EPC-15-074: Meeting Customer and Supply-side Market Needs with Electrical and Thermal Storage, Solar, Energy Efficiency and Integrated Load Management Systems

Task 4: Metering and Telemetry Report with Test Plans

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Prepared for
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Prepared by
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I. Executive Summary

The purpose of this report is to provide an overview of metering and telemetry for two portfolios of distributed energy resource (DER) aggregations for *EPC-15-074: Meeting Customer and Supply-side Market Needs with Electrical and Thermal Storage, Solar, Energy Efficiency, and Load Management Systems ("STEEL")*. Building upon previous reporting for STEEL, each portfolio is evaluated for its ability to satisfy all integration requirements relevant to metering and telemetry, prior to market participation; both real and simulated.

Section 2 of this report details which market rules for metering and telemetry apply to each portfolio. Requirements for metering are based around a discussion on two types of metering configurations: whole premises and metering generator output (MGO) and their respective data flows. Also included is a dialogue on how meter data will be managed and exchanged between portfolio resources and *Olivine DER*.

For telemetry, an introduction on market timing requirements for polling data is presented along with an outline of the parameters for which frequency regulation simulations are to be conducted. A particular focus of this section examines how *Olivine DER* will interface with resources located at each portfolio for automated dispatch and control. Also included is a conversation around the applicability of the CAISO Expanded Metering and Telemetry Options (Phase 2) initiative for this demonstration project.

Section 3 details the cost of equipment that is specific to each portfolio with an emphasis on identifying potential cost gaps in order to fulfill California Independent System Operator (CAISO) rules for metering and telemetry. Section 4 presents the operational test plans for each portfolio; identifying the relevant data points that will be tested, a timeline for all test activities, and a description of the interactions between Olivine and Tesla and Conectric, respectively.

Operational test plans are segmented into two sets of activities: connectivity and service testing. The necessary elements for which these tests are to be evaluated include:

- Telemetry
- Meter Data Exchange
- Dispatch
- Control

Included in the connectivity section is the approach (methodology) that will be taken to test for each element listed above and an identification of the relevant data points for each. Service tests are discussed in a broader context where the above listed test elements are analyzed, based upon which specific market products are being tested for: day ahead and real-time energy, regulation up and down, and spinning reserves, respectively. Included are a series of tables and figures to aid in communicating how these tests are to be conducted.

II. Requirements

The following section discusses the relevant metering and telemetry requirements for wholesale market participation. Included is a discussion around metering configurations, round trip requirements for general telemetry and frequency regulation and how the *Olivine DER* platform will interface between the CAISO and resources located at each Portfolio.

Consistent with CAISO terminology, the term *metering* is focused specifically on interval metering for the purposes of performance calculations while the term *telemetry* focuses on the real-time exchange of data for operational visibility and, when applicable, automatic generation control (AGC). The concept of AGC can be described as the available capacity that can be controlled for the continuous balancing of generation resources and load on the transmission grid.

Section 2.1 Metering

Each Portfolio is set up to be a Scheduling Coordinator Metered Entity (SCME). As such, meter data is aggregated and submitted to the CAISO by Olivine, the wholesale Scheduling Coordinator (SC) for the project. The following section describes the market rules for metering data and configuration types applicable to the Connectric and Tesla portfolios. Metering types include both whole-premises metering and meter generator output (MGO).

Both portfolios' metering systems must meet CAISO certification requirements. General requirements include the ability of metering systems to provide instantaneous demand (kW) measurements, programmable for multiple intervals, store data for up to 60-days, and provide data measurements within a +/- 2% accuracy range.

2.1.1 Metering Configurations

Traditional retail demand response programs utilize whole-premises metering (typically the electric utility distribution company's (UDC) revenue/billing meter) to base performance of load curtailment during an event. A counterfactual framework is established based upon the difference between a historical baseline value and the actual usage during the event period. The whole-premises meter is typically the distribution company's revenue meter. This counterfactual approach is the default method for determining demand response settlement for resources enrolled in a CAISO Proxy Demand Response resource (PDR).

Alternatively, the CAISO Metering Generator Output (MGO) method calculates demand response performance by relying on a sub-meter that directly measures the contribution (energy delivered) by the registered generation device located behind the whole-premises revenue meter. A historical baseline is also used in this case, with slightly different rules. The following section describes the physical metering layouts for each Portfolio and the metering rules governing the respective configurations. Note that CAISO PDR expressly prohibits MGO from counting load, i.e., charging of a battery unit and also prohibits wholesale market payment for exported energy to the distribution grid. Three MGO metering configuration options are available to STEEL Portfolio 1 (the aggregation of Tesla Powerpacks at five Chino Hills School sites):

- Option B1 (load reduction only)
- Option B2 (generation offset only)
- Option B3 (load reduction and generation offset)

Below is an illustration of the MGO metering configuration for Portfolio 1, leveraging Option B2, as listed above. This configuration is applicable to all locations under the PDR aggregation in which each public school facility is registered into the CAISO Demand Response Registration System (DRRS).

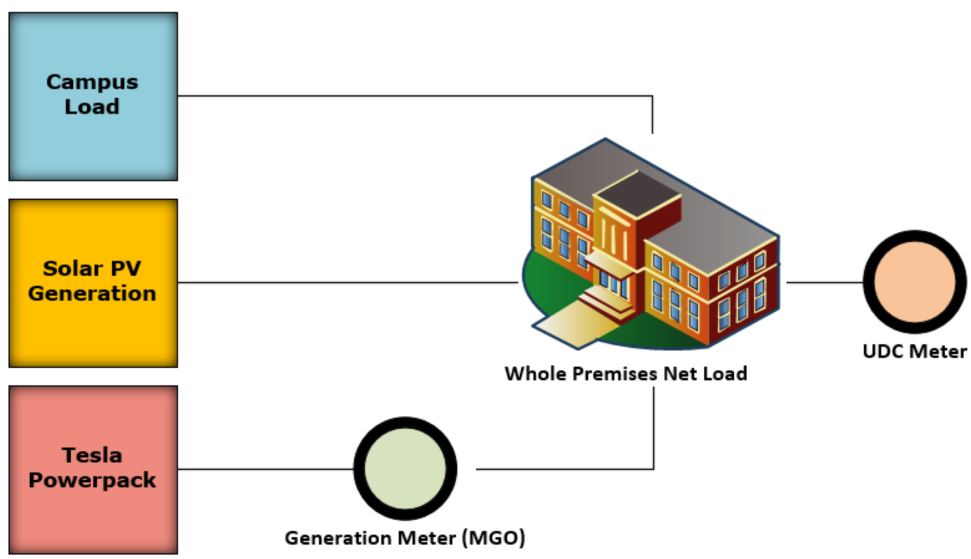

Figure 1: Portfolio 1 Metering Configuration

Under this configuration, the Tesla Powerpack storage device is sub-metered to determine the storage device's performance during a demand response event. A feature of this demonstration project will be to test the ability of MGO as a mechanism to ensure accurate compensation of behind-the-meter (BTM) storage for its contributions to a DR event dispatch.

MGO metering requirements for resources located at Portfolio 1 are as follows:

- Premises meter data intervals that indicate a net export of energy are deducted from the performance of the sub-metered resource.
- Sub Meter data must be set to zero (0) in any settlement interval that indicates the BTM storage device is in a "charging" state.

Portfolio 2 (the aggregation of Conectric, Inc. smart efficiency network of sensors at two hotels in San Diego) adopts the traditional, whole-premises metering configuration as shown in the diagram below.

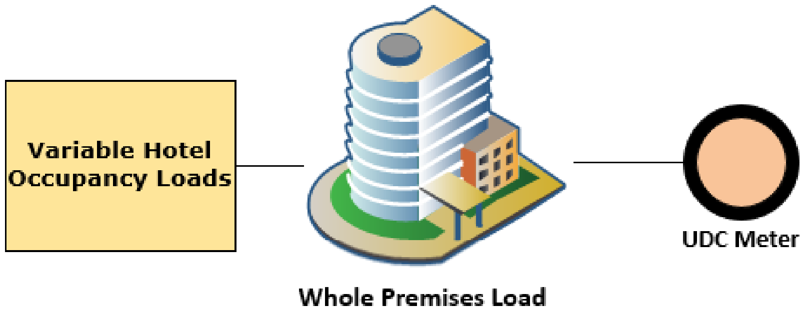

Figure 2: Portfolio 2 Metering Configuration

Under this configuration, Portfolio 2 will use the standard "10 in 10" commercial baseline (CBL) methodology. In this configuration, all end uses – whether they are controlled for demand response or not – are reflected in performance calculations for settlement purposes.

Note that there will be no need for special metering under Portfolio 2 since it will follow the normal SDG&E Rule 32 process with the customer premises meter data being provided by SDG&E directly to Olivine.

2.1.2 Meter Data Management and Exchange

There are two paths for managing the exchange of meter data. The first is utilized for both portfolios for the management of whole-premises metering data. The second is only relevant for the metering data required by MGO for Portfolio 1.

Meter data management activities are conducted by the Meter Data Management Agent (MDMA). The MDMA performs all functions related to the acquisition, storage, and validation, estimation, and editing (VEE) of raw metered data. VEE activities can include detecting faulty data, gaps in data, mismatches between device and host system, and even errors reported by the device itself. The primary objective of the MDMA is to generate Revenue Quality Meter Data (RQMD), which are data that have undergone a VEE process, in accordance with the rules of the local regulatory authority. The following section details all relevant meter data pathways and their applicability to the aforementioned metering configurations.

2.1.2.1 Utility Meter Data Collection

MDMA functions for the respective portfolios' whole-premises meter data are to be served by their local Utility Distribution Company (UDC)—Southern California Edison (SCE) for Portfolio 1 and San Diego Gas & Electric (SDG&E) for Portfolio 2.

Operating under SCE Electric Rule 24 and SDG&E Rule 32 (Rule 24/32), each UDC will receive a Customer Information Service Request (CISR) form granting them authority to share customer information, including meter data, with Olivine, the wholesale Demand Response Provider for the respective portfolios. In this capacity, the respective UDC will provide historical and ongoing interval meter data to Olivine, along with various customer location information, including:

- Customer information: Sub-Load Aggregation Point (Sub-LAP), Pricing Note (P-Node), Local Capacity Area (LCA), service voltage, and customer identifiers.
- Meter information, such as meter number, type of meter, and the intervals currently being collected.

Each UDC will perform VEE on whole premise metered data, making data available based on their own implementations in accordance with Rule 24/32. Upon retrieval, Olivine will import the data into its own meter data system for further processing.

2.1.2.2 Meter Data Management Under MGO

Participation under the MGO model will require Portfolio 1 to undergo an additional set of meter data management activities. Under this arrangement, SCE will continue to perform all MDMA functions for whole premises meter data, while Olivine and Tesla will follow a mutually agreed upon meter data exchange plan for the secure transfer of meter data between resources and *Olivine DER*. Olivine will work with Tesla to define appropriate algorithms to support VEE on these data.

For Portfolio 1, Tesla will construct raw data received from the site master controller into 5-minute intervals and post data to *Olivine DER*. Upon receiving metered data, Olivine will perform data monitoring and flag for any gaps or spikes in meter data. MGO is still a relatively new model for storage resources in the market and as such the creation of a meter data exchange plan plays a crucial role not only for this demonstration project but helps lay the foundation for future ones alike.

2.1.2.3 Submitting Meter Data to the CAISO

Olivine, as the SC for both portfolios, will manage all meter data submittals to the CAISO Demand Response System (DRS). Meter data is converted into Settlement Quality Meter Data (SQMD) following all rules and standards as set forth in the Demand Response System (DRS) Technical Interface Specification Process. The following figure is an illustration of meter data flow from resources to the CAISO DRS; using Portfolio 1 as an example.

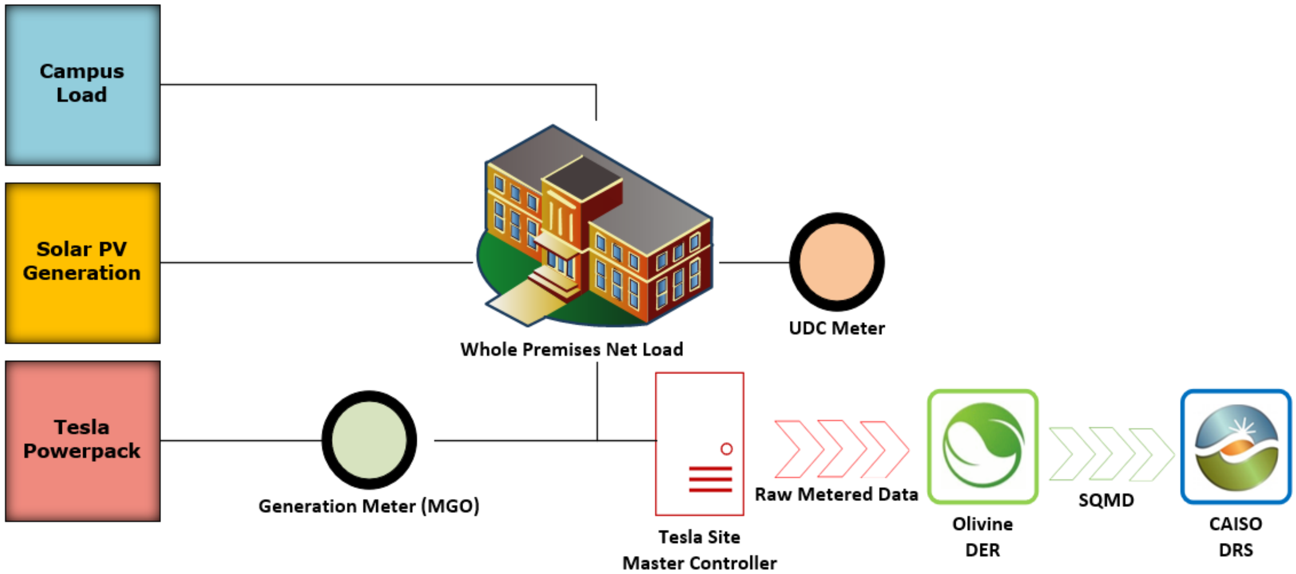

Figure 3: Meter Data Flow to CAISO-Portfolio 1

Rules for SQMD require that data is:

- Submitted for trade dates in which resources at each Portfolio have received an ISO award;
- Submitted at the resource level, representing an aggregation of data of all locations under the respective portfolios. Additionally, Olivine will apply UDC-supplied Distribution Loss Factors (DLF) prior to any data submission to the CAISO;
- Formatted into either 5 or 60-minute interval data and submitted to the CAISO DRS as generation (for MGO only).

Section 2.2 Telemetry

Participating generators and aggregated resources over 10 MW or resources providing ancillary services (A/S) are required to establish and maintain direct telemetry with the CAISO. This requirement is in place in order to provide real-time visibility to the CAISO for these resources. A/S telemetry consists of 4-second Automatic Generation Control (AGC) for regulation up and down service. The following section details telemetry requirements and communication protocols as they pertain to this demonstration project.

2.2.1 Timing Requirements

Telemetry requirements are dependent upon several factors, including resource specifications, capacity size (MW) and metering configuration, as well as the CAISO markets and participation model of the resource. Additionally, resources are expected to meet telemetry timing requirements for performance monitoring by the CAISO Energy Management System (EMS) for central grid operations and decision support.

The telemetry requirements differ for each portfolio. Portfolio 1 requires direct telemetry with the CAISO EMS in order to participate in the spinning reserve market. Both portfolios are to simulate frequency regulation services, requiring Portfolio 2 to integrate telemetry equipment as well. All activities – real and simulated – are to be conducted using the *Olivine DER* platform, utilizing a variety of web services (WS) and other protocols for all resource management activities including awards, dispatch, nominations, and direct telemetry for each portfolio. The table below summarizes the sizing, interval and frequency requirements as they pertain to the PDR model.

Market Product	Minimum size requirement for Telemetry	Minimum frequency and data measurement Interval	Data Quality
Energy	>= 10MW	5 minutes	+/- 2% of true value
Ancillary Services	Always required	Spinning Reserve: 4 seconds Non-Spinning Reserve: 1 minute	

Table 1: PDR Telemetry Options

Real-time visibility requirements for Portfolio 1 include 4-second polling of storage (generation) devices located at each public-school facility. The CAISO EMS will receive telemetered data from Portfolio 1 resources, using *Olivine DER* and the Olivine Remote Intelligent Gateway (RIG) as the principal delivery medium between the two.

At Portfolio 1, telemetry payload data points from each Tesla Powerpack storage device will be transmitted to the Tesla cloud. Data points include battery state of charge, gross and net load, and connectivity status. Olivine DER will securely poll these same data points from the Tesla cloud using the PAP 19 communication protocol, making data available to the Olivine RIG. For Portfolio 2, telemetry data is posted to *Olivine DER* using secure Representational State transfer (REST) web services. Telemetry payload data points from each whole Site Metering equipment will be transmitted to a secure Conectric cloud using a dedicated local Edge G3 Gateway connection through a VPN server.

All telemetry readings from the portfolios are conducted per-location. Considering the goal of simulating frequency regulation, all data will be provided at 4-second intervals. The diagram below presents an illustration of the telemetry environment for Portfolio 1.

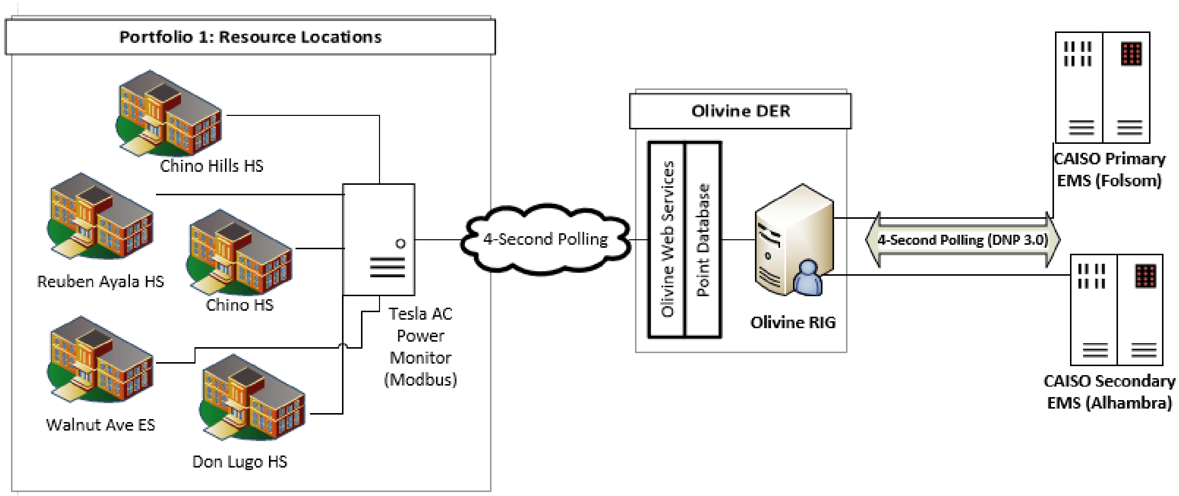

Figure 4: Portfolio 1 Telemetry Environment

All communication between the Olivine RIG and CAISO EMS follow secure DNP3 protocol with PKI encryption. Data points will be carried over a TCP/IP transport using SSL for mutual authentication. In sum, total round-trip polling will be limited to 8-seconds with no more than 4-seconds between the CAISO EMS and Olivine RIG and no more than 4-seconds between the RIG and Tesla Powerpack systems, respectively.

Operational requirements for RIG communications include the capability to provide analog and digital input values to the ISO and in the case of frequency regulation, analog output set point values from the CAISO for AGC.

2.2.2 Frequency Regulation for PDR

An area of interest for this demonstration project is the ability to simulate frequency regulation for non-exporting resources aggregated under the PDR model within a facility. Each portfolio will simulate regulation up and down services directly with *Olivine DER*.

Simulations are of CAISO functionality for telemetry and Automated Generation Control (AGC). Olivine will emulate CAISO AGC signals for all frequency regulation simulations at each portfolio. Telemetry and AGC signals will be transmitted in 4-second intervals; monitoring for maximum/minimum operating limits, the connectivity status of the resources, instantaneous state of charge (SOC), and resource AGC control status. Below in Figure 4 is an illustration of the telemetry environment for frequency regulation, using Portfolio 2 as an example.

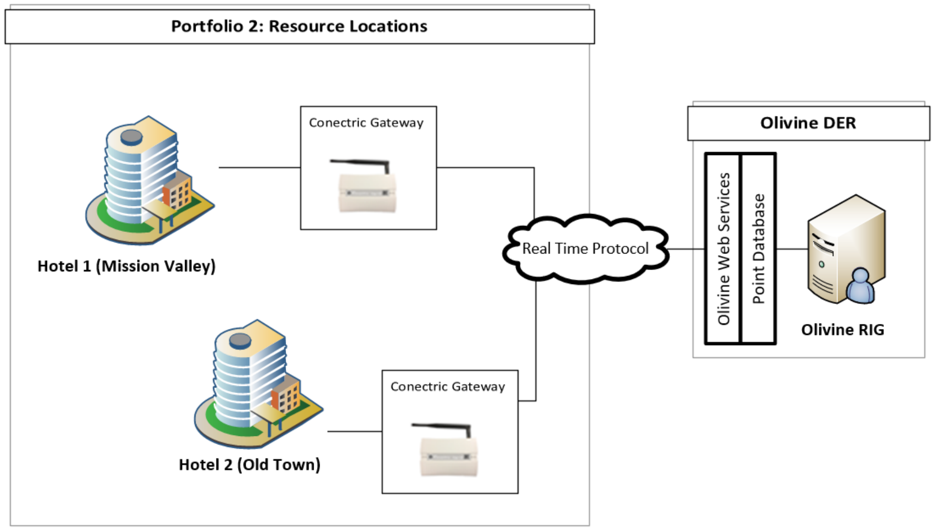

Figure 5: Portfolio 2 Telemetry Environment

A variety of protocols exist for communication between the *Olivine DER* Platform and resources located at each portfolio. For example, at Portfolio 1 AGC signals are to be transmitted every 4-seconds to each Portfolio resource from Olivine to Tesla Cloud, using Tesla API's. Portfolio 2 will use OpenADR payloads (Conectric poll of *Olivine DER* Web services) for the respective resource endpoints. Storage devices at Portfolio 1 will likely be modeled for their A/S certified quantities whereas Portfolio 2 will be modeled for its performance under frequency regulation events.

2.3 Expanded Metering and Telemetry Options

In 2016 the CAISO finalized phase two of it's expanded metering and telemetry options, introducing the CAISO Distributed Energy Resource Provider (DERP) initiative. The DERP initiative presented a new market participation opportunity for resources to aggregate and compete with other market resources on the grid. Participation requirements require resources aggregate under a Distributed Energy Resource Aggregation (DERA) and is currently open exclusively to Non-Generating Resource (NGR).

Considering this latter requirement and NGR's general incompatibility with BTM resources, DERP/DERA is not under consideration for this demonstration project. Additionally, the minimum capacity size (0.5MW) render this option incompatible with Portfolio 2. Lastly, all DERAs are required to undergo a New Resource Implementation (NRI) process, conflicting with the scope for Portfolio 2.

III. Cost of Equipment

Resources located at each portfolio are unique in terms of what their existing hardware and software capabilities can deliver to participate in the wholesale market. Metering infrastructure is evaluated for its readiness to participate in the market and incremental cost, e.g., to either retrofit an existing meter or replace the device altogether.

Resource owners may bear additional costs of installing or configuring metering or communications equipment, and connectivity charges, as well as software integration costs. Examples of such include purchasing a network interface card (NIC) or a radio frequency (RF) module for an existing meter or installing a new meter altogether.

Tables 2 and 3 detail all relevant costs of equipment respective to each Portfolio, including incremental cost gaps in order to fulfill CAISO requirements for metering and telemetry.

Equipment	Description
Metering / Telemetry	For the purposes of MGO and telemetry, Portfolio 1 will leverage existing metering infrastructure located at each school facility. Four public school facilities currently use Accuenergy ACCVim-IRR meter; quoted at $695, per unit. The Don Lugo High School location currently uses an SE-735 Power Quality meter with an estimated price tag of $1,500. The total cost for metering for Portfolio 1 is estimated at $4,280.
Network Interface	Portfolio 1 will utilize the existing communication infrastructure, carrying no additional incremental cost to either Tesla or Olivine.
Communication Protocols, Web Services, and Security	It is expected that Tesla systems can meet the latency and frequency requirements for participating in spinning reserves.

Table 2: Cost of Equipment for Portfolio 1

Equipment	Description
Telemetry Only	For the purposes of telemetry, Conectric will be required to provide alternative metering equipment to be installed at each hotel location to measure whole-premises load. Total metering equipment costs are estimated at $514-$664 for each location. Cost components include a UL-approved 3-phase EKM Omnimeter v.4 Smart Meter with ANSI C12.1 and C12.20 revenue certifications as well as CPUC revenue Type certification ($250-$400); necessary power supply ($18); fuses equipment ($41); wiring ($135); and enclosure kit ($70). Labor cost has yet to be determined but is anticipated to be in the range of $500, totaling roughly $1,528-$1,828 for alternative metering solutions at both Sites.
Network Interface	Conectric will either utilize a WiFi or LTE Network solution for the respective hotel sites. In the case of the former, total estimated costs are in the range of $250 for an advanced Conectric WiFi Edge G3 Gateway. The latter requires a LTE Edge G3 Gateway Modem (using T-Mobile carrier), estimated at $395, per site. Further tests between devices will reveal any potential upgrades necessary for frequency regulation simulations.
Communication Protocols, Web Services (WS), and Security	Conectric will leverage Olivine's existing communication protocols for telemetry; noting that issues in latency will not result in additional costs to either party as Portfolio 2 will be conducting frequency regulation market simulations only. The estimated cost is expected to be in the range of $150-$200 for software for Conectric's gateway. This includes device automation with Demand Conductor and Safety Store over a 3G/4G/LTE network.

Table 3: Cost of Equipment for Portfolio 2

IV. Operational Test Plans

The following section discusses operational metering and telemetry test plans for each portfolio, paying particular attention to connectivity and resource service test activities. Included in this discussion are the testing parameters for automated dispatch signals, which is a critical piece of service testing beyond the simplest day-ahead wholesale electricity market use case. Also included is a conversation on requirements for communication with *Olivine DER* and the applicability of the CAISO NRI process. Provided below is a table that details all tests that are to be conducted for both portfolios.

Connectivity Test	Service Test
Meter Data Exchange (MGO)	Day-Ahead Energy
Dispatch	Real-Time Energy
Telemetry	Spinning Reserve
Control (AGC)	Frequency Regulation

Table 4: Test Activites

The purpose of these tests is to demonstrate and verify the technical integration of resources located at each Portfolio to provide real time visibility to *Olivine DER* and responsiveness to control signals and dispatch instruction. Below is a timeline for when they are to take place. Note that each test is scheduled to precede real or simulated service delivery.

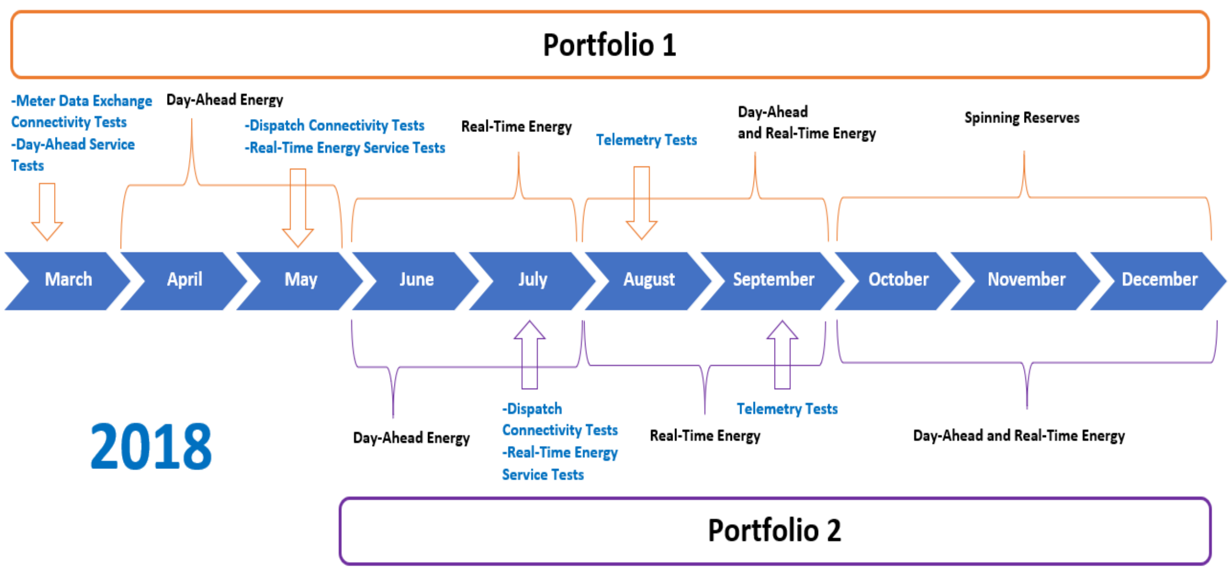

Figure 6: Testing Timeline (2018)

Testing for Frequency Regulation Services will take place in early 2019, as illustrated below.

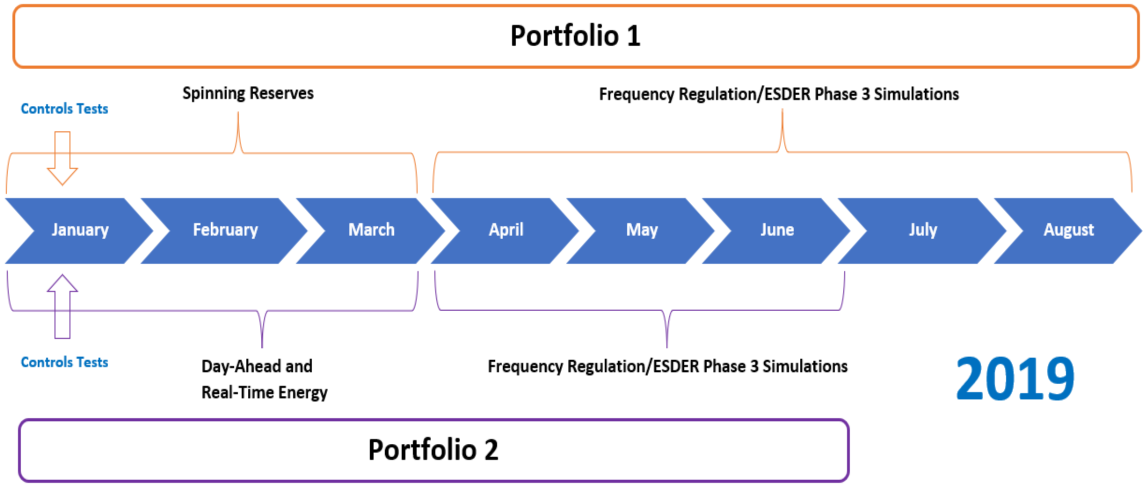

Figure 7: Testing Timeline (2019)

Test Logistics:
Olivine will administer all test activities in coordination with the respective project participants. This includes the scheduling and management of real-time connectivity and service tests. Tesla and Conectric are to provide integration and local resource expertise support.

In cases where there is a live exchange of data, Olivine will coordinate over a phone call with each participant and ask them to verbally identify the values of each data element. Olivine will confirm visibility of each element, tracking confirmation and any type of failure. Olivine will also document any latency detected between data points changing on the participants systems with visibility in *Olivine DER*. Any failures in this process will result in problem resolution followed by a retest.

In the MGO metering case where data exchange is less frequent and in bulk, the verification of data points will happen during a scheduled meeting after receipt of the data.

4.1 Connectivity Testing

Upon completion of all necessary integration activities, each portfolio is to undergo a series of connectivity tests in order to establish secure communication with *Olivine DER*. Data points will be compared between the source and destination systems, validating that all data points are available and indicate the correct values.

These point-to-point checks are to ensure that resource endpoints are properly aligned and payload data is as expected. Additionally, meter data and telemetry checks will validate the correct scaling of signals between *Olivine DER* and resources located at each Portfolio.

The parameters for connectivity tests are defined by the data points that will be exchanged along with the respective communication protocols. Connectivity tests at Portfolio 1 will encompass point-to-point checks of Tesla Powerpack storage devices located at each public-school facility. Tests at Portfolio 2 are to verify telemetry for each hotel site with *Olivine DER*, noting it is still to be determined whether each hotel will independently interface with *Olivine DER*.

The resource tests are intended to ensure that market integration is successful. Tests often uncover the following common occurrence problems:

- Endpoint and/or certificates not properly configured on either end.
- Errors in communication protocols.
- Misidentified values provided by the source system.
- Values provided with an incorrect scale or sign by the source system.

The below tables detail how point-to-point checks will be conducted at each portfolio; noting that on behalf of Portfolio 1, Olivine will also undertake the CAISO Spinning Reserves tests which is not covered in this document.

Meter Data Exchange (*Portfolio 1 Only*)

Objective:	Validate the correct submission of raw interval metered usage data to Olivine for the purposes of supporting the CAISO MGO model.
Data Points:	5-minute interval storage device discharge quantities by site in kWh (and zero for all charging quantities), keyed by agreed-to IDs.
Approach:	A time period will be determined over which meter data will be compiled for this test. The data will be compiled by Tesla and provided to Olivine through secure FTP. Olivine will confirm receipt of the data file and verify it for proper format and IDs. Olivine will examine the input for missing data, and unreasonable values.
Comments:	Test will be executed in accordance with the meter data exchange plan between Olivine and Tesla, following CAISO business rules and standards for MGO. Whole premises meter data is not subject to this test and is delivered through established integrations between Olivine and the relevant IOU.

Telemetry

Objective:	Validate operational data points of resources located at each portfolio.
Data Points:	• Maximum Operating Limit (kW) • Minimum Operating Limit (kW) • Instantaneous Output (kW) Portfolio 1 Only: • Maximum SOC (kWh) • Minimum SOC (kWh) • State of Charge (SOC) (kWh)
Approach:	Olivine will observe the exchange of telemetry values utilizing the chosen protocols and validate over the phone that received data matches the sources' expectation.
Comments:	A key feature of connectivity testing for telemetry is the ability to match received payload data with the appropriate underlying locations (i.e., schools and hotels).

Dispatch

Objective:	Validate that dispatch instructions are correctly transmitted and received for both day ahead and real-time energy tests.
Data Points:	• Resource ID • Date and Time of dispatch intervals • Dispatched Quantity (kWh)
Approach:	Olivine will initiate a test dispatch for both day-ahead and real-time energy, with the participant evaluating that deployment data is properly retrieved and formatted. Additionally, Olivine will observe and confirm with Tesla and Conectric that the portfolio systems have received the expected instruction.
Comments:	Note that this test will be performed before the real-time energy service delivery. Preceding this service, dispatch will be day-ahead only and managed through notifications outside of the Olivine APIs. Day ahead events are dispatched in hourly intervals whereas real-time energy events take place in 5-minute intervals.

Control (AGC)

Objective:	Validate AGC signals and related telemetry points are properly exchanged with resource endpoints.
Data Points:	• Resource AGC Control Status (On/Off) • Resource AGC Setpoints (kW) • Resource Ramp Rate (kW/min) • State of Charge (SoC) (kWh)
Approach:	Olivine will exchange AGC signals to resources located at each Portfolio and verify results with Tesla and Conectric over the phone.
Comments:	Regulation up and down simulations will operate around the establishment of AGC setpoints for resources located at each Portfolio.

4.2 Service Testing

Subsequent to each connectivity test, Olivine will run a service test to determine and evaluate portfolio resource performance. Additionally, service tests will create an added benefit of further validating connectivity between *Olivine DER* and resources located at each Portfolio.

Tests will utilize both meter data and telemetry readings, when available, to validate that resources are responding to dispatch and control while simultaneously testing the flexibility of data flow for both. Though not a primary focus of this report, service testing will also be leveraged in preparing Portfolio 1 for certification to provide spinning reserves in the ancillary services market.

4.2.1 Energy Service Tests

A key feature of testing for dispatch is to evaluate the performance of resources for both day-ahead and real-time energy service tests. Both sets of activities are detailed in the sections below.

4.2.1.1 Day-Ahead Energy

Under the day-ahead energy service tests, each portfolio is to receive an automated email notification at 1:00pm the day prior to demand response test event. Tests will evaluate portfolio resources for their ability to continuously deliver a dispatched energy quantity. This quantity will be based on a participant-declared capacity target for one hour in duration. In the case of Portfolio 1 this will involve the discharge of Tesla Powerpack storage devices whereas at Portfolio 2, each hotel will execute their own maximum load drop potential during the test. Additionally, this test for Portfolio 1 will also provide the added benefit in validating connectivity tests results for meter data exchange between Tesla and *Olivine DER*.

4.2.1.2 Real-Time Energy

With respect to real-time energy tests, both portfolios will receive a 2.5-minute notification prior to a demand response event, utilizing Olivine APIs for the transmittal of dispatch instructions. Each Portfolio will be evaluated for its ability to deliver energy based upon the same stated capacity and one-hour duration requirement used for day-ahead energy service tests.

4.2.2 Spinning Reserve Tests & Certification

Subsequent to the connectivity tests for telemetry, each portfolio will perform a service test modeled after the CAISO spinning reserves certification test. Note that even though Portfolio 2 will not be participating nor simulating spinning reserves, this test is a reasonable way to verify telemetry during a dispatch. The spinning reserve test evaluates a resource's ability to deliver a target capacity with 10 minutes of dispatch that must then be maintained for a full 30 minutes (known as the P_{Max} value at CAISO). In addition to these requirements, the resource providing spinning reserve must also meet the CAISO frequency response requirement of autonomic response to frequency dips within 8 seconds. Note that the latter requirement is verified by the CAISO after an under-frequency event but is not a part of any certification test nor this service test.

Olivine will serve as the test control operator for each portfolio, giving verbal dispatch instructions over the phone to a designated representative from Tesla and Conectric, respectively. Upon receiving instruction, the respective portfolios' will deploy their resources to their target capacity amount. At precisely 10 minutes after the start of the test, the resource output levels are measured by Olivine. The test will then continue for an additional 30 minutes during which time Olivine will log all telemetry readings. After the test is completed, Olivine will provide a simulated A/S certification value equal to the minimum of the 10-minute reading and the average of all readings during the next 30 minutes. The figure below provides an illustration of the service test for spinning reserve.

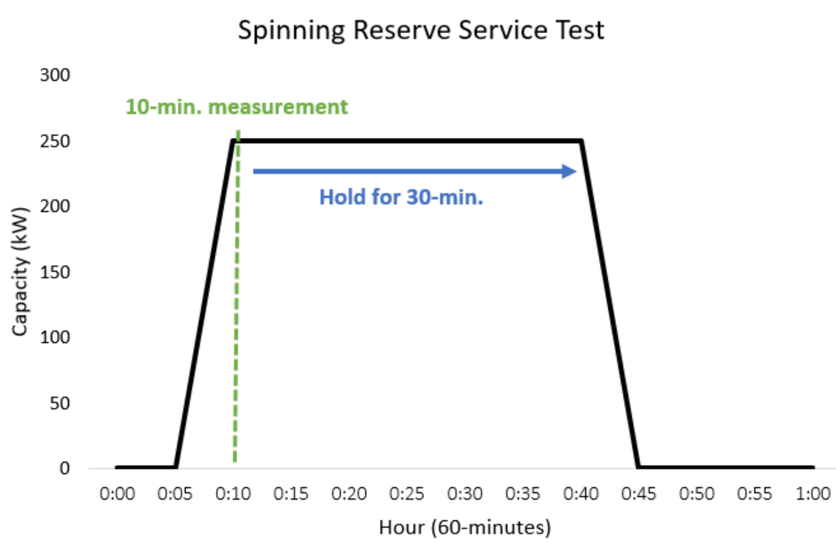

Figure 8: Spinning Reserve Service Test

All test and ramping data is to be recorded and monitored for accuracy with telemetry readings. Test-approved P_{Max} values represent the average of recorded levels during the 30-minute period. Additionally, spin service tests will prepare Portfolio 1 for eventual certification testing prior to ancillary market participation.

4.2.2.1 Spinning Reserves Certification at the CAISO

In accordance with CAISO NRI process rules and procedures, Portfolio 1 will undergo an additional set of activities in order to become certified for Spinning Reserves.

1. Olivine will establish connectivity between the *Olivine DER* Remote Intelligent Gateway (i.e., *Olivine RIG*) and the CAISO EMS. As this product is already validated with the CAISO, this will require a specific deployment of the RIG for this project, a RIG-specific certificate and database model, with a resource-specific connectivity and point to point test.
2. Olivine will request a spinning reserves certification test with the CAISO. This test will follow the same parameters as stated in the previous section.

4.2.3 Service Testing for Frequency Regulation Simulations

This test will evaluate the operating characteristics of Portfolio resources prior to conducting real-time simulations for frequency regulation. This includes an evaluation of resource responsiveness to 4-second AGC signals and performance for continuous delivery of regulation energy in a single direction for a fixed period of time that is specific to each Portfolio. Olivine will evaluate the accuracy of resource performance over the phone with Tesla and Conectric, respectively. Another key feature of these tests is the opportunity to validate telemetry readings under the same 4-second AGC signal.

Resources will be tested under similar parameters as the certification tests set forth by the CAISO for regulation energy management (REM) and non-regulation energy management (non-REM), respectively. Portfolio 1 will follow the REM model whereas Portfolio 2 will adopt the latter; non-REM.

Note that these service tests do not require that each portfolio follow a changing 4-second signal. Such an evaluation will be a part of the future frequency regulation simulations.

4.2.3.1 Regulation Energy Management (REM) (Portfolio 1)

Under REM, Portfolio 1 storage resources will be simulated as a CAISO Non-Generator Resource (NGR) and be tested for their full range from discharge to charge. The portfolio will be instructed to discharge for 15-minutes in duration then immediately proceed to charge for another 15-minutes. Olivine will assign a simulated certified value for both the maximum discharge and charge quantities based upon their average performance during the testing time period. The difference (range) in input and output defines the regulation region for Portfolio 1 storage devices. Below is an illustration of a Tesla Powerpack storage device performing the regulation energy management service test.

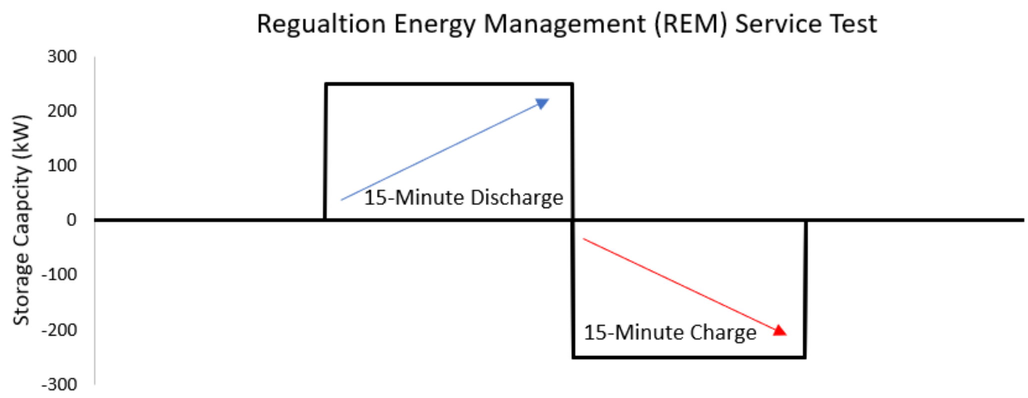

Figure 9: Regulation Energy Management (REM) Service Test

4.2.3.2 Non-Regulation Energy Management (Non-REM) (Portfolio 2)

Portfolio 2 resources will also be simulated and modeled after the CAISO NGR model as a non-REM resource. (This is because the REM option requires a storage asset.) This test will require each hotel site to curtail load for one hour in duration then immediately proceed to reverse the load curtailment for another hour. As in the case of REM, Portfolio 2 will receive a simulated certified value for the average performance in each direction, defining the regulation region for each hotel site. Challenges remain for how performance can be measured and verified in the absence of sub-metering at each hotel site.

V. Conclusion

This report provides an overview of market requirements for metering and telemetry for each portfolio of resources under the STEEL demonstration project. Operational test plans are designed to prepare the respective portfolios in meeting these requirements prior to market participation, both real and simulated. Lessons learned from this project may help identify cost-effective solutions for future metering and telemetry integration efforts undertaken by a resource owner or service provider. A key takeway from this report is the evaluation of a PDR to provide frequency regulation services to the grid. We also reiterate that stakeholder engagement is essential for the continued expansion of metering and telemetry options for customers seeking participation in CAISO wholesale markets.

Glossary of Terms and Acronyms

Term or Acronym	Definition
A/S	Ancillary Service
AGC	Automatic Generator Control
API	Application Program Interface
BTM	Behind-the-Meter
CAISO	California Independent System Operator
CBL	Commercial Baseline
CISR	Customer Service Information Request
DASMMD	Direct Access Standards for Metering and Meter Data
DER	Distributed Energy Resource
DERA	Distributed Energy Resource Aggregation
DERP	Distributed Energy Resource Provider
DLF	Distribution Loss Factors
DR	Demand Response
DRRS	Demand Response Registration System
DRS	Demand Response System
EMS	Energy Management System
LCA	Local Capacity Area
MDMA	Meter Data Management Agent
MGO	Metering Generator Output
MW	Megawatt
NGR	Non-Generating Resource
NIC	Network Interface Card
OpenADR	Open Automated Demand Response (data communication protocol)
P-Node	Pricing Node
PAP 19	Prioirty Action Plan 19 (data communication protocol)
PDR	Proxy Demand Resource
P_{Max}	A given resource's average capacity value over a specified time period as registered by ancillary service market products at the CAISO.
RDRR	Reliability Demand Response Resource
RF	Radio Frequency
RIG	Remote Intelligent Gateway
RQMD	Revenue Quality Meter Data
SC	Scheduling Coordinator

Term or Acronym	Definition
SCE	Southern California Edison
SCME	Scheduling Coordinator Metered Entity
SDG&E	San Diego Gas and Electric
SOC	State of Charge
SQMD	Settlement Quality Meter Data
STEEL	Meeting Customer and **S**upply-side Market Needs with Electrical and **T**hermal Storage, Solar, **E**nergy **E**fficiency, and **L**oad Management Systems (Internal project name for EPC-074)
Sub-LAP	Sub-Load Aggregation Point
TCP/IP	Transmission Control Protocol/Internet Protocol
UDC	Utility Distribution Company
VEE	Validation, Estimation and Editing
WS	Web Service

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