaboration—initiated in September 2012—to develop a unified platform for plug-in electric vehicle (PEV) and grid integration. The key attribute of the Open Vehicle-Grid Integration Platform (OVGIP) is the ability of the utility industry to integrate with the entire EV ecosystem through a single, unified, and open interface. Phase 1 of this effort spanned 2013 and 2014 (described in EPRI reports 3002000665 and 3002004037, respectively), culminating in a successful proof-of-concept demonstration that validated the feasibility for aggregated PEV load control by a utility through a central communications platform. Following this success, Phase 2 was launched and is continuing with the direct involvement of utility participants to advance this technology. The results published in this technical update can inform utility industry practitioners about technology development and investment requirements for PEV infrastructure–related equipment or services. In addition, the activity summarized represents recent development work between the utility and automotive participants to provide value-added grid services to utility companies. It further qualifies the attributes of the OVGIP to the utility industry and its benefit for providing a centralized, sustainable, and progressive vehicle-grid integration (VGI) implementation system.

Keywords
Demand response
Integration
PEV
Use cases
Utility programs
VGI

PRODUCT DESCRIPTION

This technical update provides the status on the automotive/utility industry collaborative efforts to develop and implement the Open Vehicle-Grid Integration Platform (OVGIP). The focus of this update is on this past year's work to define the utility engagement, use cases, and preliminary learnings that provide the communications interface and functional requirements for the OVGIP Phase 2 development and demonstration effort. The activity summarized in this report represents the recent development activities between the utility and automotive participants to provide value-added grid services to utility companies. It further qualifies the attributes of the OVGIP to the utility industry and its benefit for providing a centralized, sustainable, and progressive vehicle-grid integration (VGI) implementation system.

Background

EPRI is involved with leading global automotive manufacturers and the utility industry in a collaboration—initiated in September 2012—to develop a unified platform for plug-in electric vehicle (PEV) and grid integration. The key attribute of the OVGIP is the ability of the utility industry to integrate with the entire EV ecosystem through a single, unified, and open interface. Phase 1 of this effort spanned 2013[1] and 2014[2] (described in EPRI reports 3002000665 and 3002004037, respectively), culminating in a successful proof-of-concept demonstration in Sacramento, California, at Sacramento Municipal Utility District (SMUD) headquarters in October 2014.[3] The Phase 1 demonstration validated the feasibility for aggregated PEV load control by a utility through a central communications platform. Following this success, Phase 2 was launched and is continuing with the direct involvement of utility participants to advance this technology. The results published in this technical update can inform utility industry practitioners about technology development and investment requirements for PEV infrastructure–related equipment or services.

Objective

This technical update provides information about the status and progress of the collaborative OVGIP use cases and project development between the utilities and the automotive original equipment manufacturers (OEMs).

Approach

EPRI and the automotive OEMs are engaging with utility participants in the OVGIP program to develop and demonstrate individual utility-specific requirements through the application of the OVGIP use cases. The OVGIP-enabled PEV/grid integration demonstrations provide the basis for evaluating the performance characteristics, cost-effectiveness, and value of the OEM central server technology approach for EV charging management. Requirements are being vetted by the

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[1] *Unified PEV to Smart Grid Integration Approach within Automotive and Utility Industries*. EPRI, Palo Alto, CA: 2013. 3002000665.

[2] *Open Vehicle-Grid Integration Platform - Phase 1 Development Update*. EPRI, Palo Alto, CA: 2014. 3002004037.

[3] EPRI, Utilities, Automakers to Demonstrate Technology Enabling Plug-in Electric Vehicles to Support Grid Reliability - See more at: http://www.epri.com/Press-Releases/Pages/EPRI,-Utilities,-Automakers-to-Demonstrate-Technology-Enabling.aspx#sthash.F2cJe8oI.dpuf

automotive OEMs and the technology solutions developer and with each of the utilities supporting this program.

Results

The documented summary of the utility OVGIP program requirements in the form of PEV charging management–affiliated grid services and use cases presented in this technical update describes the progression of VGI requirements implementation between the automotive and utility OVGIP partners.

Applications, Value, and Use

Utilities are seeing the need to understand the value and costs of the alternative technologies being developed for monitoring and managing PEV charging loads. The utilities are creating EV load management programs to evaluate the value of PEVs as a utility-dispatchable load resource and to verify technology for engaging PEV on-vehicle battery storage capacity to maintain distribution system reliability and mitigate utility infrastructure investment costs.

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INTRODUCTION

Goal of Open Vehicle-Grid Integration Platform (OVGIP)

The goal of the Open Vehicle Grid Integration Platform (OVGIP) is the design, build, test, and implementation of a common Original Equipment Manufacturer (OEM) Plug-in Electric Vehicle (PEV) interface architecture. It utilizes a single central platform containing the protocols, software controls, algorithms, data parameters, function sets, and cybersecurity to provide interactive communications with utility Distribution Service Operators (DSO) and Independent System Operators (ISO)/Regional Transmission Operators (RTOs), for vehicle grid integration (VGI). The OVGIP is to enable bi-directional communications between grid and vehicle to manage localized and aggregated PEV-integrated grid support services.

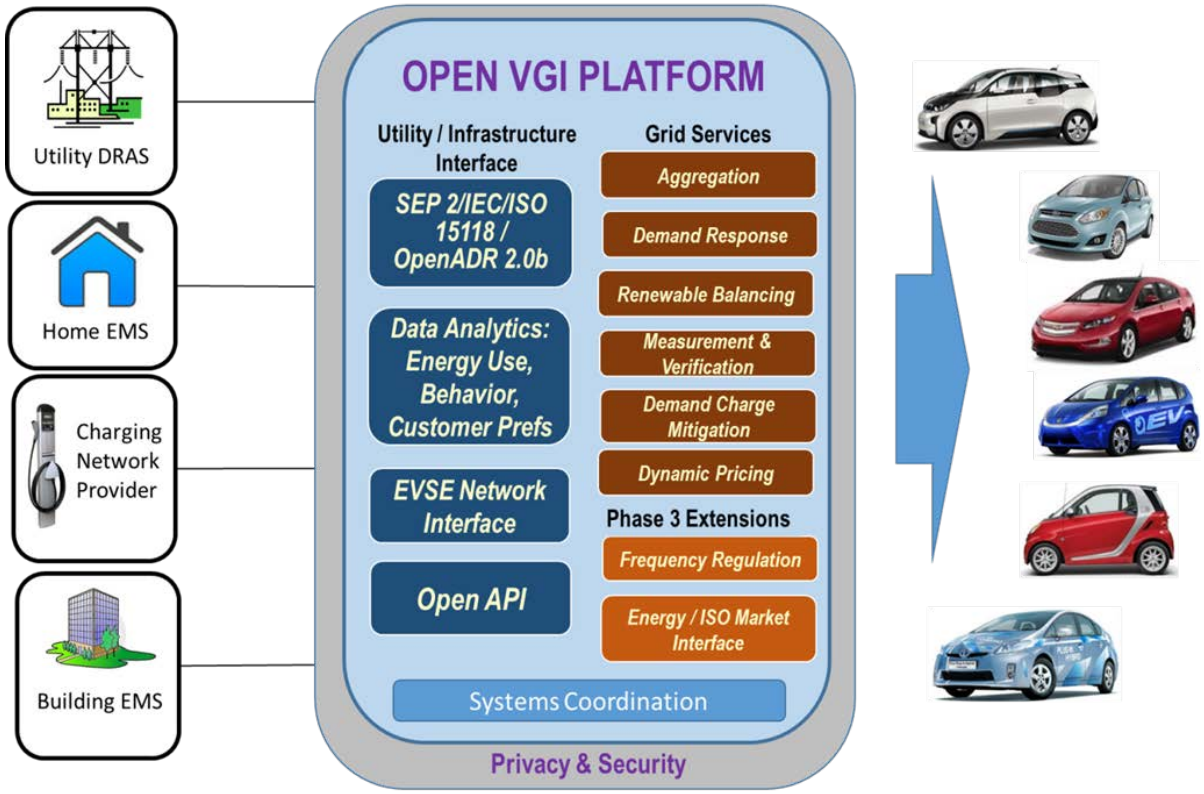

Figure 1-1
Open Vehicle-Grid Integration Platform Concept

Objective

The objective of the OVGIP is to provide a single common communications interface for all OEM PEVs to facilitate aggregated and local distribution PEV smart charging load management and control. The defining attribute of the OVGIP is to enable the grid integration of plug-in electric vehicles through a common set of protocol and security standards for vehicle grid integration providing interoperability between all appropriate VGI application standards and

industry approved protocols. A common set of interoperable standards will further support competitive innovation; and avoid the business risk and probable stranded investment caused by obsolescence of existing technologies

The principles for the OVIGP are prioritization on customer charging needs and preferences, ability to monitor customer charging behavior trends and provide current and predictive aggregated locational PEV load capacity data, accessibility to control PEV charging as a dispatchable load resource, and expanded VGI interface functionality with Electric Vehicle Supply Equipment (EVSE) Network Providers, Facilities and Home Energy Management Systems, and 3rd Party Aggregators. This technical update is to provide information about the status and progress on the collaborative OVGIP use cases and project developments between the utilities and the automotive OEMs.

OVGIP Collaboration

The OVGIP Collaboration presently constitutes active engagement between Electric Power Research Institute (EPRI), eight automotive OEMs (GM, Ford, Fiat Chrysler Automobile (FCA), BMW, Nissan, Toyota, Honda, and Tesla (observer)) and fourteen utilities (Con Edison, SCE, PG&E, SDG&E, NYPA, SMUD, AEP, PSE, Southern Company, Xcel Energy, EDF, TVA, Duke, DTE, and Ontario Power Generation (OPG)). The Electric Power Research Institute performs the program management responsibilities for facilitating the coordination and liaison with and between all participants, providing required resources for supporting technology implementation, project planning, requirements definition, and results reporting. EPRI engages and coordinates directly with the utilities and the OEMs on the determinations of the requirements, functionality, and execution criteria for the use case applications and applied business rules (i.e. measurement and verification, customer qualifications/enrollment, etc.) for each individual utility OVGIP project.

The Information Technology (IT) provider for the OVGIP development program is Sumitomo Electric Industries Innovation (SEI) who works directly with the OEMs, EPRI, and the utilities providing software architecture development, use case functional implementation, and application programming interfaces (standards based) to utility Demand Response Management Systems (DRMS), Meter Data Management Systems, (MDMS) and other utility systems required for the implementation of the utility programs.

OVGIP project started in Fall of 2012 and completed its Phase 1 demonstration in 2014[4], as a 'proof of concept' system, in the form of a live demonstration of the capability of the platform to receive a single command from a utility server over OpenADR 2.0b protocol, and then distribute it to multiple OEMs through their preferred means of communications, over open and proprietary protocols. Figure 1-2 describes how this was accomplished. The results of the Phase 1 work

[4] Ayre, J., Plug-in Cars & Utilities Communicate Via The Cloud In New Partnership, Oct 19, 2014, Cleantechnica.com, https://cleantechnica.com/2014/10/19/direct-phev-utility-company-communication-via-cloud/, accessed 03/24/2020.

were published in a publicly available EPRI report[5]. Figure 1-3 describes pictorially the demonstration site, the OEM vehicles and the audience.

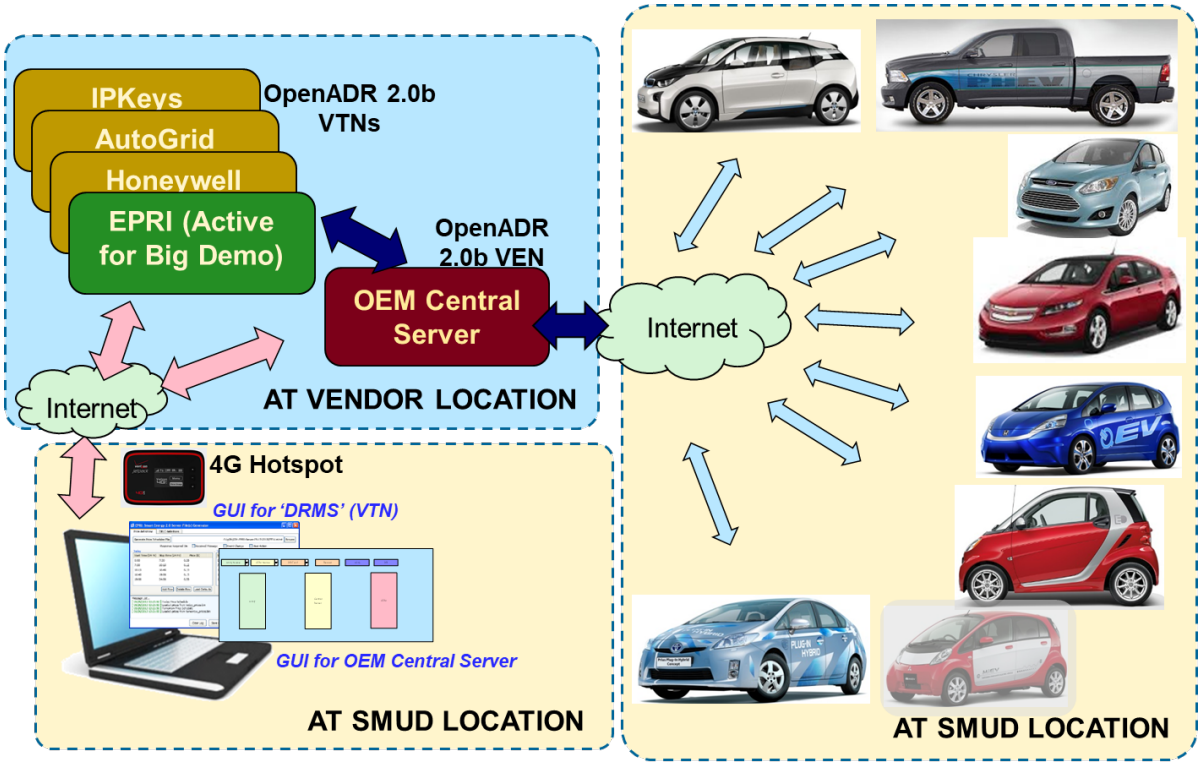

Figure 1-2
Open VGI Platform Phase 1 Demonstration Process – Off and On-Location

Utility Engagement

The growth of interest by the utilities in the OVGIP and the OEM PEV telematics communications approach for centralized smart charging load management has accelerated in the last 16 months. 8 of the 14 utilities presently involved In the OVGIP Collaboration initiated their engagement during this recent timeframe. It appears the accelerated market growth of PEVs (total 5.4M globally as of end 2018 with 64% year over year sales growth[6]/1.1M USA total end 2018 with 81% year over year sales[7]) is creating a more near term sense of urgency for utilities to start to evaluate and understand the potential impact of PEV charging load and potential infrastructure costs on their individual distribution systems. Utilities are seeing the need to understand the value and costs of the alternative technologies being developed for monitoring and managing PEV charging loads. The utilities are creating EV load management programs to evaluate the value of PEVs as a utility dispatchable load resource and verify technology for engaging PEV on-vehicle battery storage capacity to maintain distribution system reliability and

[5] *Open Vehicle-Grid Integration Platform - Phase 1 Development Update*. EPRI, Palo Alto, CA: 2014. 3002004037. https://membercenter.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002004037

[6] Global Plug-in Sales for the 1st Half of 2018 by Roland Irle, EV-volumes.com http://www.ev-volumes.com/country/total-world-plug-in-vehicle-volumes/

[7] EVVolumes.Com – Article USA Plug-in Sales for 2018 Full Year – http://www.ev-volumes.com/country/usa/

mitigate utility infrastructure investment costs. Table 1-1 below summarizes the utility and OEM engagement during the Phase 2 work of this pilot.

Table 1-1
Utility and OEM Engagement over OVGIP Pilots for Phase 2 of the Program

Utility	Program Pilot	Participating OEMs
SCE	'Save Power Day' Program (PEV Residential DR)	Honda, Ford, BMW
PG&E	Excess Supply Program (Capacity Bidding Pilot)	BMW (follow-on program in the works)
Con Edison	ToU Charging Incentive Program (NY SmartCharge)	Ford, BMW, Honda
DTE	Residential DR – event-based program	Ford, GM, 250 EVs – Next phase to be 'production'
Duke	Load Research + Load Shifting Potential Assessment	Ford, GM, BMW, possibly Honda (in the works)
AEP	Off-Peak Charging and Validation Program	Ford, BMW
Xcel	Residential Load Shifting/Renewables Integration Program	Ford, GM, BMW, Honda, ~600EVs
Puget Sound	Customer Charge Data Management/Reporting (Evaluate DR value basis) – Load Research	Ford, BMW
Southern Co	Test/Demo of ISO15118 Optimized Charging	Daimler (IoTecha provided the IEC/ISO15118 EVSE
Ontario Power Gen*	Optimized Charging (DR) and Load Curtailment for Operating Reserves (IESO Market Bidding)	Ford, BMW, Honda, GM

***Note**: Sumitomo Electric is the IT services supplier developing and managing the platform. EPRI provides the OpenADR 2.0b head-end for the utilities, and OVGIP is set up on Amazon Cloud (AWS).*
**Ontario Power Generation: Preliminary discussions*

As part of understanding the technologies, several of the utilities involved in the OVGIP Collaboration have or are instituting alternative PEV charging load management projects with EVSE network providers such as ChargePoint and Greenlots, and with Fleet Carma which requires a cellular logger be installed on the vehicle to access vehicle data for purposes of charging load monitoring and management. There are concerns about cost, scalability, and sustainability across the various technologies. Utilities are engaging with the OVGIP Collaboration which provides the option to engage with major automakers who are leveraging and enhancing their existing telematics technology to directly access the PEV data and embedded PEV smart charging functionality without need for integration of external hardware and related software.

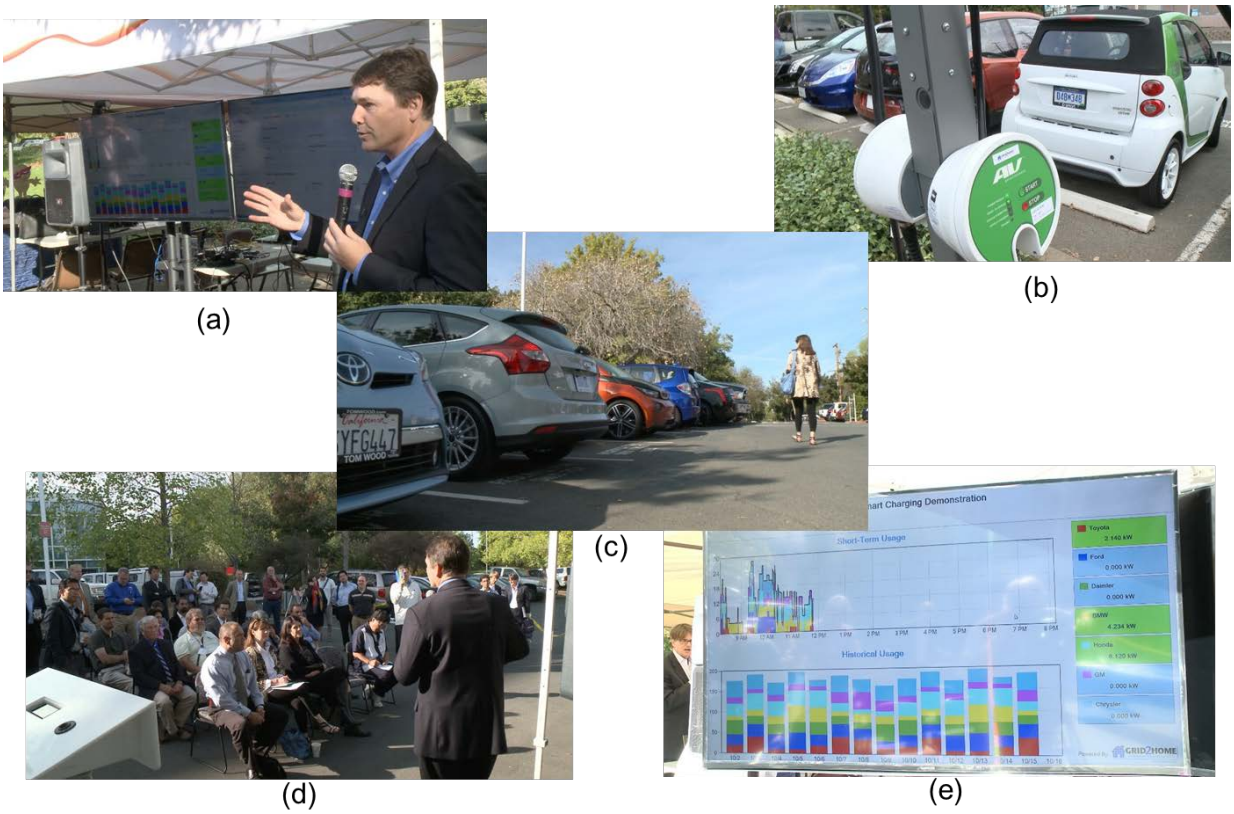

Figure 1-3
Phase 1 Demonstration at SMUD, 10/14/2014, showing (a) Mark Duvall welcoming the audience (b) EVSE infrastructure with built-in metrology and monitoring (c) OEM Vehicles participating from GM, Ford, Chrysler, Toyota, BMW, Daimler and Nissan (d) Audience from IOUs, state agencies and media (e) Visual display of the live Demand Response event status

Utilities want to compare the alternatives to discern the least complex, most cost effective and reliable approach. OVGIP, with OEMs' committed engagement in developing VGI technology, is being perceived as a potentially more sustainable, cost effective, and commercially scalable PEV grid integrated load management approach.

OVGIP Evaluation

The relevance and applicability of the OVGIP telematics capabilities for VGI was assessed as part of the California Public Utilities Commission (CPUC) initiated a yearlong VGI Communications Protocol Working Group[8] which conducted an in-depth evaluation of the VGI applicable standards based communications protocols. The purpose was to assess whether any single standard or communications protocol could provide an end to end (utility to vehicle) VGI solution. There were over 70 submitted use cases reviewed, including the OVGIP use cases, and used to develop a comprehensive matrix of VGI functional requirements forming the basis for compliance evaluation of the communications protocols. The OVGIP, specified as Telematics,

[8] Vehicle-Grid Integration Communication Protocol Working Group – http://www.cpuc.ca.gov/vgi/

was evaluated along with standards such as IEEE 2030.5, ISO/IEC 15118, IEEE 2030-1, OpenADR 2.0b, and SAE J2847 and J2931.

Telematics, based on the OVGIP architecture structure, was determined to meet the requirements for an end to end solution. Additionally, because telematics is a transfer medium it was understood that it has the ability to be interoperable and utilized with the other communications protocols, is potentially cost effective due to leveraging with automakers existing communications to vehicle technologies and would feasibly not require extensive product interoperability and compatibility certification testing as with other protocols.

The working group's summation was there was no justification for adopting any single standard requirement for VGI at this time. There needs to more evaluation and analysis to determine the high value of VGI use cases and further assessment of applied communications technologies through metrics based pilot demonstrations which is being addressed in the California Energy Commission (CEC) VGI Roadmap Update[9] proceedings.

[9] California Vehicle-Grid Integration Roadmap Update – https://www.energy.ca.gov/transportation/vehicle-grid-integration/

2
USE CASES

Use Case Summary

There are 11 primary use cases identified for the OVGIP. The determination of the use cases was based on VGI strategic requirements information from the California Vehicle-Grid Integration Roadmap[10] and the SAE J2836/1 Use Cases for Communication Between Plug-in Vehicles and the Utility Grid. The use cases were determined to provide comprehensive grid service functionality and interconnectivity for utility, PEV customer, and host site operators to interface and manage charging at the residential, workplace, and commercial environments. Additionally, to provide aggregation of load resources for ISO/RTO bulk energy market DR and DER services programs, and to provide a common functional construct that can feasibly support multiple VGI business models. The Use Cases for OVGIP are summarized as follows:[11]

Reference	Title/Description
Use Case 1	Automated Utility Electricity Rate Tariff Processing Download of authorized customer residential electricity rate tariffs to the PEV for automated scheduling of PEV recharging during the most economical periods of the day.
Use Case 2	Aggregated PEV Demand Response (DR) and Critical Peak Pricing (CPP) OVGIP interfaces with Utility, ISO, or ESP/Aggregator to receive and process DR Event and CPP signals to the individual OEM servers. The OEM servers are able to define the available aggregated load capacity of the PEVs plugged-in within the regional or locational parameters of the DR or CPP signal and determines PEV opt in availability and capacity.
Use Case 3	Interface with Home Energy Management System (HEMS) OVGIP interfaces with the HEMS to enable residential owner active load management of PEV charging in synchronization with other end load devices being managed by the HEMS. Alternatively addresses the PEV interface though an ESI in residences without HEMS capabilities. Enables customer engagement in residential DR and Dynamic Pricing programs.
Use Case 4	Interface with Building Energy Management System (BEMS) Enables interconnectivity to the PEV through the OVGIP with commercial building energy management systems. Integrates load management communications to engage the PEVs in the commercial entity's requirements for demand charge mitigation and other energy efficiency control measures.

[10] California Vehicle-Grid Integration (VGI) Roadmap: Enabling vehicle-based grid services February 2014 https://www.caiso.com/Documents/Vehicle-GridIntegrationRoadmap.pdf

[11] For Use Case details reference Open Vehicle-Grid Integration Platform – Unified Approach to Grid / Vehicle Integration *Definition of Use Case Requirements* 3002005994 Technical Update, December 2015.

Use Case 5 Interface with EVSE Network Provider
Enables automated transfer of PEV driver preference and PEV charge status information with EVSE network providers that are the controlling resource for PEV infrastructure energy management.

Use Case 6 Real Time Price (RTP)/ Signal Event Processing
Provide automated processing of RTP or other dynamic pricing signals through the OVGIP from the Utility or ESP or Aggregator to the OEM Servers to the PEV.

Use Case 7 Optimized Load Management (ISO/IEC 15118)
Provide process for optimized PEV load management utilizing the ISO/IEC 15118 communications protocol. Addresses interoperability between the OVGIP and ISO/IEC 15118 compliant eMobility operators.

Use Case 8 Vehicle Roaming
Establishes the capability for the OVGIP to reconcile and confirm customer account authentication between multiple EVSE network providers.

Use Case 9 EVSE Network Provider Functionality
OVGIP is to provide EVSE manufacturers and distributors with networking functionality to monitor and manage their EVSE location, status and utilization, and capability to interface the individual EVSE provider information to the separate OEM servers for PEV customer access to the information.

Use Case 10 Metering and Data Exchange
Provide data management elements for utility planning operations' determinations about grid reliability and capacity requirements. Address requirement for Measurement and Verification of PEV charge consumption utilizing meter data, and the OVGIP role in retrieving, tracking, and communicating such data as required to verify PEV customer participation in utility and ISO energy service programs.

Use Case 11 Automated OVGIP Customer Enrollment Portal
Automated OVGIP enrollment web portal providing a single customer entry point to access specific utility program information and related OEM customer vehicle enrollment authorization criteria.

Use Case Applications

The automated utility rate tariff (Use Case 1) is being applied by utilities for customer scheduling of charging based on Time of Use (TOU) and/or off peak discounted rate tariffs. This is a simple PEV load management approach to provide customers with an automated methodology to receive rate tariffs through the OVGIP to the PEV and for the PEV to apply the schedule and determine the charging profile for each session per the customer preference for time charge is needed. Utilities are providing customer incentives based on level of compliance with charging during the off peak periods. The utilities are requiring OEMs provide PEV charge session data as verification of customer compliance.

Many utilities are focusing on the primary use cases for aggregated DR and Dynamic Pricing/Real Time Pricing management of PEV charging (Use Case 2/6). The aggregated DR

programs are being implemented relative to residential charging applications and is predominantly due to the ability to utilize whole house metering or EVSE sub-meters as the basis for measurement and verification. As part of the projects the utilities are initiating a comparative analysis of the PEV telemetry to provide quantified reporting of charge session data such as location, interval kWh consumption, date, start/end charge times, and charging power level. This engages the Metering and Data Exchange (Use Case 10) which is the determination of measurement and verification requirements for verifying customer participation and entitlement to performance incentives per the utility program criteria. This is a process to determine the role of the OVGIP and OEMs in retrieving, tracking, and communicating customer charging data for purposes of validating aggregated capacity and/or customer PEV response data for compensation purposes and for utility PEV load data analyses.

Use Cases 3 and 4 deal with integration of PEV smart charge management through interfaces with Home Energy Management and Building Energy Management Systems. The objective is the integration of PEV load management with other home and facilities distributed energy resources such as solar, stationary battery storage, and smart load devices. Intended attributes are demand charge mitigation at workplace and commercial facilities and enabled participation in extended resource utility aggregated demand response programs. There is expressed utility interest in these use case applications but there is no established adoptability of standards based protocols by energy management systems product providers for enabling programs with a PEV integrated DR/DER capability at this present time. This will become a more significant issue and technology need with the enablement of electric vehicle to grid (V2G) capable automotive OEM products.

The EVSE Network Provider interface and networking functionality (Use Cases 5/9) are intended to provide a methodology to communicate PEV customer charge preference and PEV charge status information from the OVGIP/OEM to the infrastructure host site EVSE provider for automated processing of customer charging need, primarily at workplace and commercial infrastructure sites that implement local PEV managed charging at the EVSE. Additionally, intended the OVGIP can provide EVSE networking functionality to EVSE manufacturers who utilize 3rd party networking services. OVGIP access to multiple EVSE providers networks will provide OEM PEV customers consolidated information on EVSE locations, availability, and price.

The Optimized Load Management (ISO/IEC 15118) Use Case 7 addresses the implementation of the Demand Clearing House (DCH) capability and interface communications with eMobility Operators that provide IEC 15118 communications enabled EVSE products. An actual implementation was demonstrated with the SEI developed OVGIP Demand Clearing House (DCH) transmitting charging profiles and pricing to the IoTecha eMobility server, and via OCPP 1.6 protocol, to the ISO 15118 enabled EVSE. The vehicle utilized for the demonstration was the Daimler Smart Fortwo EV which was specifically integrated with the IoTecha EVSE for the demonstration. The demonstration was provided at the 1st CharIN North America Conference March 19, 2018.

Vehicle Roaming Use Case 8 is to address transaction clearing house for customer contract/account authentications between eMobility operators providing ISO15118 enabled EVSE charging. This is an element of the secondary actor billing and payment functions in the ISO15118 standard that is to provide automated customer authorization to charge and back end

clearing house for billing between eMobility operators to provide customers a singular invoice and payment process. Presently there is no viable product availability either vehicle and EVSE for implementing and demonstrating this function as a part of the OVGIP.

Automated enrollment (Use Case 10) was initiated by the OEMs in late 2017. The process for manually enrolling customers via email communications is a lengthy process and labor resource intensive. Privacy protection rules require customer acknowledgement and permission to collect and report data on their PEV charging behavior and must address permission for sharing data between the utility and the OEM. It was determined to develop a customer single point OVGIP automated enrollment portal that will interact directly with the utility and OEM websites for program terms and conditions, and customer authorizations. The basic OVGIP portal with access to OEM websites is developed. Implementation requires direct coordination with each utility IT to ensure OVGIP portal to utility website interface access and cyber security.

3
UTILITY PROJECTS

Southern California Edison

Residential DR Program

The project entailed the development and demonstration of the OVGIP to provide the communications interface between Southern California Edison and Honda FIT EV customers to respond to day ahead DR signals. The communications architecture consisted of SCE generated OpenADR signals for EV load curtailment to the OVGIP to the Honda vehicle telematics system. The measurement and verification process were predicated on an applied 10/10 baseline (average of previous 10-day specific watt hour meter data) methodology utilizing EV customer's whole house meter data extrapolated from the SCE Green Button system. A separate report was published by EPRI on this program[12].

The OVGIP was responsible to access the customer's residential meter data from the SCE Green Button system through the 3rd party access, calculate the 10/10 baseline for the DR event and provide the correlated customer aggregated charging data reported to the OVGIP from the OEM to verify the kWh reduction during the DR Event. This was a five-month (May through October 2018) test and demonstration pilot to assess the functionality and effectiveness of the OVGIP central server interface between the utility and the PEV, the EV customer level of participation and performance, and an analysis of the resulting data to formulate an estimate of the larger scale impact from using EVs as a DR resource.

Conclusion is the project was successful in verifying the utility to OVGIP connectivity to the vehicles utilizing OpenADR and telematics protocols, and responsiveness to the DR requests. The scope of the program included 5 PEV owners who were employees of Honda. The OEM customer data showed the vehicles were able to stop charging during the event period and then resume charging to meet the customer required time charge is needed setting. Project further demonstrated the 10/10 baseline from the whole house meter data is not an effective measurement and verification methodology for quantifying PEV DR kWH reduction.

1. The time of day of the event in relation to when customers usually charge is an issue. If the customer does not usually charge during the event time duration (in the case of this project between the hours of 10pm and 11pm) in the previous 10 days, then there is no baseline to measure the EV charging reduction against.
2. More appropriate time of day for a residential EV DR event might be during the evening peak hours from 5pm to 9pm when customers arrive home and tend to charge.
3. Other household loads may offset the reduction in EV Charging during an event such as air conditioning during hot summer evenings.

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[12] SCE – Open Vehicle Grid Integration Platform (OVGIP) Residential Demand Response (DR) Project Summary Report 3002015029 Technical Update, December 2018.

4. No measurable basis to determine actual EV charge reduction except when you compare the vehicle telemetry data.
5. Established that the customer must be plugged in and charging prior to an event to qualify. Still does not resolve the ineffectiveness of using the 10/10 baseline methodology because the charging load just prior to the event is not included nor quantified in the baseline data.
6. Without a method to directly and separately quantify the EV load increase or decrease it potentially mitigates the compensation value for the EV customer and the EV aggregator.

The OEM, through the OVGIP, provided the anonymized data analysis between the OEM reported data and the OVGIP extracted Green Button customer meter data required for evaluating the effectiveness of the applied 10/10 Baseline measurement and verification approach.

Smart Energy Program

Southern California Edison (SCE) is presently in the process of discussing and determining the requirements for engaging PEVs in the existing SCE Smart Energy Program which presently includes DR aggregation of smart thermostats. SCE is seeking to expand the program to include and address PEV load DR aggregation through the utilization of the OVGIP to provide 3rd party aggregator program services support to SCE.

The present structure is that Smart Energy Program events ("energy events") can occur anytime throughout the year during non-holiday weekdays with a minimum duration of one-hour and a maximum duration of four-hours per event, between specified time periods of the day. Multiple events may be called in the same day, but the total number of event hours will not exceed a maximum duration of four-hours in a day.

OEMs, SCE, and EPRI are in the process of determining the incentive parameters for PEV customer involvement in the Smart Energy Program, customer qualification requirements, operations cost for OVGIP/OEM aggregator services, and OEM costs to establish, maintain, and administer the customer base. The incentives value is to consider the amount of kWh reduction the PEVs can provide on a per vehicle average basis and the projected market scale of PEV customers. Measurement and verification criteria is also being addressed.

Once the programmatic determinations are made SCE will be required to submit an application letter to the California Public Utilities Commission (CPUC) for approval to initiate the PEV Smart Energy Program. Expectation is the application letter and approval process will be accomplished within the 3rd quarter of 2019 enabling the program to be launched in the 1st quarter of 2020. This is a commercial intent based program with no specified limitation to scale for customer participation.

Con Edison

Smart Charge NY Program

Con Edison initiated the Smart Charge New York Program in 2017 to incentivize off peak charging by PEV owners that charge in the New York and Westchester areas. This includes Con Edison service customers and non-service customers (commuters from outside Con Edison territory). The commercial program was launched utilizing FleetCarma as the customer services administrator and data provider for the program. Con Edison interest in the OVGIP approach is

the potential avoidance of recurring costs incurred from the FleetCarma requirement to install and maintain cellular log devices in the PEV for data access.

The OVGIP pilot was constructed as a parallel to the FleetCarma program whereby a small number of already enrolled customers were approached to allow the OEMs via telematics to collect and share their charging data with Con Edison over a period of several weeks. Customers were incentivized to participate through an upfront cash payment. The OEM participants in this program were Ford, Honda, and BMW.

The requirement of the OVGIP and OEMs was to provide the customer the off peak tariff schedules and to monitor and report each customer's charging session data including date, start/end times, SOC at start and end of session, average charge power level throughout the session, GPS location, and kWh consumption. This data is the basis for verifying PEV customers degree of compliance for charging off peak. The customer charge data from the OEMs and the data from FleetCarma for the same customer were compared for compatibility.

The predominant challenge for initiating the pilot were the legal requirements by the individual OEMs to establish a contractual agreement with Con Edison defining responsibilities and criteria for safeguarding customer personally identifiable information (PII). Con Edison was the first utility to engage in this process with the OEMs effectively requiring a lengthy negotiation to derive a contract with each OEM that is compatible across all OEMs with common requirements and obligations. This has resulted in an acceptable contract template for each of the OEMs involved that is to be readily acceptable to utilities going forward.

Con Edison is continuing to work with the OEMs on the development of a service territory data dashboard that will provide anonymized aggregated and localized PEV load profile data with breakdown to day time and seasonal parameters. Data details are being worked. In addition, the OEMs are working on requested modifications and enhancements to the customer charging data. One example is the capability to monitor and report 15 min or less interval charge consumption and power level data.

DTE Energy

EV Demand Response Event Based Program

The DTE OVIGP pilot is constructed as a customer incentivized event based demand response program. The primary participants in the program are Ford, GM, and DTE with Sumitomo Electric Industries (SEI) providing the OVGIP interface communications functionality between DTE and the OEMs. Events are being communicated from DTE to the OVGIP utilizing the EPRI provided OpenADR 2.0b server. The OVGIP transmits the events to the OEMs back end servers via individual API specifications including cyber security applications for each OEM.

The project encompasses a target for 300 PEV owners extracted from employees of Ford and General Motors. A prescribed set of 12 events segmented into four separate timeframes during the day are planned over the project's 6 month duration (Mar through Aug 2019). OEMs are to provide customer event measurement and verification report data to DTE immediately following each event.

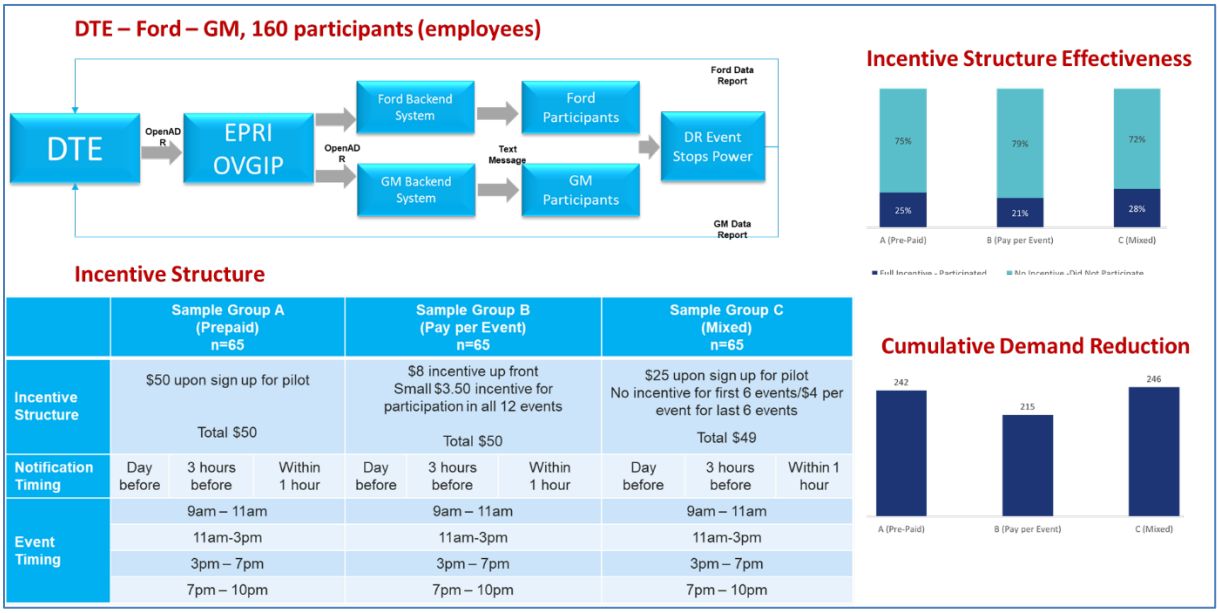
The PEV owners are segmented into three different customer incentive payment categories which is intended to provide a basis for assessment and comparison of customer responsiveness

(Opt In/Out behavior) between the different incentive structures. The total incentive for the 12 events is $50 with each category providing a variation on the incentive pay out based on certain customer performance criteria. The project is including the testing of OVGIP/OEM capabilities to execute PEV customer response to DR event signals on a day ahead, three hour ahead, and one hour ahead basis. Evaluation of variability in PEV customer response across these different notification scenarios is to be accomplished to ascertain any effects on customer ability to participate in the event. There is a post DR Event survey being utilized to capture specific PEV owner feedback on reasons and perspectives related to ability and desire to participate or not participate in the DR Event.

The main objectives of the project are to ascertain qualified learnings about:

- Proportion of enrollees who opt in to each event
- How is event participation affected by the time of DR window
- How is event participation affected by incentive level
- What are the economics (business case) for the value that EVs provide to the utility?

The program was completed with mixed success given the early nature of the project, and the key aspects of this project are described in Figure 3-1 below.



	Sample Group A (Prepaid) n=65			Sample Group B (Pay per Event) n=65			Sample Group C (Mixed) n=65		
Incentive Structure	$50 upon sign up for pilot Total $50			$8 incentive up front Small $3.50 incentive for participation in all 12 events Total $50			$25 upon sign up for pilot No incentive for first 6 events/$4 per event for last 6 events Total $49		
Notification Timing	Day before	3 hours before	Within 1 hour	Day before	3 hours before	Within 1 hour	Day before	3 hours before	Within 1 hour
Event Timing	9am – 11am			9am – 11am			9am – 11am		
	11am-3pm			11am-3pm			11am-3pm		
	3pm – 7pm			3pm – 7pm			3pm – 7pm		
	7pm – 10pm			7pm – 10pm			7pm – 10pm		

Figure 3-1
DTE Energy Residential DR Pilot – Key Details and Results

Duke Energy

Data Management Reporting/Residential DR Program

The Duke OVGIP program is still in the planning phase. Duke is in the process of preparing a PEV load management program proposal for submission to the North Carolina utilities commission which is to include implementing and evaluating EV direct charging load management utilizing the OVGIP.

The target for customer participation is 500 PEV owners with a planned incentive constituting an up-front enrollment payment and ongoing quarterly payments throughout the course of a three-year pilot term.

Customers are to provide required permissions and agreements to allow collection and sharing of charging load data to participate in the DR load management program. The intent is the outreach and enrollment responsibilities will be collaborative between the OEMs and Duke Energy.

The program is to include a data management reporting requirement to assess and analyze PEV customer charging behaviors to determine specifications for the DR program and will be supported by the OVGIP Data Dashboard that is to provide aggregated PEV load profile data across the utility's territorial regions. The basic PEV load management requirement will apply residential demand response events with the option during the three year term to implement and pilot additional use cases and applications in other infrastructure environments such as workplace and public charging.

The results of this program especially its effectiveness and value will be used to determine viability of the need to develop VGI strategies and requirements for ongoing commercially sustainable EV charging load management programs. The program evaluations are to address:

- Customer cost, convenience, transparency, performance, and interactive experience.
- Data collection and management functionality and reliability
- Extensibility to address additional load management use cases such as demand charge mitigation, excess supply (add charging load during periods of high renewables generation), automated charge scheduling relative to TOU electricity retail pricing, response to Dynamic Pricing scenarios, and EV owner specific tariffs.
- Application to fleet, public, and work place environments with analysis of potential benefits to the facility owner/operator.
- Utility cost and value assessment including customer enrollment and administration.

The application filing is to be submitted during the 2nd quarter 2019 with the intent, dependent on the utilities commission approval process, to start program implementation in the 4th quarter 2019. The program is planned to operate for three years through end 2022.

Xcel Energy

Residential Load Shifting/Renewables Integration Program

The focus of the Xcel Energy OVGIP pilot and evaluation program is to be able to directly manage customer charging at the residence by applying specific use cases addressing both Level 1 and Level 2 managed charging functionality. Xcel is planning to implement this program with customers in their Colorado utility services territory. The scale for the first segment of the program is approximately 200 customers with ability to scale up over the duration of the program and feasibly extending the program based on positive analysis and results to achieve value objectives.

The Level 1 charging management requirements considers the extended length of time required to completely charge the PEV. The premise is to initiate event notifications to Level 1 charging customers to shift charging to time periods outside of morning and afternoon peaks. Example is

during the summer events would notify and incentivize customers to start charging after 8pm when residential peak load starts to decrease. The events (estimated 10 – 20 events per year) would be based on utility projected excessive residential peak loads. In all cases, excepting for emergency grid conditions, the customer has the option to opt out.

The Level 2 charging management requirements will be daily load shifting with DR event based functionality. Options include creating a charging schedule that is remotely set and provided to the PEV with monthly and/or seasonal resets. Also considers DR events to charge early in the daytime to reduce grid renewables generation curtailment. Customers will have the option to opt out of the events based on PEV driver requirements and settings for time charge is needed and SOC required.

Objectives for the program are to:

- Test the technology – Evaluate communications pathway – does it work, latency, etc., and integration with utility Demand Response Management Systems (API or OpenADR 2.0b)
- Test customer response – Evaluate and assess interest through analysis of enrollment processes and customer Opt Out behavior
- Gather basic EV data – kWh consumption average per charge session and charging behavior in terms of plug-in frequency and plug-in time

Xcel Energy is presently in the program planning phase and are in discussion with the OEM collaboration on further clarification of objectives and use case applications/requirements. This represents preliminary thinking on the part of Xcel Energy about their concept for an OVGIP pilot/program. Expressed the requirement to start the implementation of an OVIGP program during the 3rd quarter 2019. Duration of the program execution is not yet defined.

Ontario Power Generation (OPG)

Management and Optimization of Charging / Load Curtailment Events for Operating Reserves

Ontario Power Generation is defining a comprehensive multi-year program with the OVGIP and OEMs addressing the implementation and execution of two PEV load management use cases.

1. Management and Optimization of Charging

   This is a demand response program that is to provide day-ahead and hour- ahead notification of priority hours to charge based on available surplus electricity and/or renewables generation on the grid. The objective is to manage and monitor customer charging behavior and schedules to maximize EV charging loads during prescribed periods of the day/night when excess electricity and renewables generation are available, and cost of electricity is typically the lowest.

2. Load Curtailment Events for IESO Market Services (Operating Reserves, Demand Response, Capacity Bidding)

   This use case is to leverage demand reduction potential of aggregated EV charging load for purposes of providing operating reserve capacity offers into the Independent Electricity Service Operator (IESO) electricity market. The objective is to provide capability to develop

day-ahead and three hour-ahead aggregated hourly EV charging load reduction capacity projections, monitor and validate customer participation, and comply to energy market measurement and verification and response time requirements.

The program is being proposed as a 3 phase development and demonstration process. The following provides a summary of the phases and the objectives.

Phase 1 (Q3 2019 – Q2 2020) – has three parts consisting of the initiation of the OEM collective data dashboard, qualifications of measurement and verification techniques, and initiation of the Management and Optimization of Charging project use case pilot and demonstration.

- Initiate data dashboard to collect and report aggregated EV charging load profile data. The objectives are:
  - OEMs provide aggregated anonymized data via the OVGIP Data Dashboard– no customer enrollment or permission required
  - Provide hourly locational EV load data for analysis
  - Qualify affected changes in load profiles before and after implementation of Use Cases
- Verify Measurement & Verification Techniques – this is intended to be accomplished using fleet PEVs within the OPG fleet environment through comparative evaluation of different measurement data sources.
  - Examine the quality of data from the OVGIP/OEM vehicle telemetry through comparative analysis against data from the following sources to develop an on-going measurement and verification strategy:
  - Data from Utility Meter
  - Data from EVSE submeter (if applicable to vehicle)
  - FleetCarma Device (if applicable to vehicle) - OPG fleet vehicles are already equipped FleetCarma devices and charge using EVSEs that can be sub-metered. These vehicles can be leveraged to examine quality of OVGIP data to share with the IESO as well as establish an on-going measurement and verification strategy for the remaining Pilot
- Initiate execution of Management and Optimization of Charging Use Case.
  - Implement automated enrollment process/legal requirements/outreach and continuous enrollment to maximize scale
  - Qualify and verify incentive requirements
  - Define customer qualification criteria for participation and quantification of load management
  - Establish data collection and analysis on customer Opt In/Opt Out behavior patterns / reasons

Phase 2 (Q2 2020 – Q4 2020) – focuses on beta testing of Load Curtailment Events for IESO Market Services to provide operating reserves through Demand Response and capacity bidding processes.

- Simulate the qualification of the OVGIP/OEMs to engage in energy market processes that apply capacity thresholds / criteria, revenue / penalties, and aggregated capacity measurement / verification requirements
- Beta test the capacity projections, monitoring, and reporting capability of the OVGIP in a safe, penalty free environment – apply the customer participation factors derived from Phase 1 of the Management and Optimization of Charging Use Case project
- Leverage lessons learned to establish customer qualification and incentive requirements
- Continue data collection and data dashboard reporting process
- Continue operation of the Management and Optimization of Charging Use Case project demonstration

Phase 3 (Q4 2020 – Q4 2021) – addresses full scale implementation of the Load Curtailment Events Operating Reserves use case implementing and executing electricity market activities (Operating Reserves, Capacity bidding, Demand Response, etc.)

- Define the scope of the IESO market services project (Day-time vs. Nighttime vs. both) and the market activities to be targeted (Operating Reserve, Demand Response, Capacity Bidding, etc.)
- Verify and define customer qualification criteria for participation based on lessons learned from Phase 2
- Validate and establish the approach for quantification of load reduction and development of capacity bids based on lessons learned from Phase 2
- Define OVGIP/OEMs incentives and penalties for participation
- Continue operation of the Management and Optimization of Charging Use Case project demonstration

This is a multiyear (2019 – 2021) three phase program targeting a 1000 or more PEV customer participants. The customer enrollment will be progressive throughout the phases of the program.

American Electric Power (AEP)

Off Peak Charging and Validation Program

AEP is addressing the need for off peak charging integration supported by a customer data measurement and verification process utilizing the OVGIP as the primary interface to the PEVs and customer data source. The program would follow the same price signals as are available through Time of Use rates which provides reduced kWh pricing during the off peak periods (i.e. 11pm - 6am) resulting in cost savings to the customer.

The objectives of the program are to validate the accuracy and reliability of the data from the OVGIP regarding charging session elements such as energy usage, power level, and date/time/duration. Intent is to compare with meter available data to provide a baseline for evaluating credibility of the OVGIP data.

The OEMs are seeking to engage AEP in the Data Dashboard program to identify current PEV load profiles within their region including identifying period of day intervals and/or separation of periods based on their TOU tariff schedule to analyze the effectiveness and value of the proposed

off peak charging integration program. The Data Dashboard provides anonymized data not requiring customer permissions for data extraction and reporting. This would be the initiation of the program with AEP followed with a customer engaged off peak charging incentive and data validation program.

Other Utility Status

The remaining OVGIP Collaborative utility members (PG&E, PSE, NYPA, TVA, SMUD, Southern Co, EDF) are in the formulation process of their strategic vehicle grid integration (VGI) initiatives. A couple of notable utility strategic development activities for the OVGIP are PG&E and PSE.

Pacific Gas & Electric (PG&E) has been engaged with BMW under a California Energy Commission funding grant over the past three years in the Charge Forward Pilot Program utilizing vehicle telematics technology for EV load management and smart charging.

Initially, the pilot focused specifically on demand response and load curtailment. Utility provided a signal to the OEM to decrease the load on its vehicles and would then respond. In the second phase, presently ongoing, focus is more on the customer experience by giving users more information on the smart-charging process and the impact of their participation. The demand response events are longer, extending from one to two hours, and beyond. The scale of the present pilot is approximately 350 customers. There is also an "optimization" use case — such as charging when there's an abundance of renewables on the grid. Under the current arrangement, it is less about responding to event-based signals called by the utility and more about optimizing vehicle charging over a period of time. If an EV is parked for five hours, the OEM will pick the best three hours to charge based on driver needs and grid conditions.

The intent is to upscale the pilot program to include multiple other OEMs through the utilization of the OVGIP as the single aggregator source for managing PEV charging. There is ongoing dialogue between PG&E and the OEMs with interest in the development of the data dashboard to provide visibility on PEV load profiles for PG&E's service territory to evaluate the use cases required to provide load capacity for consuming renewables overgeneration, which feasibly requires interactive SOC management based on customer daily commuting and travel behaviors to ensure customers have available load capacity for charging during the appropriate times of the day and without impacting their driving needs.

Puget Sound Energy (PSE) is interested in the engagement of the Data Dashboard to provide a basis for evaluating and determining appropriate VGI use case projects. The initial interest is in the development of an off peak charging incentive program similar to the Con Edison program. Territory wide PEV load profile data and ability to analyze aggregated customer charging behavior data will inform PSE about the value of instituting an off peak incentive project and/or whether to consider other alternatives for demand response based PEV charging management projects.

The collaborative process is continuing with each of these utilities to devise and implement an OVGIP PEV grid integrated load management pilot designed to meet their individual requirements and objectives for evaluating the value of PEV load management and the comprehensive technology and data management benefits from utilizing the OVGIP standards based open source central server interface.

4
SUMMARY

Learnings

Experience from the previous pilots such as the Con Edison off peak charging incentive, the SCE residential aggregation DR pilot programs and the recently launched DTE DR pilot revealed a lead time from 4 to 12 months to define the final use cases and functional requirements; implement the measurement and verification tracking and reporting procedures; implement and complete the customer outreach, incentive and enrollment process; and implementation of the utility communications interface.

One of the primary drivers is the time and resources required for addressing upfront legal agreements required between the OEM and the utility, and implementation of the customer outreach and enrollment process.

Depending on the required level of detail for customer data reporting and sharing between the OEMs and the utilities there may be legal documentation required between the parties for ensuring protection of customer personally identifiable information (PII), including the need for customer permissions and authority to collect and share their PEV charging data with both the OEMs and the utilities.

The processes regarding customer data collection and reporting between the Con Edison and SCE pilot programs were inversely different. The Con Edison pilot required the OEMs provide customer identifiable charging session data be collected and reported by the OEMs to Con Edison. The customer incentive was direct between Con Edison and the customer. This required legal agreements between Con Edison and the individual OEMs stipulating the PII protection terms and conditions for sharing the data, as well as the separately required customer permissions for each entity.

The SCE residential aggregation DR pilot program was based on collecting and reporting just the consolidated 10/10 Baseline whole house meter data for the DR event period. No customer PII was required for reporting to SCE so therefore no requirement for any legal agreements between SCE and the OEM. The OEM was solely responsible for the customer enrollment process, the customer incentive, and coordination to acquire permission for 3rd party access to their Green Button meter data (the access and permission process is provided by the Green Button system).

This is a significantly acknowledged learning for the OEMs who initiated the development of a standardized automated customer enrollment process and OVGIP central customer enrollment web portal. There are to be two primary use cases for enrollment and customer resource management: Utility direct incentive programs and OVGIP direct to customer aggregation programs. The use case defines the responsible entity for customer outreach, interface, and administration which dictates the need for contractual liability agreements and customer interaction between the utility and the OEMs.

The OVGIP web portal is to provide a single customer interface with the required interfaces to the specific utility program, the terms and conditions, the templates for required customer

permissions, and provides the interfaces to the individual OEM customer certification web sites for identification and enrollment of customer owned or leased PEVs. The OVGIP will provide the relative customer authorization and associated customer utility account information, as required, to the utilities. The process is to be streamlined to provide standard agreement templates and to incorporate any utility specific customer authorization documentation and procedures. The basic OVGIP enrollment portal has been developed to incorporate the OEM web site interfaces for vehicle identification and enrollment. Next step is the integration of the utilities' customer enrollment requirements for the utility programs being developed. This will be especially critical for large scale commercial intent VGI pilots and programs such as the SCE EV Smart Energy Program.

Next Phase of Work

Through the close engagement and collaboration of the utility industry and the automotive manufacturers, this project, as an industry-first, has demonstrated the viability of telematics as a means through which many low-cost, high-value grid services can be delivered cost-effectively and scalably. This has stimulated the utility industry interest in exploring more focused but higher-scale pre-production type pilots that have the attributes of commercial pilots but within a controlled environment, so that statistically significant datasets can be analyzed, summarized and applied as the foundation for any future rate cases to support scale deployment of these programs. The automotive community has found this interest to be sufficiently motivating to continue exploring product integration of this technology so that grid-awareness and grid-compliance is 'designed-in' into the on-board chargers and the telematics systems in the cloud.

Conclusions

The utilities are being much more progressive in the expectations, requirements, and scale of their programs. The primary objectives are the verification of the OVGIP and OEM technical capabilities, performance reliability, data integrity, and customer behavioral data monitoring attributes for grid integrated PEV load management. There is the need to achieve a scale within the programs to ascertain statistically relevant customer behavior data for understanding the reasoning and applied factors for opt in/out decisions. Understanding customer charging behaviors and preferences are necessary to evaluating and determining the value of the programs.

There are presently seven programs in the development and implementation process with Duke Energy, OPG, Xcel, SCE, and PSE, and potentially with AEP. The seventh program is the DTE EV Demand Response Event Based Program which was just launched in early March this year. The basic use case functionality and technical requirements are predominantly common between the programs. However, the OPG proposed program is most aggressive with requiring the capability to provide aggregated load capacity projections for bidding purposes and near real time performance monitoring and reporting to qualify for participation in the IESO energy market operating reserves program. Development of these requirements will add to the OVGIP use case functional portfolio that will be available to all utilities and other energy service providers.

The expectation is the programs will progress in steps or phases starting with basic DR and scheduled charging use cases and evolve to address use cases for demand charge mitigation, excess supply (add charging load during periods of high renewables generation), automated

charge scheduling relative to TOU electricity retail pricing, response to Dynamic Pricing scenarios, and EV owner specific tariffs.

An important action is the need to quantify the OVGIP cost structure for providing commercial based VGI and data management service programs and the need for establishing a legal OVIGP commercial business entity that is qualified to contract for VGI services to utilities and other energy service providers on behalf of the OEMs. This is needed for cost benefit analysis and basis for evaluation by utilities for funding and investment requirements addressing the OVGIP application for PEV customer aggregated VGI services.

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