SOUTHERN CALIFORNIA EDISON COMPANY'S DEPARTMENT OF DEFENSE VEHICLE-TO-GRID FINAL REPORT

I. INTRODUCTION

This report is submitted in compliance with California Public Utilities Commission (CPUC or Commission) Resolution E-4595 (Resolution), which on July 11, 2013 approved a vehicle-to-grid (V2G) pilot tariff schedule to be offered by Southern California Edison Company (SCE) and applicable to two retail customer accounts of the Department of Defense (DOD).[1] The V2G pilot was intended, among other things, to test the ability of DoD to use its plug-in electric vehicle (PEV) fleets at LAAFB to bid energy and ancillary services directly in the California Independent System Operator's (CAISO's) wholesale markets. Ordering Paragraph (OP) No. 5 of the Resolution states, "SCE is directed to file no later than 24 months after the Start of the Pilot a report on their findings and results in collaboration with the Department of Defense and its contractors, and the CAISO [California Independent System Operator]."[2] Because the pilot began on December 24, 2015, this report is timely submitted. The Resolution requires that the report cover five topics,[3] addressed more fully below: (1) quantitative pilot activity data; (2) pilot financial data; (3) qualitative evaluations; (4) an assessment of quantitative and qualitative data; and (5) recommendations.

A. Summary of the V2G Pilot

The primary purpose of the V2G Pilot was to advance the knowledge of demand response and electric vehicle-to-grid programs to promote the reduction of transportation greenhouse gas (GHG) emissions. Before the V2G Pilot began, in September 2011, the DoD announced that the LAAFB would serve as the initial pilot location for the DoD's PEV Program. LAAFB thus became the first federal facility to replace its entire general-purpose fleet with PEVs and, to the greatest extent possible, the PEVs were used to demonstrate V2G technologies.

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1 The DoD subsequently determined that only one account, at the Los Angeles Air Force Base (LAAFB), would avail itself of the tariff offering.

2 Resolution E-4595 (Resolution), OP #5, p. 25. The body of the Resolution (page 10) refers to collaboration with the DoD, CAISO *and* the Energy Division in preparing the report. Due to a regrettable oversight, SCE focused on OP #5 and worked with CAISO and DoD only, consistent with what it did for the interim reports. Should Energy Division staff have comments or questions about this report or otherwise desire a supplemental report to address additional issues, SCE will absolutely do so.

3 Resolution, pp. 9-10.

SCE began working with the DoD in January 2011 to understand LAAFB's PEV Program and to implement a plan to assist LAAFB achieve its V2G project objectives, which were focused on evaluating the revenue potential of PEVs through their participation in wholesale markets as demand response resources. SCE assembled a team of technical, regulatory, legal and PEV subject matter experts who collaborated closely with the DoD and the CAISO to develop an implementation approach for creating the V2G Pilot. SCE filed an Advice Letter[4] on April 23, 2013 to implement the V2G Pilot.

The V2G Pilot consisted of 41 fleet vehicles of various classes and configurations. Procurement and delivery of vehicles was slated to begin by December 2012, but the lack of "commercially available off the shelf items" (COTS) extended the development and delivery timeline. The V2G Pilot required a collaborative effort among the Commission, the CAISO, the California Office of Planning & Research (OPR), contractors, and vendors.

Installation of charging infrastructure for the V2G Pilot was funded through the Air Force Research Laboratory (AFRL), and was managed by Concurrent Technologies Corporation (CTC). The infrastructure design of the V2G Pilot was a success, and is being used as a template for the other three pilot locations participating in the DoD PEV Program. The designed system calls for a single charging station per vehicle with each charging station capable of bi-directional power flow. The PEV charging infrastructure remained on the installation's electrical grid but was to be sub-metered separately from any other source or load. Similarly, the communications infrastructure was separate from the installation's Local Area Network (LAN) until the software control systems were appropriately certified. Groundbreaking for the construction of charging infrastructure began in November 2012.

Lawrence Berkeley National Laboratory (LBNL) and Kisensum were contracted to develop and implement the software control systems to manage the PEV fleet and V2G activities at LAAFB. This software system managed the check-out and dispatch of fleet vehicles, optimized charging schedules, and served as the primary interface with electrical utilities for V2G services.

CAISO resource certification testing occurred on October 15, 2015. The LAAFB received a letter from SCE, as the interconnecting utility, on December 15, 2015, granting the V2G Pilot project Permission to Operate (PTO). CAISO then issued a letter on December 18, 2015 acknowledging the Project's Commercial Operation Date (COD) of December 15, 2015. The

[4] Advice Letter 2889-E, filed on April 23, 2013.

COD is the first date that bids could be submitted, allowing all vehicles in the V2G Pilot to bid into the ancillary services market. The first bid was made on December 23, 2015 and awarded for December 24, 2015. On December 28, 2015, the CPUC issued a clarification that the V2G Pilot commenced upon the date the first bid was accepted, or December 24, 2015. SCE ended its V2G pilot demonstration period on September 30, 2017.[5]

B. Summary of the V2G Pilot Challenges

The first V2G system demonstration was pioneered by the University of Delaware (UDel) and NRG. The DoD PEV-V2G program hoped to build off of this groundbreaking work. Unfortunately, many of the UDel components were not transferable to the V2G Pilot due to the proprietary and closed architecture of their control systems. Moreover, the UDel communications protocols did not comply with Society of Automotive Engineers (SAE) or other evolving pertinent PEV standards, nor was their inverter UL1741 certified as required by all United States utilities. Additionally, COTS items for this nascent technology were not readily available.

After an exhaustive search for V2G components, the only COTS vehicle participating in the demonstration was the Nissan LEAF. The lack of COTS vehicles required significant testing of "first of their kind" products specifically designed for this Pilot. While the SCE testing added time on the front end of the schedule, it proved to be vital for the other demonstration sites as the vendors were able to correct faults that were identified in this process for their second-generation products.

There were no COTS solutions available to field a functional V2G PEV / electric vehicle support equipment (EVSE) system, although seven different companies (several of them start-ups) offered to tailor their products to meet the requirements for the V2G Pilot. Thus, four different vehicle manufacturers, along with three different charging station manufacturers, rolled out a "first of its kind" product specifically for the V2G Pilot. Because the components were designed and built on an accelerated small batch production schedule, there was not enough time to perform a thorough test and evaluation cycle to work out any issues. Despite meeting all regulatory requirements like UL Certifications, SCE thought it was prudent to take each of the paired systems (EVSE and PEV) through its own testing and validation process.

[5] On September 23, 2016, SCE filed AL 3479-E, which was made effective on October 23, 2016. In AL 3479-E, SCE requested, among other things, to extend the V2G Pilot for LAAFB through September 30, 2017.

Thus, while the V2G concept was solid, there was a longer than anticipated journey to find, test, and sustain the components that would make V2G a reality at LAAFB. Additionally, there were several hurdles to be surmounted to enable a small resource to participate in the ancillary services market. The first step to removing such barriers was the issuance of the Federal Energy Regulatory Commission's (FERC) Order No. 755.[6] This order removed unduly discriminatory and preferential practices from Regional Transmission Operators (RTOs) and Independent System Operators (ISOs) tariffs. Specifically, FERC Order 755 requires RTOs and ISOs to compensate frequency regulation resources based on the actual service provided, including a capacity payment that includes the marginal unit's opportunity costs and a payment for performance that reflects the quantity of frequency regulation service provided by a resource when the resource is accurately following the dispatch signal.

C. Summary of the V2G Pilot Findings

Overall, SCE has determined that the V2G Pilot was successful largely based on SCE supporting a pioneering customer in the direct participation space. This demonstration provided many tangible benefits that include:

- Maximized the use of underutilized vehicle assets by using the batteries as an energy source
- Reduced installation energy and fleet vehicle costs
- Reduced local GHG emissions associated with liquid-fuel vehicles
- Lowered environmental risk from petroleum processing, transportation, and spillage
- Advanced the state of PEVs and charging stations
- Advanced the state of V2G engineering and software applications
- Stimulated cooperativeness with utility operators and regulators to embrace an alternative energy solution
- Increased grid energy storage capacity
- Promoted energy surety across the nation while decreasing dependence on foreign oil.

[6] *Order No. 755,* 137 FERC ¶ 61,064 (2011).

Additional intangible benefits identified were derived under this effort that include:

- Piloted new national energy security capabilities
- Advanced technologies for national, state, and local energy assurance
- Strengthened relationships and partnering with electric regulating authorities and communities to meet future requirements
- Paved a path for smaller generation sites to enhance energy assurance
- Supported grid stability
- Provided a future capability for LAAFB energy resiliency/islanding and assurance
- Supported Executive Order 13693 – Sustainability
    - Decreased petroleum consumption
    - Reduced GHG emissions
- Supported California Vehicle-Grid Integration Roadmap Track 3, "Support Enabling Technology Development" through research, development and demonstration.

SCE agrees with DoD that the greatest accomplishment of the V2G Pilot is that it has paved the path for smaller resources to participate in the ancillary services market going forward.

II. COLLECTING QUANTITATIVE PILOT ACTIVITY DATA

A. Regulation Up, Regulation Down, and Non-Performance Events

Submitting Bids and Receiving Awards

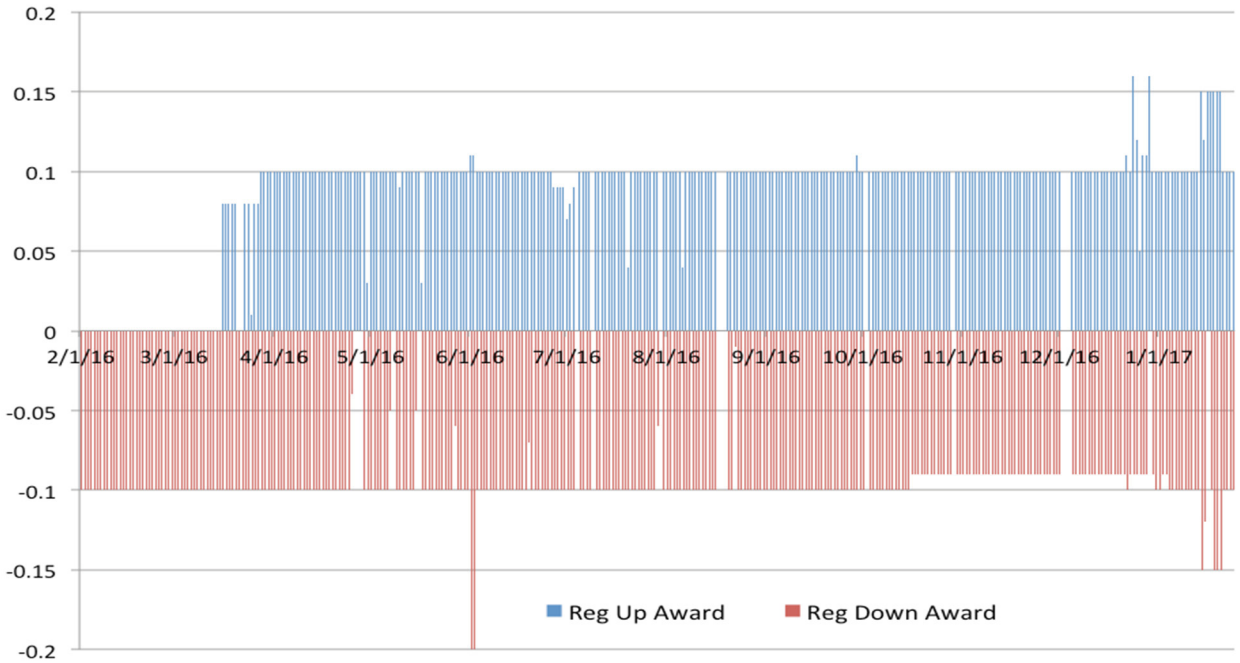
The goal of submitting bids each day was met for the most part over the course of the V2G Pilot. Regulation up and down awards were almost always equal to the bids that were placed. From January 30, 2016 to September 30, 2017, the LAAFB V2G resource provided a total of 255 megawatt hours (MWh) of regulation up and 118 MWh of regulation down.

Each hourly award from January 30, 2016 to January 24, 2017[7] is shown in Figure A. Due to limited resource capacity, bids were nearly all 0.1 MW (reg up) and -0.1 MW (reg down) in each hour, with some exceptions when operation of a subset of the EVs/EVSEs was more consistent.

[7] The date range reflects the time period starting from the date CAISO established consistent bidding and awards through the last day of regulation down certification (see CAISO Decertification of Regulation, Section II.C. below).

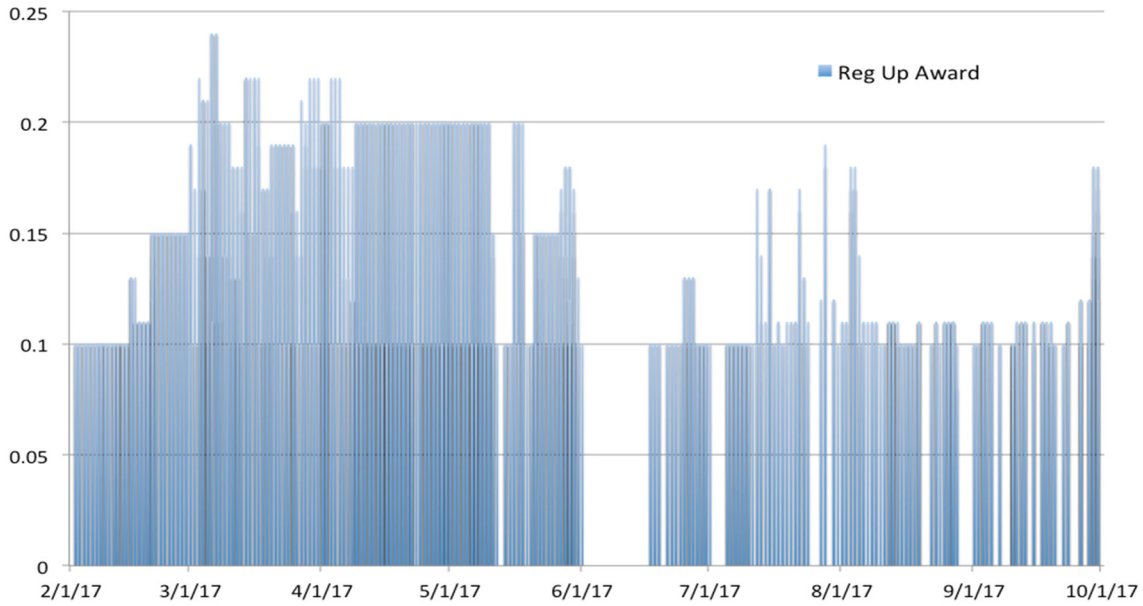
Distributed Energy Resources Customer Adoption Model (DER-CAM) optimized schedules were implemented when the availability of PEVs and Electronic Vehicle Supply Equipment (EVSE) stabilized at the beginning of 2017. Before that, inconsistent resource performance required fairly static minimum bids of 0.1 MW and -0.1 MW to reduce market settlement risk.

Figure A: All Hourly Awards from 1/30/16 to 1/24/17



When bidding was regulation up only, bid magnitudes increased in March-May 2017, as shown in Figure B. From early June through September 2017, bid magnitudes were mostly reduced due to lower hardware availability. In fact, in early June no bids could be made for that reason.

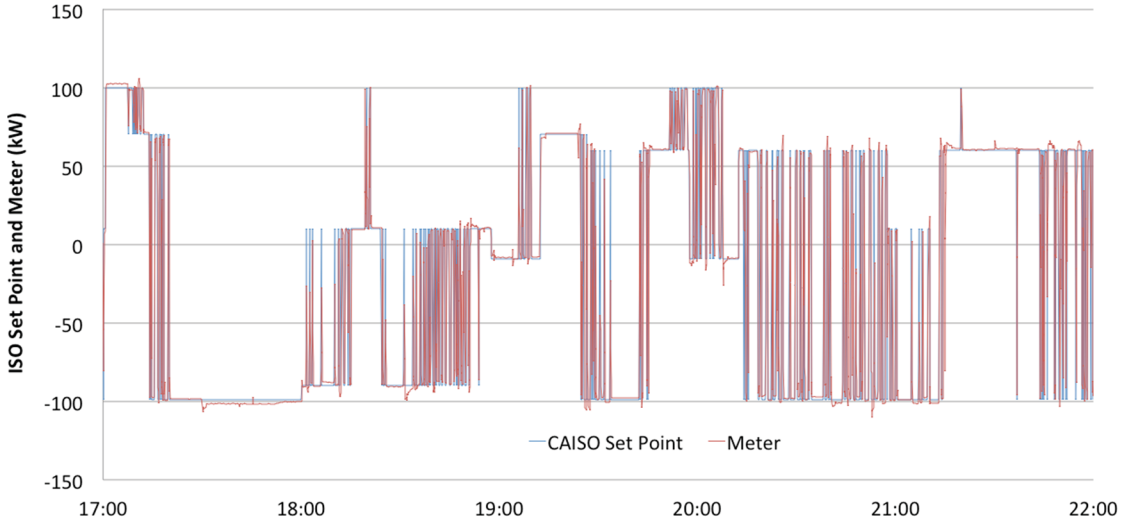
Figure B: All Hourly Awards from 2/1/17 to 9/30/17



Following AGC Dispatch

An example of several hours of the LAAFB V2G battery resource following the AGC setpoint dispatched by CAISO at 4-second intervals is shown in Figure C.

Figure C: CAISO AGC Dispatch Setpoint (blue) and Resource Meter (Red) Over Five Hours with ±15 kilowatts (kW) EVSEs/EVs Only



Zooming into a single hour illustrates the quick response time and accurate tracking of the aggregate EV meter relative to the set point dispatched by CAISO. Figures C and D show a period when only ±15 kW EVSEs were active.

Figure D: CAISO AGC Dispatch Setpoint (blue) and Resource Meter (Red) Over One Hour with ±15 kW EVSEs/EVs Only

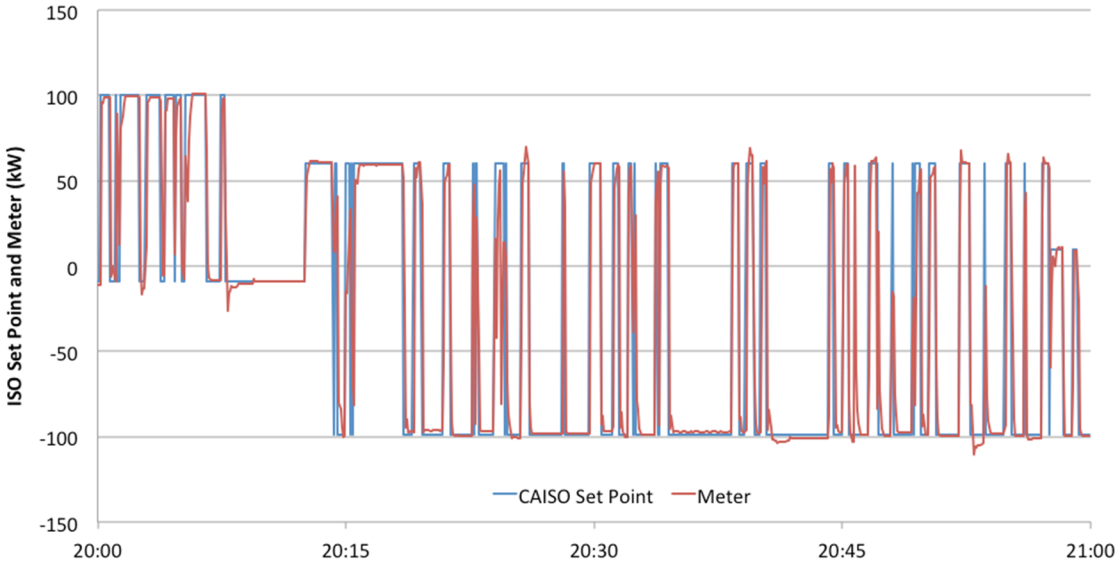
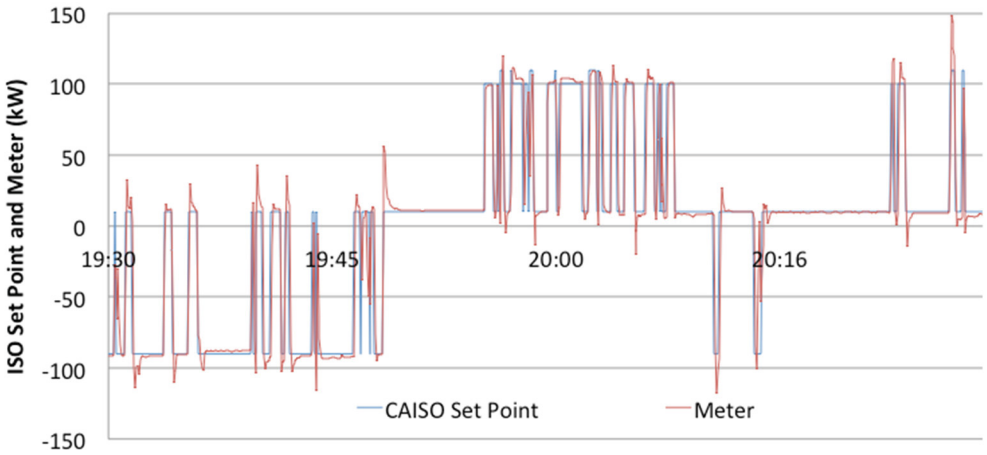


Figure E shows a period when both ±15 kW EVSEs and a ±50 kW EVSE were active. There is greater overshoot of the meter value relative to the target CAISO set point. This results from the longer time that it takes for the ±50 kW EVSE to reach its higher set point. The real-time charge controller compensates for that lag time by setting individual set points that overshoot the target CAISO set point. The benefit of this overshoot is that it leads to overall lower error between the aggregate meter value and the CAISO set point, when compared at 4-second intervals.

Figure E: CAISO AGC Dispatch Setpoint (blue) and Resource Meter (Red) Over One Hour with Both ±15 kW and ±50 kW EVSEs/EVs



Double-Benefit Events

SCE submitted a nine-month report to the CPUC on September 26, 2016. According to Attachment B of that report, there were no double benefit events, and this continued through the end of the V2G Pilot. A double benefit in this Pilot is defined as the customer gaining two separate benefits for performing a single action; specifically, a double benefit would occur if LAAFB's retail demand charge, also known as peak-shaving, was reduced at the LAAFB's master metered load, and LAAFB was also compensated by the CAISO for its simultaneous participation in the wholesale market. Market participation continued to occur outside of the base's peak load, so it was not necessary to adjust the meter data to address any simultaneous participation in retail peak shaving and in the CAISO market. Since there were no adjustments to the meter data, there were no costs incurred by the LAAFB related to the third provision under the Rates section of Schedule V2G Pilot.

Timing and Other Issues with Major Pilot Processes

CAISO Decertification of Regulation Down

A letter from CAISO to SCE dated October 14, 2016 stated that the LAAFB V2G Pilot resource, resource ID ELNIDS_2_DODEV, had received accuracy scores for regulation down that were less than the allowable threshold of 25% for the months of July (23.6%) and August (11.4%), 2016. The low accuracy scores were partly due to hardware and control system faults, but primarily due to a problem with null accuracy values stemming from the need to use operating limits. Accuracy scores for August 2016 were nearly all null values for regulation down (only three 15-min accuracy scores were reported). According to the CAISO Business Requirements Specification: Pay for Performance Regulation document, a null value will result when the absolute value of the difference between the Automatic Generating Control (AGC) set point and the Dispatch Operating Point (DOP), what will be referred to here as "net regulation", is less than 0.1 MW. For example, the resource bid was awarded -0.010 MW energy and -0.100 MW regulation down. The AGC should have been -0.110 to get -0.100 regulation down relative to the -0.010 MW energy, but the operating limit was erroneously hard-coded to -0.100 MW. With an AGC of -0.100 and a DOP of -0.010 the net regulation down was -0.09 MW, which led to null values for these time periods because the absolute value was less than 0.1 MW. The resource was following AGC and providing regulation down, albeit 0.01 MW lower than the awarded value.

The primary reason for setting an operating limit was due to a defect within the CAISO Outage Management System (OMS) which prevented limits from being established. The effect of that defect caused a condition where the AGC set points being received were not limited to award values, but instead went to the maximum certified values for regulation up and down (or to limits set in the OMS). Ultimately is was the resource's responsibility for incorrectly setting the operating limit (-0.100 instead of -0.110), but limits would not have had to be set dynamically if AGC set points were constrained to award values rather than to the resource certified maximums or to the limits set in the OMS, which cannot be dynamically adjusted in a manner suitable for the varying capacity of an aggregated EV resource. Although the CAISO OMS defect was corrected in June 2016, it was a contributing factor to overall performance accuracy.

Also the root cause here, outage limits incorrectly set by the resource operator, could have been easily corrected before accruing too much performance error in July and August if there was some more timely performance feedback. If performance reports were available in timeframes shorter than quarterly, it could greatly increase a resource's ability to correct operation problems.

The participants had the option of repeating the certification test procedure with CAISO to maintain status as a regulation down resource, but several of the PEVs and EVSEs that were operational in the original October 2015 certification test were no longer reliably operational in October 2016. Thus, after decertification, beginning on January 24, 2017, the V2G Pilot was no longer able to bid or receive awards to provide regulation down. After that date, V2G Pilot alternated between bidding regulation up only for one to two hours and recharging the vehicle fleet back to full capacity out of market, multiple times in weekday evenings and throughout the day and evening on weekends (when resource capacity and performance allowed). The CAISO decertification of the V2G project as a regulation down asset was the only significant major issue that impacted the V2G Pilot.

Load Impacts

The net total energy consumption recorded by the "EV meter"[8] was 249 MWh from May 1, 2016 to September 30, 2017. The total energy for charging (for travel, testing, and regulation down) was 321 MWh and for discharging (for testing and regulation up) was 72 MWh. The total energy consumed by the entire base over the same period was 58.6 gigawatt hours (GWh). The net

[8] CTC reported the EVSEs were all behind a single "EV meter" (Schneider Electric Model S8600), which itself was behind the SCE revenue meter for the entire LAAFB.

PEV load was a miniscule portion of the total load at only 0.4%. The peak 15-min average demand on the EV meter was 329 kW and was not observed to coincide with any monthly peak demand value. On average, PEV charging demand increased peak period demand, over off-, mid-, and on-peak periods, by 0.9% with a range of 0.4% to 2.7%.

III. COLLECTING PILOT FINANCIAL DATA

A. DoD Regulation Revenues

Market participation revenue for the V2G Pilot was dependent on many factors, including equipment availability, day-ahead pricing for the regulation up and regulation down markets, and CAISO's energy needs. The aggregated gross revenue through April 2017 totaled $7,639. However, high monthly fees including a scheduling coordinator (SC) fee of $1,000, a manual billing fee of $118.46, and a meter data feed fee of $216.50 offset the gross earned revenue to a net negative cost of $17,138. The revenue and fees appeared as adjustments on LAAFB's monthly utility bill from SCE.

Below is a project settlement summary provided for October 2015 through September 2017 (operation period). All months are based on T55 CAISO settlement statements, except for August and September 2017, which are based on T12 statements.[9] Typically, the V2G Pilot incurred more charges during the operational period than it earned in revenue, with an exception of one month in May 2016. The V2G Pilot generated net revenues of $86.89 in May 2016, while on average, it incurred monthly charges of $745 for all other months. Actual monthly CAISO settlements are shown in Figure F below.

The CAISO charges are summarized in the table below for the operation period. The CAISO settlement is the sum of over 30 different charge codes, of which about a dozen make up the bulk of the net settlement. The charges are received from the CAISO in the form of charge codes that are provided in the spreadsheet in Appendix I. For simplicity, these charge codes have been categorized under broader groups to provide a better overview of the financial transactions. These categories are defined as:

[9] Please refer to Appendix I for supporting data in CAISO Settlements convention: positive values are payments made to CAISO while negative values are credits received from CAISO.

- Grid Management Charges (GMC) – charges assessed on SCs for recovering CAISO's administrative and operating costs associated with operating the Energy and Ancillary Services markets.
- Regulation Up/Down – these categories included the day-ahead, real-time and mileage payments associated with regulation along with any obligation charges and "no-pays" assessed due to non-compliance or non-performance.
- Flexible Ramping – Compensation for ramping capacity provided in Real-Time market to meet imbalance that may arise in future intervals
- Energy – Revenue and costs associated with providing energy in the Day Ahead, Fifteen Minute, and Real-Time markets along with and adjustments due to deviations from prior market schedules and make whole payments (bid cost recovery).
- Miscellaneous – marginal allocation and invoice related charges.

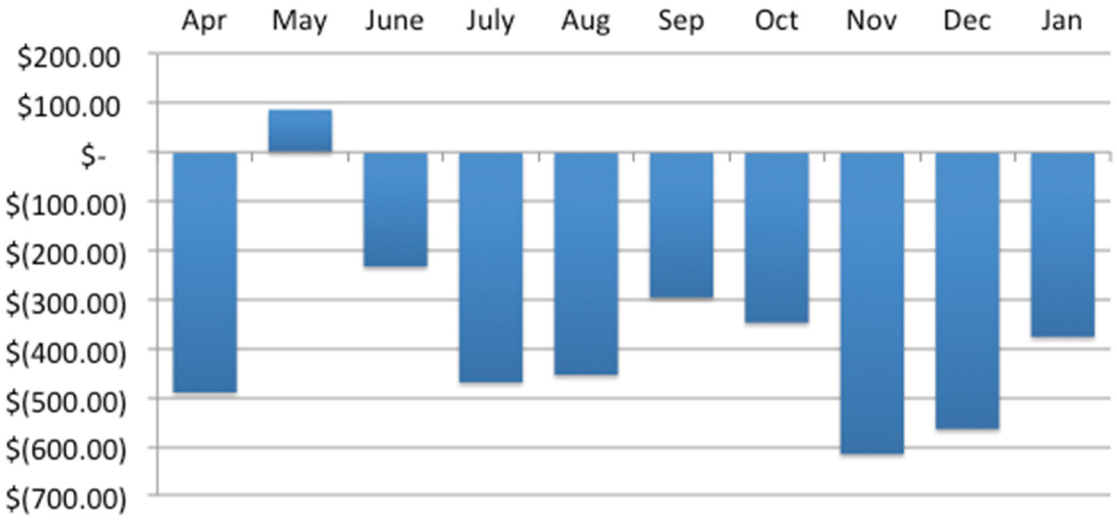
Table 1 – DoD Regulation Revenues

DoD Regulation Revenues		
October 2015 through September 2017 (operation period)	**Grand Total**	**Monthly Average**
Regulation Up Charge	**($5,196.87)**	**($228.43)**
Regulation Down Charge	**($939.80)**	**($64.12)**
Flexible Ramp Charge	**$104.35**	**$4.35**
Grid Management Charge	**$23,237.76**	**$1,010.64**
Energy Charge	**($103.24)**	**($13.47)**
Miscellaneous Charges	**$36.59**	**$1.53**
Grand Total:	**$17,138.79**	**$710.50**

In Table 1 above, revenues received from CAISO are indicated by red numerals in parentheses, and fees paid to CAISO are indicated by black numerals. This table does not include SCE costs billed to the V2G Pilot set forth below in Section III.B.

In total, the V2G Pilot incurred net CAISO charges of $17,138 mainly driven by the monthly Scheduling Coordinator ID charge of $1,000 per month which typically outweighed revenues associated with the project operation.

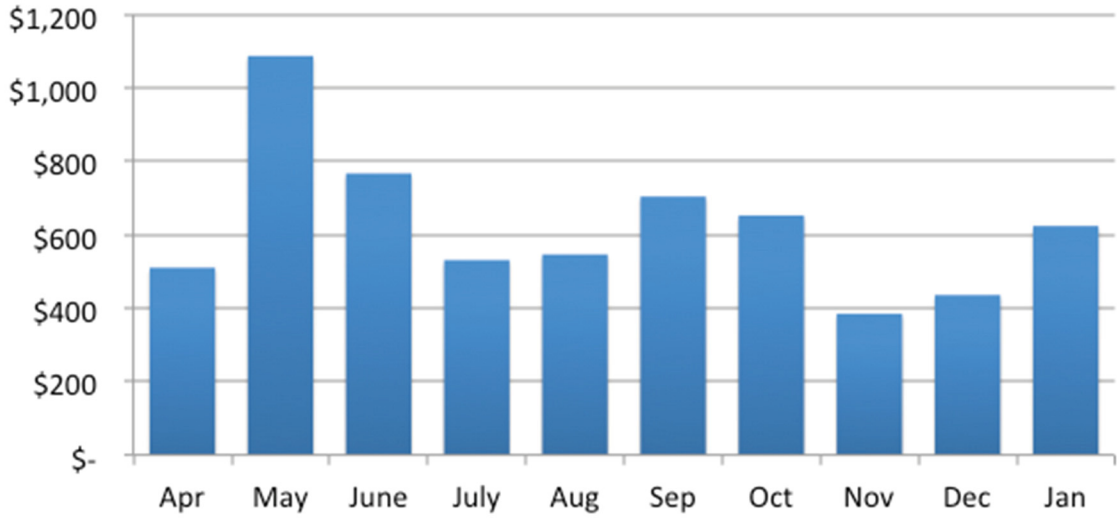
Figure F: Monthly CAISO Settlement with Both Reg Up and Reg Down



CAISO and other fees obviously negatively impacted the net settlement value of the V2G Pilot project, but these fees represent costs incurred by the market facilitators, i.e. CAISO and the Scheduling Coordinator, and thus are part of the project cost. In the future, these fees may change or be scaled to resource size either by the facilitators or by division of the fees among aggregations of resources. Initial DoD consultant estimates for revenue from V2G providing Ancillary Services (AS) regulation in other studies, and the preliminary analysis for this V2G Pilot, did not include these fees. The preliminary analysis assumed that this resource would become part of a portfolio and thus avoid paying incremental fees to provide AS, but this was not the case for the V2G Pilot.

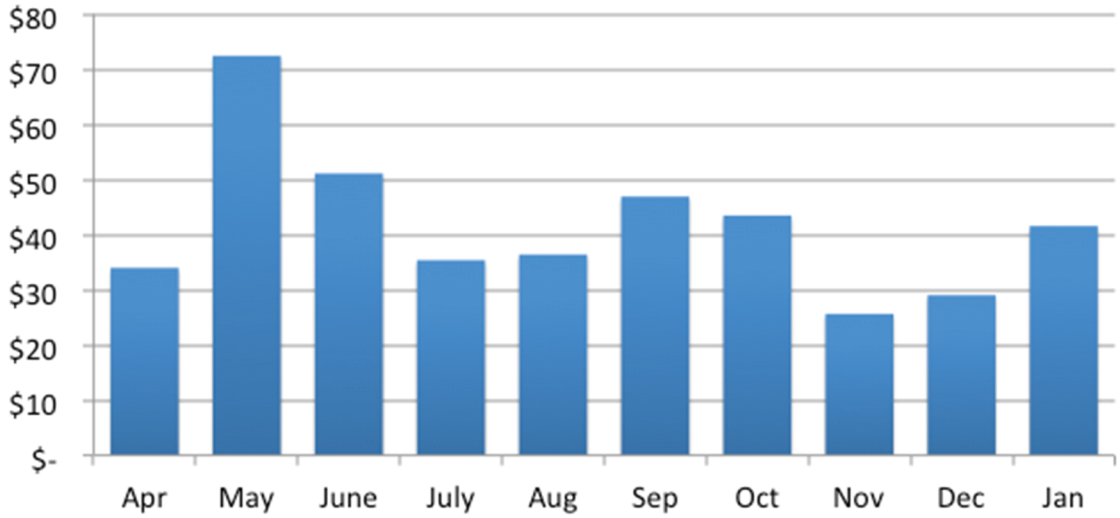
Figure G shows the monthly net settlement, not including fees, for April 2016 through January 2017. While LAAFB was in the market from December 2015 through March 2016, that period was primarily spent working with CAISO and the Scheduling Coordinator to investigate why awards were not being made or were being dispatched incorrectly, which prevented the resource from participating to any meaningful extent over that period. January 2017 was the last month before decertification for regulation down as described in the Decertification section above. Figure G shows, that without fees, settlements were net positive, and reasonably good considering that the bids were typically only 0.1 MW regulation up and -0.1 MW reg down each hour for an average of about five hours per night.

Figure G: Monthly Net Settlement Not Including Fees with Both Reg Up and Reg Down



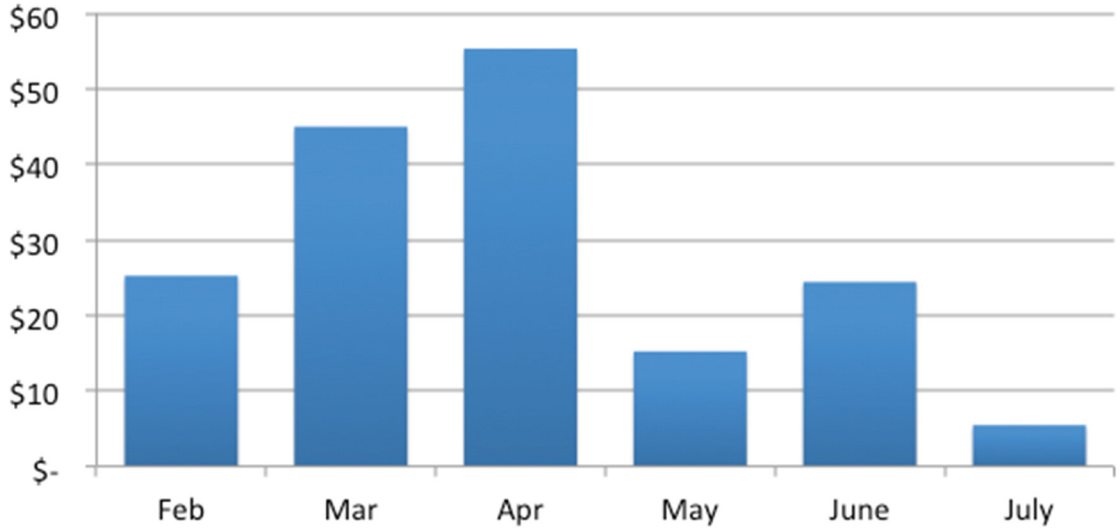
On a per vehicle basis, Figure H shows the net settlement per vehicle where up to 15 PEVs/EVSEs (12 of the sedans or vans and three of the larger capacity vehicles) participated in market operations over that period. Figure H also excludes market participation fees, whose effects could be minimized by utilizing a significantly larger resource (i.e., more PEVs integrated into a single resource). This would decrease the market participation cost per vehicle by spreading the cost across a larger number of PEVs. With the limited bids due to CAISO decertification, the revenue per vehicle ranged from $25 to $72 per month with an average of $41 per vehicle-month.

Figure H: Per Vehicle Monthly Net Settlement Not Including Fees with Both Reg Up and Reg Down



Because the CAISO decertified the asset's participation in the Regulation Down Market on January 24, 2017, the V2G Pilot was only able to bid reg up from that date forward. Despite this limitation, bidding nearer to the low end of the range between 0.1 MW to 0.24 MW reg up for 3-12 hours per day (about 5 hours average), monthly per vehicle revenue ranged from $5 to $55, excluding market participation fees, as shown in Figure I below.[10] The range of monthly revenue earned is due to market price volatility and actual versus instructed performance.

Figure I: Per Vehicle Monthly Net Settlement Not Including Fees with Both Reg Up Only



B. SCE costs

SCE costs for the V2G Pilot were charged to LAAFB as single item fees on its monthly bill. These fees included a CAISO based scheduling coordinator fee of $1,000 that SCE passed through the LAAFB, a manual billing fee of $118.46, and a meter data feed fee of $216.50. Consistent with the Resolution, SCE did not pass through any of its costs to non-participating customers, and thus they remained indifferent.

C. LCFS Credits

As part of the GHG emissions reductions effort, LAAFB coordinated with SCE to participate in the Low Carbon Fuel Standard (LCFS) Program to generate LCFS credits for fleet and workplace charging. The V2G Pilot was ideal to participate in the LCFS Program due to its diverse general-purpose fleet of plug-in hybrid electric vehicles across different gross vehicle

[10] As of the date of this Report, the most recently-available settlement data is from July 2017.

weight ratings. LAAFB accumulated a total of 21 credits, valued at approximately $1,827 (weighted average historical price of $87.00 per credit) since the inception of the V2G Pilot.

IV. QUALITATIVE EVALUATIONS

A. Key Implementation Process Assessment

Base Infrastructure Design and Permitting

In August 2011, United States Air Force (USAF) officials unveiled a plan to establish LAAFB as the first federal facility with an all-electric non-tactical fleet. As a result, LAAFB was selected to be the first PEV-V2G pilot location. The parking lot and infrastructure design and construction were completed in September 2013.

Interconnection Studies and Execution of WDAT, GIA, and DSA

The USAF submitted an Interconnection Request to SCE for Interconnection Service and Distribution Service under the terms of SCE's Wholesale Distribution Access Tariff (WDAT) under the Fast Track Process.[11] After deeming the Interconnection Request complete on January 20, 2014, SCE reviewed the Interconnection Request under the Initial Review and Supplemental Review screens of the Fast Track Process. SCE issued a Fast Track Review report on April 15, 2014 determining that the V2G could interconnect safely and reliably and providing the scope and cost to interconnect. The scope consisted of telemetry for SCE to monitor the generation at LAAFB with an estimated cost of $14,500.

A Generator Interconnection Agreement (GIA) and Distribution Service Agreement (DSA) between USAF and SCE were executed on August 22, 2014 and filed at FERC, in Docket No. ER14-2758, on September 4, 2014 with a requested Effective Date of September 5, 2014. The filing was accepted by FERC on October 9, 2014.

[11] In order to participate in the CAISO's Ancillary Services' market, the battery discharges would be treated as exports to the CAISO grid. Hence, the proper instrument for interconnection was SCE's WDAT.

Table 2 - Timeline Summary of Interconnection Studies and Execution of WDAT, GIA, and DSA

Date	Events
January 20, 2014	Interconnection Request deemed complete
April 15, 2014	SCE issued Fast Track report
August 22, 2014	Executed GIA and DSA between USAF and SCE
September 4, 2014	Filed GIA and DSA at FERC
October 9, 2014	FERC accepted GIA and DSA

V2G Pilot Bidirectional Charging Evaluation Summary

SCE's Electric Drive Systems (EDS) Group tested each of the bidirectional vehicle/charger systems prior to deployment at LAAFB. The purpose of the test was to ensure safety compliance with utility interconnection rules as influenced by IEEE 1547-2003 - IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems, SAE J2894 Power Quality Requirements for Plug-In Electric Vehicle Chargers, and to ensure the systems were functional and safe to use for the LAAFB. The vehicle and charger systems that were tested are shown in Table 3 and Figure J.

Figure J – Each bidirectional vehicle/charger system was tested prior to deployment: Nissan Leaf and Princeton Power Systems Charger under test

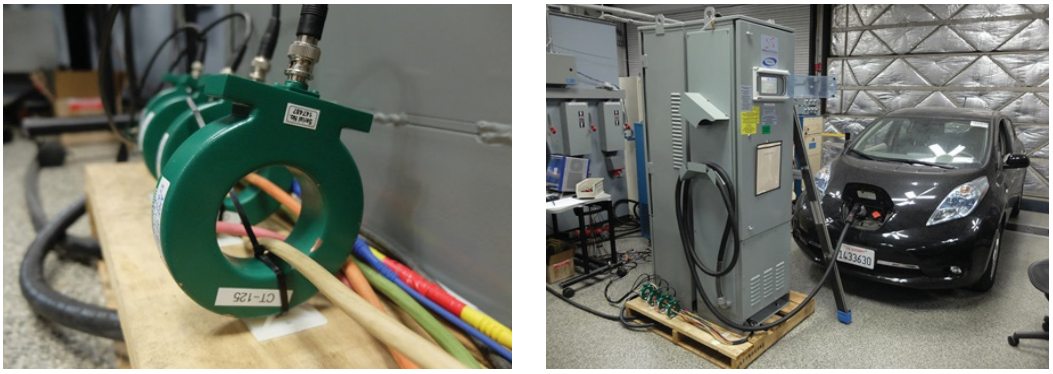


Table 3 - Bi-Directional Systems

Bi-Directional Vehicle	Bi-Directional Charger Manufacturer	Charger Type *AC – Alternating Current DC – Direct Current*	Charger Rated Power (kW)	Vehicle & Charger Count
Nissan Leaf	Princeton Power System	DC Off-board	15	13
Phoenix Bus	Coritech	DC Off-board	50	1
EVAOS Truck	Coritech Charger / Bel Power Solutions Inverter	AC On-Board	15	5
EVI Truck	Coritech	DC Off-board	50	4
VIA Van	Coritech Charger / Bel Power Solutions Inverter	AC On-Board	15	11
			Total Systems Tested	**34**

Figure K - Vehicles and chargers under test for the LA AFB project

Test Results and Analysis

The vehicles and chargers were evaluated for general safety, functionality, and compliance with interconnection rules and SAE J2894, under an agreed-upon test procedure between CTC and SCE. On-road vehicle tests and post-drive charges were performed to validate the safety and functionality of the vehicles and chargers, as well as to determine basic fuel economy, as requested by the DoD. The vehicles and chargers were then subjected to simulated grid event testing during bi-directional charging (transferring power from the vehicle to the grid) as a subset of IEEE 1547 procedure to test their ability to detect an abnormal grid event, and quickly disconnect from the grid to avoid damage to the charging system, grid, or personnel.

During both charging (grid to vehicle) and bi-directional charging (vehicle to grid), the vehicles were also evaluated for their compliance with SAE J2894 to ensure that the vehicles charged efficiently and safely with no negative impact on the grid or nearby equipment. A test summary is shown in Table 4, with colors corresponding to the final testing outcome (green meaning the equipment was ultimately full compliant, and yellow meaning that the equipment was not fully compliant in that category).

Table 4 - Test Summary

	Vehicle Functionality	Charger Functionality	IEEE 1547 Compliance	SAE J2894 Compliance	Test Start	Test End	Months of Testing
Nissan & Princeton Power Systems Charger					Nov, 2013	Nov, 2014	12
Phoenix bus & Coritech Charger	Not Performed				Jan, 2015	March, 2015	3
EVAOS Truck & Coritech Charger					Sep, 2015	Dec, 2015	4
EVI Truck & Coritech Charger					Mar, 2015	Sept, 2015	6
VIA Van & Coritech Charger					Aug, 2015	Apr, 2016	9

Summary of Issues Encountered

During testing, it was discovered that many of the vehicles and chargers had various issues that needed to be resolved before they were suitable for field operations. These issues included, but were not limited to, limited charger functionality, standby load that was higher than SCE's recommendations for charging infrastructure, heavy parasitic loads that reduced the reliability of the vehicles, and inverter issues. The parties worked together to resolve most of these issues to make the V2G Pilot a successful endeavor.

Discussion on extended duration of testing

The time for testing the vehicles and chargers in the LAAFB program was initially expected to be six months. Unfortunately, primarily due to the issues noted above, none of the vehicle and charger systems SCE received passed initial testing in their "as-is" configuration from the manufacturer. At each failure point, SCE worked with each manufacturer to re-calibrate and address all compliance and functionality issues with each vehicle and charger. Testing for some of the vehicle and charging systems varied dramatically and took anywhere from three months to a full year to pass relevant testing. SCE worked with CTC to conduct pre-delivery screening by the manufacturer prior to shipping to SCE, but the manufacturers were unable to perform the tests, according to CTC. Overall the time to test the vehicles and chargers took over two years to complete – 1.5 years longer than expected.

Testing Conclusion

Although the testing process took a full year-and a half longer than expected, it was clear that testing these vehicles for the LAAFB was critical in ensuring that the systems were functional,

safe, and compliant with utility interconnection rules. All vehicles were eventually able to comply with all relevant standards, at least to the extent that ensured that there were no critical safety issues and the equipment worked as intended. SCE's EDS group monitored the vehicles and equipment throughout the Pilot and captured lessons learned. In addition, EDS conducted limited power quality tests at the base and had no findings of any abnormal behavior for the charge sessions observed.

V2G Pilot Operations

The V2G Pilot began data collection efforts for a 12-month demonstration period on May 1, 2016. The V2G Pilot received a notice of decertification from CAISO on January 26, 2017, decertifying the program from the Regulation Down Market. According to CAISO, the V2G fleet failed to accurately respond to the regulation down AGC signal a minimum of 25% of the time during July and August 2016. This meant LAAFB's V2G fleet was no longer permitted to participate in the Regulation Down Market. Regulation up only bidding commenced.

SCE ended its pilot demonstration period on September 30, 2017, in compliance with the CPUC's Resolution E-4595; consequently, the V2G Pilot ceased all market participation activities after that date.

Table 5 - Timeline Summary V2G Pilot Operations

Date	Events
October 15, 2015	Successful qualification testing
December 15, 2015	LAAFB received PTO from SCE and submitted to CAISO
December 18, 2015	CAISO issued acknowledgement of COD
December 24, 2015	LAAFB's first bid awarded
December 28, 2015	CPUC clarified that LAAFB's V2G pilot would begin upon first bid acceptance
May 1, 2016	V2G team began data collection efforts
January 26, 2017	LAAFB received notice of decertification from CAISO
September 30, 2017	Pilot Ended

B. Lessons learned

Technical, business operations, legal, and regulatory issues

SCE coordinated with the DoD to prepare this final report for the V2G Pilot. According to DoD staff, the security and environmental benefits of reducing fossil-fuel by using PEVs for non-tactical military vehicle fleets are clear; however, there are several operational and technical challenges inherent in effectively managing PEV fleets. For example, the V2G Pilot made clear that vehicle charging can be more expensive if not managed well relative to the prevailing utility tariff time-of-use rates and other constraints. Thus, to implement a PEV fleet on a large scale, SCE believes that customers will need to have well-conceived energy management and charging plans that consider the costs, the benefits, and the cross-over impacts between the retail and the wholesale markets.

This V2G Pilot demonstrated that a small vehicle-to-grid program is not currently cost effective because the costs and fees in each month are higher than the income realized by participating in the CAISO markets. Some of this cost can be offset by retail savings, also known as peak shaving, or aggregating resources across multiple locations. However, a significantly larger resource would be more cost effective, and thus another lesson learned is that future programs should utilize a larger resource.

It is clear that the fast-responding energy storage capability in vehicle batteries can provide valuable services to help satisfy building and facility energy requirements. Further, while each vehicle is not itself a large electricity load or source, an aggregated fleet that is collectively integrated with the buildings at which the fleet is interconnected, may be large enough to provide even more value. A larger fleet of PEVs can ameliorate the effects of variable local resources and loads and provide DR+AS service to the local utility and the surrounding power system.

The V2G Pilot proved that electric vehicles can meaningfully participate in CAISO's wholesale market. The Pilot was successful in providing frequency regulation to the CAISO market for a total of 243 MWh of Regulation Up and 102 MWh of Regulation Down from May 2016 to September 2017. While CAISO is one of the most advanced markets for DER integration, the varying resource availability parameters of a vehicle fleet aggregation add complexity in providing CAISO market systems accurate resource inputs, such as State of Charge (SOC), which can impact Day-ahead market award, or real-time resource optimization using the Regulation Energy Management model which controls SOC based on a fixed energy capacity. For continuous

regulation provision over long periods, it will be necessary to have an automated method for communicating hour-ahead energy bidding to maintain the stored energy in EV batteries. Because this was unavailable through the scheduling coordinator, LAAFB reduced the hours in the market to create break periods in which the fleet energy storage could be recharged without impacting regulation performance. Additionally, a large spread of battery capacity and charge/discharge rates presented a challenge for setting proportional individual dispatch set points.

Customer experience and satisfaction

Overall, the DoD and the USAF indicated that they saw value in the V2G Pilot, and the team appreciated the services provided by SCE to shepherd the pilot through myriad testing, qualification and participation wickets. Even though this demonstration concluded on September 30, 2017, LAAFB has indicated that it will continue to advance V2G technologies in other areas like vehicle-to building as it persists to build a more secure energy future along with SCE. The SCE EV Technical Center was instrumental in ensuring that every paired PEV and EVSE was ready for market participation.

V. ASSESSING QUANTITATIVE AND QUALITATIVE DATA

A. Revenue and Cost to DoD and SCE

Which costs were one-time costs due to this novel pilot?

Costs for SCE's services for the V2G Pilot were novel to this V2G Pilot and charged to LAAFB as single item fees on its monthly bill. As noted above, these monthly fees included a CAISO- scheduling coordinator fee of $1,000 that SCE passed through the LAAFB, a manual billing fee of $118.46, and a meter data feed fee of $216.50.

SCE does not have information about any DoD costs regarding the elements listed below:

- Electrical infrastructure and equipment costs;
- Net effect on PEV operation costs, in comparison to charging/discharging PEVs on otherwise applicable tariff;
- Net effect on facility retail electric costs;

SCE's role was limited to that of a Scheduling Coordinator, and SCE did not have visibility the vehicle operating cost or the effect on the facility's costs.

Estimation of degradation impact on PEV battery life

According to a Massachusetts Institute of Technology (MIT) Lincoln Laboratory report, the battery data collected showed that no statistically measurable level of degradation occurred due to V2G tied cycling. Additionally, a study is being planned by MIT and others to demonstrate hardware prototypes which investigate the types of operation that are possible for the battery. For example, the study will investigate second life operation, which is a process to extract further value from batteries no longer suitable for vehicle use.

B. Qualitative Assessment

SCE believes that the V2G Pilot, while not without its challenges, was an overall success and supported California's goals of promoting a future that includes a high number of distribution level energy sources, including EV fleets, that will be managed and coordinated within, or parallel to, transmission grid wholesale markets.

The V2G Pilot was the first of its kind to demonstrate that it is possible for EVs to participate as an ancillary service in the CAISO wholesale market. This was made possible through the collective efforts of the CAISO, CEC, the Commission, SCE, Lawrence Berkeley Labs, Kisensum, and several other participants. While not all state-level policy and regulatory requirements were in place to support this V2G Pilot, SCE notes that all existing CAISO Tariff requirements were met, which demonstrates that it is possible to interconnect a behind-the-meter EV fleet as a distribution resource capable of participating in the ISO wholesale market.

SCE is also encouraged because since the start of the V2G Pilot, the CAISO has implemented Tariff changes that will better support future aggregations of distributed energy resources in the wholesale markets, through its Energy Storage and Distributed Energy Resources (ESDER) and Distribution Energy Resource Provider (DERP) Stakeholder initiatives. The CAISO is also conducting several outreach efforts with a broad group of energy stakeholders to define and incorporate the necessary transmission-to-distribution interface communication requirements to ensure a reliable electrical grid while establishing pathways for distribution resources to more easily provide services to the CAISO.

Many energy technology developers and energy market service providers around the country and around the world have been following this V2G Pilot and are anticipating the results. This Pilot was the first opportunity to collect data on actual wholesale market participation experience and revenues from a behind-the-meter aggregated resource utilizing a relatively new

CAISO market model designed for storage resources. As a first of its kind, it is not surprising that the time from project initiation to actual wholesale market participation took longer than expected. There are still regulatory challenges in terms of the retail obligation to serve load even while the EV resource was separately metered by the CAISO and financially settled in the wholesale market.

The key lessons of this V2G Pilot will help to fulfill the goals of the Air Force and DoD, to enhance energy security using renewable energy and storage, and will also provide insight into all future projects attempting to achieve the same capabilities. It must be recognized that the results of this V2G Pilot provide only a glimpse of the possibilities for future projects. Technologies are advancing and becoming less expensive, interconnection processes are becoming more efficient and flexible, and energy market participants are becoming more knowledgeable in working with distribution level energy resources. While there is still a lack of available data about potential wholesale market revenue from these types of projects, this V2G Pilot has provided invaluable information on behind-the-meter EVs participating within the CAISO Market.

C. Communication Protocols

DoD reported that to make V2G a reality, two communications standards were used with the EVSE: Open Charge Point Protocol 1.5 (OCPP) and the SAE-adopted Smart Energy Profile 2.0 (SEP2).

Open Charge Point Protocol is an initiative of the E-Laad Foundation in the Netherlands aimed at creating an open application protocol that allows EV charging stations and central management systems from different vendors to communicate with each other. To date, OCPP is not as widely adopted in the United States as it is in Europe and Asia.

Although not widely adopted in the United States, OCPP protocol was selected early in the project by LBNL. The initial efforts were challenging as OCPP did not natively support control of power flow magnitude or direction between the vehicle and grid. It also lacked a native support for the communication of vehicle state of charge (SOC) attributes like vehicle battery voltage and current.

OCPP is built on Internet standards of Simple Object Access Protocol (SOAP) and Extensible Markup Language (XML) and uses the concept of a single Central System (server) and multiple Charge Points (vehicle charging stations). Extensions were developed to the OCPP 1.5 standard to address shortcomings that would allow the server to query and command the V2G

power magnitude and direction and the EVSE operating mode. Added functionality provided the ability to query the vehicle energy capacity and the instantaneous energy remaining.

Smart Energy Profile 2.0 (SEP2), an initiative of the ZigBee Alliance, was the other communications protocol selected for this demonstration. The SEP2 standard establishes a broad IP-based protocol to monitor, control, inform and automate the delivery and use of energy. The National Institute of Standards and Technology (NIST) Framework and Roadmap for Smart Grid Interoperability Standards (NIST 1108) identified SEP2 as a key "standard for implementation."

SCE and the DoD desired to adopt an industry standard that would address both EVSE-to-server and EVSE-to-vehicle communications. SAE shared the same vision and also embraced the SEP2 standard for its electric vehicle roadmap. Adoption of SEP2 and SAE standards for the PEV-V2G program was a logical and optimal choice, albeit not without its challenges.

SEP2 is built on Internet standards of Hypertext Transfer Protocol (HTTP), XML, and Representational State Transfer (REST), to name a few of significance. The concept of a Distributed Energy Resource (DER) is fundamental to the industry standard and is comprised of the PEV and the EVSE. The DER makes itself discoverable to the server, whereupon the server establishes a connection to the DER. This connection allows the DER to publish information to the server, which describes nameplate capabilities, vehicle and EVSE identity, and real-time status and performance attributes. The server commands the DER by manipulating attributes within a server data object called the DER Control, whereupon the DER retrieves those attributes and affects the desired V2G power flow. SEP2 defines the DER endpoint, which performs communications with the SEP2 server, as the equipment that contains the grid-tied electric inverter. Therefore, the endpoint is the vehicle in the case of AC V2G vehicles while the EVSE is the endpoint for DC V2G vehicles.

The relevant SAE standards apply a particular industry standard, Use Case 6, specifically for a Basic Distributed Energy Resource. CTC contracted Coritech to develop the EVSE Interface Module (EIM) and the Vehicle Interface Module (VIM), which support digital communications between the vehicle, EVSE, and server at various levels as directed by the SAE standards to satisfy SAE Use Case 6. The EIM and VIM enabled this solution to be applied to both AC and DC vehicles and EVSE from a variety of vendors. This approach efficiently leveraged a single development effort across application to several vendor products.

OB-EVI Software Communication/Aggregator

The transition from conventional vehicles to a PEV fleet requires a fundamental change in fleet management strategies. Primarily, the fleet manager must maintain cognizance of the charge state of each PEV battery, as well as the range capabilities of each PEV, at all times, to dispatch vehicles properly.

Integrating V2G activities into a PEV fleet creates additional layers of complexity. In a V2G model, the PEV is treated as an energy asset in addition to its traditional role as a mobility asset. Information regarding the PEV charge state and range capabilities must be integrated with energy data from the facility and public electrical grid to optimize the PEV's energy functions without diminishing its primary mobility requirements.

The PEV-V2G software, which is called OB-EVI, contains five modules:

1. Fleet Management System (FMS);
2. Charge Control;
3. Grid Scheduling;
4. EV Asset Coordination; and
5. Grid Interface.

The FMS software is designed to support military base transportation scheduling by providing an automated solution to base personnel to administer reservations and input requests to drive PEVs on or off the base. This software also creates key schedule information that can be used to optimize the use of the PEV batteries when the PEVs are not in use, and collect limited driving/usage behavior and patterns to further optimize PEV usage. This software is largely self-contained, but needs the present PEV battery SOC to determine whether a PEV has sufficient battery to safely perform a scheduled trip. This system provides a web browser interface that can be accessed by drivers, dispatchers, and unit vehicle control officers to schedule and manage the dispatching of PEVs. Additional software details are available in the PEV-V2G Implementation Approach and Demonstration Report.

The software must communicate with the CAISO in order to bid available vehicle battery power into the ancillary services market, receive subsequent market participation awards and real-time power transfer commands, and communicate real-time performance data. At the site, the software must communicate to all the V2G EVSE/PEV DER pairs. Communication to all the

Coritech SAE-compliant EVSE is accomplished through the SEP2 protocol. Communication to all Princeton Power Systems (PPS) EVSE is accomplished through the OCPP v1.5 protocol.

In addition to the basic V2G distributed resource communications, the software has the responsibility to separately monitor each EVSE power level, making sure that it reasonably matches the FMS request. This monitoring occurs through Modbus TCP/IP communications with Charging Station Isolation Module (CSIM). If the power levels differ significantly from the FMS command, the FMS has the ability to disconnect the potentially defective or rogue EVSE from the grid through control of the CSIM.

Communications between CAISO and Scheduling Coordinator

Communications between CAISO and the scheduling coordinator (SC) were made via a CAISO-approved AT&T ANIRA VPN router connected to the CAISO's private communication network known as the Energy Communication Network (ECN). Kisensum created its own translator to communicate with CAISO and the SC using the DNP3 communications protocol. The PPS and the Coritech VGI-50-DC EVSEs are equipped with AC-to-DC inverters that provide DC power to their respective vehicles. The Coritech VGI-15-AC provided AC power to its corresponding EVs (an inverter on-board the EV converted from AC to DC power). The PPS EVSEs connected to the EV with the CHAdeMO standard connector and communicated via the Open Charge Point Protocol (OCCP). Both of the Coritech EVSEs communicated via the Smart Energy Protocol 2.0 (SEP2).

VI. RECOMMENDATIONS

SCE recommends that participants interested in engaging in a V2G pilot such as this be prepared by ensuring that resources are functionally tested at least a few months prior to adding the complexity of live market participation. This would give parties sufficient time to test the hardware with the software before commencing commercial operations.

SCE also recommends that participants are aware of potential technical challenges in the implementation of communications, control, and feedback. Although the V2G Pilot was an overall success in terms of participating in the CAISO market, the Pilot suffered from several technical challenges, which limited its full participation in the CAISO market.

Finally, before entry into the market, it would be beneficial for owners and operators of new resources to gain a better understanding of how the resource will perform in market

operations. It would be useful guidance for many stakeholders to have a simulation environment for testing day-ahead and real-time market interactions, structuring bidding and receiving awards, receiving dispatch signals from a simulated AGC system, and sending telemetry data that allows it to provide a simulated settlement. This capability in a risk-free environment would provide new potential resources an opportunity to evaluate their performance before entering the wholesale market operations.

A) Program expandability

SCE sees opportunities for expansion of similar V2G activities, particularly if the PEVs are aggregated as a single resource managed by a single scheduling coordinator. Scheduling coordinator services such as this are available in the general market place and not specific to SCE, and SCE does not intend to offer its services as a scheduling coordinator for these types of programs in the future.

B) Enhancement of opportunities for vehicle electrification and direct participation

SCE believes there are opportunities for enhancement based on the V2G Pilot and SCE's engagement with the DoD. In addition to this Final Report, the DoD is developing its own lessons learned document so that this technology can be further advanced. The DoD's final report will be available after its published in December 2017-January 2018 timeframe.

VII. CONCLUSION

SCE believes the V2G Pilot was a worthwhile effort, and SCE appreciates the Commission's support for the Pilot, as well as the collaboration from all other parties involved. SCE believes that future pilots or programs in this space have the opportunity to build on the work of all stakeholders in this effort and to create increasingly more successful market solutions.

Appendix I

DoD REGULATION REVENUES 2017 REPORT

DoD Regulation Revenues

		T12	T12	TSS	TSS	TSS	TSS	TSS	TSS	TSS	TSS	TSS	TSS	TSS	TSS	TSS		TSS	TSS	TSS	TSS	TSS	TSS	TSS	
ChargeCode	Desc	2017-09	2017-08	2017-07	2017-06	2017-05	2017-04	2017-03	2017-02	2017-01	2016-12	2016-11	2016-10	2016-09	2016-08	2016-07	2016-06	2016-05	2016-04	2016-03	2016-02	2016-01	2015-12	2015-11	2015-10	Grand Total
721	Intermittent Resources Net Deviation Allocation	$0.00	$48.52	$0.00	($44.42)	($3.86)	$64.89	($50.94)	$30.90	($10.75)	$0.00		$0.00	($0.25)	$0.07	$0.16	$0.07	($0.01)	$0.11	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$34.49
752	Monthly Participating Intermittent Resources Export Energy Allocation	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00							$0.00
1592	EpPenaltyAllocationPayment									($13.13)																($13.13)
4515	Bid Segment Fee	$3.78	$3.67	$2.31	$1.62	$5.57	$6.51	$4.52	$4.11	$6.14	$5.86	$3.53	$5.80	$7.92	$9.96	$5.76	$7.17	$7.65	$5.10	$2.99	$1.56	$0.98	$0.21			$95.06
4560	BaDayMarketServices	$1.79	$1.75	$1.27	$0.92	$3.62	$4.42	$3.29	$1.87	$4.76	$2.26	$1.40	$3.63	$6.82	$7.14	$6.21	$7.68	$7.71	$4.83	$2.75	$1.23	$0.23	$0.14			$68.02
4561	BaDaySystemOperationsCharge	$5.11	$5.63	$5.83	$4.80	$6.37	$7.75	$8.22	$6.19	$5.71	$1.41	$1.10	$1.86	$1.79	$1.86	$1.56	$2.36	$2.20	$1.34	$1.58	$1.31	$1.19	$0.64	$0.17	$0.91	$74.67
4575	Gmc - Schedu ling Coordinator Identification Charge	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$23,000.00
6011	DavAheadEnerayConaestionLossSettlement	($56.31)	($61.72)	($44.23)	($31.47)	($70.27)	($73.80)	($39.59)	($56.86)	$49.92	$86.23	$107.55	$178.20	$80.54	$53.34	$121.37	$44.95	$70.22	$106.48	$31.88		($0.74)	($0.63)			$424.85
6460	FMM Energy Settlement	($8.31)	($9.18)	$0.08		($1.14)	$0.12	($0.27)	$1.34	$16.06	$1.34	($23.66)	($2.27)	($125.64)	($2.68)	($7.63)	$15.19	$7.80	$6.82	$1.87		$43.58	$28.38			($66.00)
6470	RealTimeInstructedImbalanceEnergySettlement	($116.52)	($157.28)	($154.40)	($43.08)	($76.21)	($244.20)	($103.62)	($70.39)	($131.21)	($174.14)	($123.77)	($265.56)	($169.77)	($210.46)	($213.72)	($386.66)	($186.54)	($135.02)	($11.21)		($23.26)	($99.39)			($2,909.86)
6475	RealTimeUninstructedImbalanceEnergySettlement	$538.29	$687.88	$626.54	$378.77	$489.46	$621.25	$411.39	$382.53	$241.67	($82.24)	($182.76)	($294.44)	($197.42)	($145.92)	($152.98)	($146.39)	($111.41)	($148.23)	($90.00)	($103.48)	($177.57)	($108.15)	($22.96)	($124.80)	$2,400.43
6486	RealTimeExcessCostForInstructedEnergyAllocation	$2.36	$11.38	$3.18	$3.56	$26.82	$0.00	$0.00	$0.62	$0.02				$0.20												$48.14
6500	DayAheadRegulationUpCapacitySettlement	($230.02)	($275.90)	($192.54)	($161.84)	($482.94)	($683.02)	($525.31)	($324.35)	($289.57)	($221.17)	($160.47)	($232.30)	($183.17)	($181.89)	($147.64)	($169.35)	($263.36)	($217.02)	($48.94)	$0.00	($1.18)	($1.36)			($4,730.18)
6524	Non Compliance Regulation Up Settlement	$46.80	$65.21	$23.65	$29.01	$273.85	$310.10	$98.43	$19.44	$18.68	$12.47	$22.40	$20.64	$12.29	$38.23	$25.87	$13.83	$0.34	$0.98	$0.28		$0.00	$0.00			$1,032.16
6570	RealTimeRegulationUpCapacitySettlement	($231.41)	($29.89)	($32.93)	($110.93)	($86.21)	($534.29)	($169.41)	($41.27)	($69.74)	($21.38)	($7.03)	($10.54)	($9.06)	($7.39)	($79.28)	($8.91)	($22.54)	($16.58)	($3.78)	$0.00	($6.53)	($2.71)			($1,479.26)
6594	RegulationUpObligationSettlement	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00			$0.00
6600	DayAheadRegulationDownCapacitySettlement									($64.95)	($51.14)	($26.63)	($40.61)	($43.95)	($46.71)	($30.57)	($45.07)	($105.67)	($40.43)	($23.56)	($13.25)	($0.94)	$0.00			($427.81)
6620	BidCostRecoverySettlement	($0.05)	($0.21)	($0.06)		($0.04)	($0.27)				($0.01)	($0.08)	($0.01)	($0.00)	($0.03)	($0.00)				($0.02)						($0.80)
6624	NonCompliance RegulationDownSettlement									$6.84	$4.82	$3.96	$6.69	$6.65	$23.52	$12.61	$10.05	$5.44	$3.01	$0.05	$0.00	$0.00				$78.19
6636	ffmBidCostRecovervTier1Allocation	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00						$0.00
6670	RealTimeReeulationDownCapacitvSettlement									($58.18)	($0.02)		($22.69)	($87.60)	($81.60)	($72.11)	($109.85)	($492.99)	($81.31)	($52.67)	($16.04)	$0.00	$0.00			($582.07)
6694	RegulationDownObligationSettlement									$0.00	$0.00		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00			$0.00
6800	DayAheadResidualUnitCommitmentAvailabilitySettlement	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00			$0.00
6824	NoPayResidualUnitCommitmentSettlement	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00			$0.00
7056	BaSettlementIntervalFlexRampCostAllocationAmount												$0.00	$0.05	$0.00	$0.00	$0.00	$0.00	$0.05	$0.00						$0.10
7057	Flex Ramp Supply Cost Allocation Reversal												($0.00)	($0.05)	($0.00)	($0.00)	($0.00)	($0.00)	($0.05)							($0.10)
7058	Flex Ramp Supply Cost Allocation												$0.00	$0.02	$0.01	$0.00	$0.00	$0.00	$0.02	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.06
7070	Flexible Ramp Forecasted Movement Settlement	$0.20	$0.46	$0.15	$0.06	($0.41)	$0.85	$0.60	$0.13	($0.88)	$0.01	$0.08														$1.24
7071	Flexible Ramp Up Uncertainty Capacity Settlement										$0.00															$0.00
7077	Daily Flexible Ramp Up Uncertainty Award Allocation	$5.80	$2.44	$3.10	$3.55	$10.12	$8.89	$15.46	$9.27	$8.65																$67.28
7078	Monthly Flexible Ramp Up Uncertainty Award Allocation	$3.20	$3.51	$2.95	$2.79	$7.54	$12.49	$8.00	($0.37)	($4.66)																$35.46
7087	Dailv Flexible Ramp Down Uncertaintv Award Allocation	$0.00			$0.00	$0.01	$0.00	$0.05	$0.03	$0.01		$0.00														$0.10
7088	Monthlv Flexible Ramp Down Uncertaintv Award Allocation	$0.00	$0.00		$0.02	($0.01)	$0.01	$0.01	($0.02)	$0.10	$0.07	$0.04														$0.22
7251	Regulation Up Mileage Settlement	($2.30)	($1.45)	($0.21)	($0.15)	($0.21)	($0.47)	($1.00)	($7.01)	($0.12)	($0.10)	($0.01)	($0.02)	($2.93)	($3.50)	($0.08)	($0.04)	$0.00	($0.00)			$0.00				($19.59)
7261	Regulation Down Mileage Settlement									($3.90)	($0.00)		($0.86)	($0.12)	($0.00)	($0.52)	($1.95)	($5.75)	($0.35)	($0.07)	($0.35)					($8.12)
7989	InvoiceDeviationInterestDistribution			($0.11)				($0.10)	($0.19)	($0.34)	($0.07)	($0.52)	($0.24)	($0.17)	($0.25)	($0.16)	($0.02)	($0.03)	($0.05)	($0.10)	($0.24)	($0.10)				($2.66)
7999	InvoiceDeviationInterestAllocation	$5.81	$1.04	$0.96	$1.83	$4.32	$3.64						$0.14			$0.13	$0.02	$0.06								$17.89
8526	InvoiceDeviationInterestAllocation									($0.00)																($0.00)
Grand Total		$968.23	$1,295.86	$1,245.55	$1,035.03	$1,106.38	$504.86	$659.72	$955.99	$711.13	$564.20	$615.12	$347.44	$295.96	$453.70	$468.98	$233.06	($86.89)	$489.71	$811.05	$870.74	$835.65	$817.13	$977.21	$876.10	$17,138.79

DoD Regulation Revenues

ChargeCode	Desc	T12 2017-09	T12 2017-08	T55 2017-07	T55 2017-06	T55 2017-05	T55 2017-04	T55 2017-03	T55 2017-02	T55 2017-01	T55 2016-12	T55 2016-11	T55 2016-10	T55 2016-09	T55 2016-08	T55 2016-07	T55 2016-06	T55 2016-05	T55 2016-04	T55 2016-03	T55 2016-02	T55 2016-01	T55 2015-12	T55 2015-11	T55 2015-10	Grand Total
Regulation Up Charge																										
6500	DayAheadRegulationUpCapacitySettlement	($230.02)	($275.90)	($192.54)	($161.84)	($482.94)	($683.02)	($525.31)	($324.35)	($289.57)	($221.17)	($160.47)	($232.30)	($183.37)	($181.89)	($147.64)	($169.35)	($263.36)	($217.02)	($48.94)	$0.00	($1.18)	($1.36)			($4,730.18)
6524	Non Compliance Regulation Up Settlement	$46.80	$65.21	$23.65	$29.01	$273.85	$310.10	$98.43	$19.44	$18.68	$12.47	$22.40	$20.64	$12.29	$38.23	$25.87	$13.83	$0.34	$0.98	$0.28		$0.00	$0.00			$1,032.16
6570	RealTimeRegulationUpCapacitySettlement	($231.41)	($29.89)	($32.93)	($110.93)	($86.21)	($534.29)	($169.41)	($41.27)	($69.74)	($21.38)	($7.03)	($10.54)	($9.06)	($7.39)	($79.28)	($8.91)	($22.54)	($16.58)	($3.78)	$0.00	($6.53)	($2.71)			($1,479.26)
7251	Regulation Up Mileage Settlement	($2.30)	($1.45)	($0.21)	($0.15)	($0.21)	($0.47)	($1.00)	($7.01)	($0.12)	($0.10)	($0.01)	($0.02)	($2.93)	($3.50)	($0.08)	($0.04)	$0.00	($0.00)			$0.00				($19.59)
	Regulation Up Total:	**($416.93)**	**($242.03)**	**($202.02)**	**($243.91)**	**($295.50)**	**($907.68)**	**($597.29)**	**($353.18)**	**($340.75)**	**($230.18)**	**($145.11)**	**($222.21)**	**($183.07)**	**($154.55)**	**($201.13)**	**($164.47)**	**($285.56)**	**($232.62)**	**($52.44)**	**$0.00**	**($7.71)**	**($4.07)**	**$0.00**	**$0.00**	**($5,196.87)**
Regulation Down Charge																										
6600	DayAheadRegulationDownCapacitySettlement									($64.95)	($51.14)	($26.63)	($40.61)	($43.95)	($46.71)	($30.57)	($45.07)	($105.67)	($40.43)	($23.56)	($13.25)	($0.94)	$0.00			($427.81)
6624	NonCompliance Regulation Down Settlement									$6.84	$4.82	$3.96	$6.69	$6.65	$23.52	$12.61	$10.05	$5.44	$3.01	$0.05	$0.00	$0.00				$78.19
6670	RealTimeRegulationDownCapacitySettlement									($58.18)	($0.02)		($22.69)	($87.60)	($81.60)	($72.11)	($109.85)	($492.99)	($81.31)	($52.67)	($16.04)	$0.00	$0.00			($582.07)
7261	Regulation Down Mileage Settlement									($3.90)	($0.00)		($0.86)	($0.12)	($0.00)	($0.52)	($1.95)	($5.75)	($0.35)	($0.07)	($0.35)					($8.12)
	Regulation Down Total:	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**($120.18)**	**($46.35)**	**($22.68)**	**($57.47)**	**($125.02)**	**($104.78)**	**($90.60)**	**($146.83)**	**($598.97)**	**($119.09)**	**($76.25)**	**($29.63)**	**($0.94)**	**$0.00**	**$0.00**	**$0.00**	**($939.80)**
Flexible Ramp Charge																										
7056	BaSettlementIntervalFlexRampCostAllocationAmount												$0.00	$0.05	$0.00	$0.00	$0.00	$0.00	$0.05	$0.00						$0.10
7057	Flex Ramp Supply Cost Allocation Reversal												($0.00)	($0.05)	($0.00)	($0.00)	($0.00)	($0.00)	($0.05)							($0.10)
7058	Flex Ramp Supply Cost Allocation												$0.00	$0.02	$0.01	$0.00	$0.00	$0.00	$0.02	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.06
7070	Flexible Ramp Forecasted Movement Settlement	$0.20	$0.46	$0.15	$0.06	($0.41)	$0.85	$0.60	$0.13	($0.88)	$0.01	$0.08														$1.24
7077	Daily Flexible Ramp Up Uncertainty Award Allocation	$5.80	$2.44	$3.10	$3.55	$10.12	$8.89	$15.46	$9.27	$8.65																$67.28
7078	Monthly Flexible Ramp Up Uncertainty Award Allocation	$3.20	$3.51	$2.95	$2.79	$7.54	$12.49	$8.00	($0.37)	($4.66)																$35.46
7087	Daily Flexible Ramp Down Uncertainty Award Allocation	$0.00			$0.00	$0.01	$0.00	$0.05	$0.03	$0.01		$0.00														$0.10
7088	Monthly Flexible Ramp Down Uncertainty Award Allocation	$0.00	$0.00		$0.02	($0.01)	$0.01	$0.01	($0.02)	$0.10	$0.07	$0.04														$0.22
	Flexible Ramp Total:	**$9.21**	**$6.40**	**$6.21**	**$6.42**	**$17.25**	**$22.24**	**$24.11**	**$9.04**	**$3.22**	**$0.08**	**$0.13**	**$0.00**	**$0.02**	**$0.01**	**$0.00**	**$0.00**	**$0.00**	**$0.02**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$104.35**
Grid Management Charge																										
4515	Bid Segment Fee	$3.78	$3.67	$2.31	$1.62	$5.57	$6.51	$4.52	$4.11	$6.14	$5.86	$3.53	$5.80	$7.92	$9.96	$5.76	$7.17	$7.65	$5.10	$2.99	$1.56	$0.98	$0.21			$95.06
4560	BaDayMarketServices	$1.79	$1.75	$1.27	$0.92	$3.62	$4.42	$3.29	$1.87	$4.76	$2.26	$1.40	$3.63	$6.82	$7.14	$6.21	$7.68	$7.71	$4.83	$2.75	$1.23	$0.23	$0.14			$68.02
4561	BaDaySystemOperationsCharge	$5.11	$5.63	$5.83	$4.80	$6.37	$7.75	$8.22	$6.19	$5.71	$1.41	$1.10	$1.86	$1.79	$1.86	$1.56	$2.36	$2.20	$1.34	$1.58	$1.31	$1.19	$0.64	$0.17	$0.91	$74.67
4575	Gmc - Schedulling Coordinator Identification Charge	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$23,000.00
	GMC Total:	**$1,010.68**	**$1,011.05**	**$1,009.41**	**$1,007.34**	**$1,015.55**	**$1,018.67**	**$1,016.03**	**$1,012.17**	**$1,016.60**	**$1,009.54**	**$1,006.03**	**$1,011.29**	**$1,016.53**	**$1,018.96**	**$1,013.53**	**$1,017.21**	**$1,017.56**	**$1,011.28**	**$1,007.32**	**$1,004.09**	**$1,002.40**	**$1,000.99**	**$1,000.17**	**$1,000.91**	**$23,237.76**
Energy Charge																										
6011	DayAheadEnergyCongestionLossSettlement	($56.31)	($61.72)	($44.23)	($31.47)	($70.27)	($73.80)	($39.59)	($56.86)	$49.92	$86.23	$107.55	$178.20	$80.54	$53.34	$121.37	$44.95	$70.22	$106.48	$31.88		($0.74)	($0.63)			$424.85
6460	FMM Energy Settlement	($8.31)	($9.18)	$0.08		($1.14)	$0.12	($0.27)	$1.34	$16.06	$1.34	($23.66)	($2.27)	($125.64)	($2.68)	($7.63)	$15.19	$7.80	$6.82	$1.87		$43.58	$28.38			($66.00)
6470	RealTimeInstructedImbalanceEnergySettlement	($116.52)	($157.28)	($154.40)	($43.08)	($76.21)	($244.20)	($103.62)	($70.39)	($131.21)	($174.14)	($123.77)	($265.56)	($169.77)	($210.46)	($213.72)	($386.66)	($186.54)	($135.02)	($11.21)		($23.26)	($99.39)			($2,909.86)
6475	RealTimeUninstructedImbalanceEnergySettlement	$538.29	$687.88	$626.54	$378.77	$489.46	$621.25	$411.39	$382.53	$241.67	($82.24)	($182.76)	($294.44)	($197.42)	($145.92)	($152.98)	($146.39)	($111.41)	($148.23)	($90.00)	($103.48)	($177.57)	($108.15)	($22.96)	($124.80)	$2,400.43
6486	RealTimeExcessCostForInstructedEnergyAllocation	$2.36	$11.38	$3.18	$3.56	$26.82	$0.00	$0.00	$0.62	$0.02				$0.20												$48.14
6620	BidCostRecoverySettlement	($0.05)	($0.21)	($0.06)		($0.04)	($0.27)				($0.01)	($0.08)	($0.01)	($0.00)	($0.03)	($0.00)				($0.02)						($0.80)
	Energy Total:	**$359.46**	**$470.87**	**$431.10**	**$307.77**	**$368.61**	**$303.09**	**$267.91**	**$257.25**	**$176.46**	**($168.81)**	**($222.72)**	**($384.07)**	**($412.08)**	**($305.75)**	**($252.96)**	**($472.92)**	**($219.93)**	**($169.94)**	**($67.48)**	**($103.48)**	**($158.00)**	**($179.78)**	**($22.96)**	**($124.80)**	**($103.24)**
Miscellaneous Charges																										
721	Intermittent Resources Net Deviation Allocation	$0.00	$48.52	$0.00	($44.42)	($3.86)	$64.89	($50.94)	$30.90	($10.75)	$0.00		$0.00	($0.25)	$0.07	$0.16	$0.07	($0.01)	$0.11	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$34.49
1592	EpPenaltyAllocationPayment									($13.13)																($13.13)
7989	InvoiceDeviationInterestDistribution			($0.11)					($0.10)	($0.19)	($0.34)	($0.07)	($0.52)	($0.24)	($0.17)	($0.25)	($0.16)	($0.02)	($0.03)	($0.05)	($0.10)	($0.24)	($0.10)				($2.66)
7999	InvoiceDeviationInterestAllocation	$5.81	$1.04	$0.96	$1.83	$4.32	$3.64						$0.14			$0.13	$0.02	$0.06								$17.89
	Miscellanous Total:	**$5.81**	**$49.56**	**$0.85**	**($42.59)**	**$0.46**	**$68.53**	**($51.04)**	**$30.71**	**($24.22)**	**($0.07)**	**($0.52)**	**($0.10)**	**($0.42)**	**($0.18)**	**$0.13**	**$0.07**	**$0.02**	**$0.06**	**($0.10)**	**($0.24)**	**($0.10)**	**$0.00**	**$0.00**	**$0.00**	**$36.59**
	Grand Total:	**$968.23**	**$1,295.86**	**$1,245.55**	**$1,035.03**	**$1,106.38**	**$504.86**	**$659.72**	**$955.99**	**$711.13**	**$564.20**	**$615.12**	**$347.44**	**$295.96**	**$453.70**	**$468.98**	**$233.06**	**($86.89)**	**$489.71**	**$811.05**	**$870.74**	**$835.65**	**$817.13**	**$977.21**	**$876.10**	**$17,138.79**