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C. Documents Submitted as Requested by Other Requirements

If the document submitted is in compliance with something other than a proceeding, (e.g. Resolution, Ruling, Staff Letter, Public Utilities Code, or sender's own motion), please explain: **This submission is required pursuant to Ordering Paragraph 2 of Resolution E-5260.**

D. Document Summary

In the attached pdf file, SDG&E presents its Operational Flexibility Pilot Report pursuant to Ordering Paragraph 2 of Resolution E-5260.

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F. Confidentiality

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Names of Commission staff that sender copies on the submittal of this Document: **Caitlin Pollock, Frank McElvain, Eric Martinot, and Cydnie Golson.**

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Consider Streamlining Interconnection of Distributed Energy Resources and Improvements to Rule 21.	Rulemaking 17-07-007 (Filed July 13, 2017)

OPERATIONAL FLEXIBILITY PILOT REPORT OF SAN DIEGO GAS & ELECTRIC COMPANY (U 902-E)

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Dated: September 9, 2024

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Consider Streamlining Interconnection of Distributed Energy Resources and Improvements to Rule 21.	Rulemaking 17-07-007 (Filed July 13, 2017)

OPERATIONAL FLEXIBILITY PILOT REPORT OF SAN DIEGO GAS & ELECTRIC COMPANY (U 902-E)

Pursuant to Ordering Paragraph 2 of Resolution E-5260, San Diego Gas & Electric Company (U 902-E) submits its Operational Flexibility Pilot Report.

Respectfully submitted,

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September 9, 2024

Operational Flexibility Pilot Report

San Diego Gas & Electric Company

September 9, 2024

Executive Summary

Pursuant to Ordering Paragraph (OP) 18 of Decision (D.) 21-06-002 issued on June 4, 2021, San Diego Gas & Electric Company (SDG&E) submitted a Tier 3 advice letter (AL) that proposed a pilot of Proposal F-1, which would determine whether a distributed energy resource (DER) operational alternative would be sufficient mitigation for operational flexibility constraints.[1] Resolution E-5260 approved the advice letters filed by the utilities[2] proposing Operational Flexibility (OpFlex) Pilots pursuant to D.21-06-002

Pursuant to Resolution E-5260, SDG&E provides this Operational Flexibility Pilot Report.[3] This report includes a description of SDG&E's OpFlex Pilot, the analysis undertaken by SDG&E, the conclusions SDG&E reached based on that analysis, and recommendations for the California Public Utilities Commission's (CPUC or Commission) consideration.

SDG&E's OpFlex Pilot was developed by leveraging an existing project, the Electric Program Investment Charge (EPIC) 3, Project 7. This third module of EPIC 3, Project 7 included operational flexibility demonstrations using the Institute of Electrical and Electronics Engineers (IEEE) 2030.5 communication protocol to communicate with the Mobile Battery Energy Storage System (MBESS), as well as deployment of the MBESS during planned outages, emergency events, and Public Safety Power Shutoffs (PSPS). The project approach included the following tasks:

- Integrate the IEEE 2030.5 standard with an existing SDG&E-owned MBESS.
- Demonstrate operational flexibility use cases identified by the CPUC's Energy Division, from the Smart Inverter Operationalization Working Group's (SIOWG) list of potential use cases for modern smart inverters.
- Demonstrate the consequence of several communication loss scenarios of the IEEE 2030.5 standard use with the MBESS.
- Select one site for use case demonstration by a MBESS integrated with the IEEE 2030.5 standard.
- Provide the test plan document before the demonstrations.
- Relocate and connect the MBESS electrically at the chosen site and demonstrate the use cases using the test plans created.
- Provide a test report after the demonstrations.
- Complete the final report document after completing all the demonstrations.

Overall, the project demonstrated methods for mitigating overload conditions, caused by DERs, using the IEEE 2030.5 communication protocol. SDG&E's testing had two goals; first, SDG&E tested the integration and interoperability of the selected 2030.5

[1] SDG&E Advice Letter 4017-E.
[2] Pacific Gas and Electric Company, San Diego Gas & Electric Company, and Southern California Edison Company.
[3] Ordering Paragraph 2 requires that each utility's report be submitted within 120 days of the completion of all OpFlex Pilots by that utility, or within 120 days of the effective date of this resolution, whichever is later, but in no circumstances later than February 28, 2025.

environment. This environment included a 2030.5 server, communications infrastructure, 2030.5 client communication gateway, and inverter components. Second, SDG&E examined the efficacy of the use cases themselves to validate that our objectives could be accomplished while simultaneously proving our chosen communications architecture.

This report shares the results of SDG&E's findings regarding the effectiveness of the use cases and insights regarding the application of the IEEE 2030.5 protocol. It is important to note that pilot hardware and software (communications, energy storage, grid interface, etc.) may have limitations that will need to be taken into account when analyzing the effectiveness of the use cases. In these cases, SDG&E documented where test limitations were encountered and possible mitigation steps for follow-on analysis. A discussion of key findings is presented below.

Key Findings

The demonstration at the Cameron Corners field site showcases the MBESS's utilization of the IEEE 2030.5 standard, highlighting successful use cases such as flexibility during grid reconfiguration, capacity increase, voltage boosting with fixed reactive power injection, and voltage reduction with Volt/Var curve mode. Additionally, various communication loss scenarios were tested at SDG&E's Integrated Testing Facility (ITF), including loss between the IEEE 2030.5 server and gateway, and between the gateway and MBESS local controller, occurring at different times. The results suggest that integrating the MBESS with the IEEE 2030.5 standard will facilitate further developments of SDG&E's Electric Rule 21 tariff and enable effective monitoring and control of both stationary and portable DERs in the field.

This project demonstrated that the IEEE 2030.5 standard can be integrated successfully with the MBESS. Through the IEEE 2030.5 standard integration, the MBESS can perform the following use cases:

- Flexibility during grid reconfiguration
- Power injection increase
- Voltage boosting with fixed reactive power injection.
- Voltage reduction with Volt/Var curve mode

The integration of the MBESS with the IEEE 2030.5 standard enhances scalability, visibility, operational flexibility, and power quality. The OpFlex Pilot project addresses bidirectional communication, studying various communication loss scenarios, and successfully provides solutions during disruptions. Additional use cases will be identified for implementation when SDG&E sources and integrates a Distributed Energy Resource Management System (DERMS) to optimize operations for the broader network.

Compliance with Resolution E-5260

Resolution E-5260 requires that each utility individually submit a comprehensive report on its respective pilot projects that provides analysis, conclusions, and recommendations about the projects, including but not limited to the following:

- What operational alternatives are a sufficient mitigant to OpFlex Constraints?
- What are the challenges and barriers to implementing operational alternatives?
- What interconnection rules are recommended to facilitate and/or support operational alternatives?
- What timelines are feasible for implementing the interconnection rules to facilitate and/or support operational alternatives?
- Analysis of the availability and or capability of equipment to implement OpFlex solutions.
- Analysis of the scalability of the OpFlex DER Operational Alternatives studied in the pilot.
- Commentary on the economic viability of the OpFlex DER operational alternatives studied in the pilot.
- Analysis of the pilots against the Joint IOU Pilot Metrics of Success given in Appendix B of the Resolution.
- Recommendations as to whether and how to scale the use of DER operational alternatives as a mitigation for operational flexibility constraints, including the constraints and timing of ADMS and DERMs development. [4]

Overall, this report addresses the items above. Targeted responses to these items are provided as follows:

- Operational alternatives for managing OpFlex Constraints include transferring (offloading) a circuit, or portion of a circuit, to another substation transformer or to adjacent circuit via a tie switch. This switching transfer allows SDG&E to continue providing service to the distribution customers on the switched circuit while allowing SDG&E to perform maintenance on the facilities causing the "constraint" or waiting for the condition to subside. However, depending on the configuration of the affected circuits, such switching may not be the desired approach or even possible (e.g., there may not be another geographically close circuit with the required tie capacity). At times, SDG&E may decide to utilize mobile generators to serve a portion of a circuit. In such circumstances it may be possible to use a MBESS to energize the circuit, or portion of circuit, that SDG&E would otherwise want to switch. To be a "sufficient mitigant," the MBESS would need to have the generating capacity and state of charge sufficient to supply the energized circuit for the desired duration of energization. SDG&E's pilot addressed the ability to use IEEE 2030.5-compliant communication to control the MBESS. Depending on the

[4] Resolution E-5260, Ordering Paragraph 2.

test case, the pilot demonstrated the ability to supply up to 25 kW, and between -2 and 60 kVar,[5] with durations of 16 to 55 minutes.[6]

- As noted in the previous bullet, a barrier to implementing a switching alternative may be that there is no back-tie capability. In these situations, MBESS may provide a functional alternative. However, depending on the need, MBESS may face the challenge of insufficient generating capacity and/or not having a state of charge sufficient for the desired duration of the circuit energization.

  As indicated in the previous bullet, SDG&E's pilot demonstrated the ability to use 2030.5 communication protocols to control a MBESS via signals to provide a scheduled level of real power output and a scheduled level of reactive power injection/consumption. The MBESS provided capacity and voltage support in sufficient magnitudes and durations indicated on Tables 5-1, 4-4, 4-5 and 4-6.

  It should be noted that MBESS used for mitigating an OpFlex Constraint would not normally operate on the basis of *scheduled* real power output or *scheduled* reactive power consumption/injection. Instead, control signals would be sent to the MBESS such that the MBESS would autonomously maintain frequency and voltage within a specified range for a designated period of time.

  Finally, a potential barrier to the expanded use of MBESS to mitigate OpFlex Constraints is the cost of acquiring, maintaining and deploying the storage devices and connection equipment. SDG&E's pilot addresses the use of the 2030.5 communication protocol to control the MBESS; it does not address overall cost-effectiveness.

- No interconnection rules are needed for utility-owned or controlled MBESS that are used to mitigate OpFlex Constraints. The utility is responsible for providing safe and reliable distribution service and utility-owned or controlled MBESS are one of the mechanisms by which SDG&E provides this service.

- As noted in the previous bullet, there would be no applicable interconnection timelines for utility-owned or controlled MBESS used only for mitigating OpFlex Constraints.

- As demonstrated by SDG&E's pilot, MBESS is available for and capable of mitigating OpFlex Constraints of the magnitudes and durations tested (see Tables 5-1, 4-4, 4-5 and 4-6).

- MBESS technology has the potential to be easily scalable in terms of the number of mobile devices. Section 7 describes how the use of the 2030.5 communication

[5] See Table 5-1.
[6] See Tables 4-4, 4-5 and 4-6.

protocol enhances this scalability. However, as the number of devices and deployment locations increase, necessary coordination with SDG&E's Electric Distribution Operations (EDO) organization becomes more challenging.[7] At some point, not assessed in this pilot, control through SDG&E's Network Management System (NMS) may be needed. Eventually—depending on overall distribution system management needs—control by an Advanced Distribution Management System (ADMS) or a Distributed Energy Resource Management System (DERMS) may be necessary.

While MBESS could be easily scaled, the threshold question of the need for such scaling must be answered. SDG&E's MBESS pilot was limited to testing the IEEE 2030.5 communication protocol. The pilot was not designed to, and did not, answer the question of need.

- Use of back-tie capability to switch circuits or portions of circuits to another circuit is highly cost-effective where the capability exists. Where such capability does not exist, or where use of such capability would not mitigate the specific OpFlex Constraint which occurs, mobile diesel generators may be a cost-effective alternative for maintaining distribution services. However, use of diesel generation is subject to strict environmental rules and there are noise and fueling challenges. In terms of capital costs, the MBESS is more costly but charging the devices from the grid significantly reduces adverse environmental impacts compared to the use of mobile diesel generators. The MBESS would also give the utility superior visibility, historical data and flexibility. Also, compared to mobile diesel generators, MBESS are quieter to operate.

  Table 4.3 provides a summary of all MBESS benefit areas, metrics, and outcomes identified and discussed in Modules 1 and 2 of this project. Section 6.2 sets forth cost elements that will be involved in commercializing the IEEE 2030.5 communication protocol. Assessing commercial viability of the MBESS solution is outside the scope of this pilot, given that commercial viability would depend on the costs of acquiring, maintaining and deploying MBESS compared to other alternatives for mitigating OpFlex Constraints, as well as the estimated magnitude of the need for such devices (which would require an assessment of how suitable the SDG&E distribution system is for the expanded use of MBESS to mitigate OpFlex Constraints). SDG&E is evaluating the cost benefit analysis of having MBESS, and Operational Flexibility use cases would only be a part of the suite of use cases for having MBESS.

- An "analysis of the pilots against the Joint IOU Pilot Metrics of Success" is provided in Appendix B of this report under the "Metrics for Measuring Success or Failure" heading.

[7] The pilot controlled the MBESS through SDG&E's Integrated Test Facility (ITF) in coordination with SDG&E's EDO organization.

In terms of recommendations for scaling MBESS for use as an alternative for mitigating OpFlex Constraints, SDG&E reemphasizes points made in the bullets above: MBESS is easily scalable in terms of the number of devices and use of the 2030.5 communication protocol supports this scalability (see section 7). However, as the number of simultaneous deployments increases, the ability to use SDG&E's ITF to control the devices becomes more challenging and may eventually require integration with NMS and ultimately with a ADMS or DERMS. Before scaling-up the use of MBESS, an assessment of the need for such devices should be undertaken.

Importantly, as emphasized in the previous bullet, scaling MBESS for purposes of managing OpFlex Constraints is dependent on commercial viability. Commercial viability was not the subject of this pilot and was not evaluated.

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List of Acronyms

Acronym	Acronym Description
ADMS	Advanced distribution management system
BESS	Battery energy storage system
BMS	Battery management system
BTM	Behind the meter
C&I	Commercial and industrial
CPUC	California Public Utilities Commission
CSIP	Common Smart Inverter Profile
DAC	Disadvantaged community
DER	Distributed energy resource
DERMS	Distributed energy resource management system
EPIC	Electric Program Investment Charge
GCM	Grid-connected mode
GHG	Greenhouse gas
HMI	Human-machine interface
IEEE	Institute of Electrical and Electronics Engineers
ITF	Integrated testing facility
LTE	Long-term evolution
MBESS	Mobile battery energy storage system
NFPA	National Fire Protection Association
PCC	Point of common coupling
PCS	Power conversion system
POI	Point of interconnection
SDG&E	San Diego Gas & Electric
SIOWG	Smart Inverter Operationalization Working Group
SLD	Single-line diagram
SOC	State of charge
USD	U.S. dollar
UV	Undervoltage

Acronym	Acronym Description
VPN	Virtual private network

1. Introduction

SDG&E's Electric Rule 21 tariff (Rule 21) is a generator interconnection standard that SDG&E administers within its distribution service territory. The standard describes the interconnection, operating, and metering requirements for generation assets to be connected to the utility's distribution system. It allows customers with generating or storage facilities to access the grid while protecting the safety and reliability of the distribution and transmission infrastructure [[1]].

Deploying Rule 21 compliant smart inverters consists of three chronological implementation phases:

- Phase 1: Autonomous inverter functions
- Phase 2: Communications requirements
- Phase 3: Advanced smart inverter functions

In Phase 1, smart inverters are configured with settings that conform to each utility's interconnection handbook. Once configured, they operate autonomously by adjusting their output to local conditions.

In Phase 2, Interconnection Customers interconnecting Generating Facilities with smart inverters are required demonstrate the capability to communicate using IEEE 2030.5 protocols and the Common Smart Inverter Profile (CSIP) so they can establish bidirectional communications between the utility and the smart inverter or aggregator. Rule 21 designates the IEEE 2030.5 standard (also known as Smart Energy Profile 2.0) as the default communications protocol. Although Phase 1 functions can operate autonomously, their parameters cannot be updated. Furthermore, most, if not all Phase 3 functions require communications. Hence, bidirectional communication allows functional and security updates to be issued to the smart inverters as required.

IEEE 2030.5 is a secure and scalable application-layer protocol built upon standard Internet protocols. The standard contains distributed energy resource (DER) object models based on IEC 61850, direct controls, autonomous curves, and status and meteorology information. Additionally, IEEE 2030.5 standard integration ensures that the utility has the necessary tools to maintain grid stability and reliability.

The CSIP guidelines create a common communication profile for inverter communications and together with the IEEE 2030.5 specification and interconnection handbook, provide the tools to implement Phase 2 requirements.

In Phase 3, several smart inverter functions are mandated to be enabled to permit the systems to play an active role in distribution system stabilization, power system reliability, and overall energy efficiency.

This project focused on demonstrating the IEEE 2030.5 operational flexibility use cases as identified by the California Public Utilities Commission's (CPUC) Smart Inverter Operationalization Working Group (SIOWG). The project successfully demonstrated the ability to monitor, control, and schedule mobile battery energy storage system (MBESS) events through the IEEE 2030.5 standard over a private Long-Term Evolution (LTE) network.

2. Project Objective

With the increasing penetration of DERs within SDG&E's service territory, monitoring and control of DER assets becomes a critical aspect of utility operations to mitigate any adverse impact of DERs on the distribution grid and leverage their benefits. Furthermore, Rule 21 has mandated IEEE 2030.5 as the default communications standard protocol for bidirectional communication between the utility and DERs or aggregators. This may eventually enable the utility to monitor and, as may be required by commercial contracts for distribution services, control DER assets through the use of a distributed energy resources management system (DERMS) platform that communicates directly with DER assets or with aggregators that manage DER assets.

SDG&E originally initiated EPIC 3 Project 7[8] to perform a pre-commercial demonstration of an MBESS as an emerging technology for evaluating its benefits and assessing its value proposition across SDG&E's territory for several use cases. Subsequently, SDG&E's EPIC-3, Project 7, Module 3 project objective was to further improve the value proposition of MBESS by remote monitoring and control of the unit through the IEEE 2030.5 communication protocol. Specifically, the project focused on demonstrating the operational flexibility provided to utility operators by monitoring and control of a DER asset through the IEEE 2030.5 communication protocol. MBESS, as an energy storage asset in the field, was used in conjunction with an IEEE 2030.5 master platform to perform operational flexibility use cases. The project demonstrates how the IEEE 2030.5 communication protocol can be leveraged for a mobile energy storage system or other DERs (which do not inherently support IEEE 2030.5 communication) to enhance monitoring and control of field assets, which in turn provides operational flexibility to the operators for better using the assets for grid support functions.

3. Project Focus

This project focuses on integrating the IEEE 2030.5 standard with the MBESS and demonstrating the MBESS' capability to perform several use cases using the IEEE 2030.5 standard as the core bidirectional communication standard between the utility and the MBESS. Before performing the use cases, the suitable MBESS with the IEEE 2030.5 standard utilization use cases were identified and include:

[8] https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%201%20Final%20Project%20Report.pdf and https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%202%20Final%20Project%20Report.pdf

1. Flexibility during grid reconfiguration event
2. Power Injection increase
3. Voltage boosting through reactive power increase.
4. Voltage reduction with local Volt/Var support

Two additional scenarios were identified and demonstrated regarding communication loss:

5. Loss of communication between the server and gateway
6. Loss of communication between the gateway and local MBESS controller

The communication loss use cases were evaluated during capacity[9] increase use cases. These demonstrations were done at two different locations, the Integrated Testing Facility (ITF) in Escondido and at Cameron Corners, Campo, CA.

These demonstrations were done with a single-phase 150 kVA rated MBESS integrated with the IEEE 2030.5 standard. The MBESS internal datalogger captured all essential data during system operation and demonstration to support more inclusive investigation and verification.

3.1 General Description of the MBESS

The selected MBESS for this demonstration is designed for frequent relocation and fast interconnection at a new site, using a standard generator terminal box with Cam-Lok plugs.

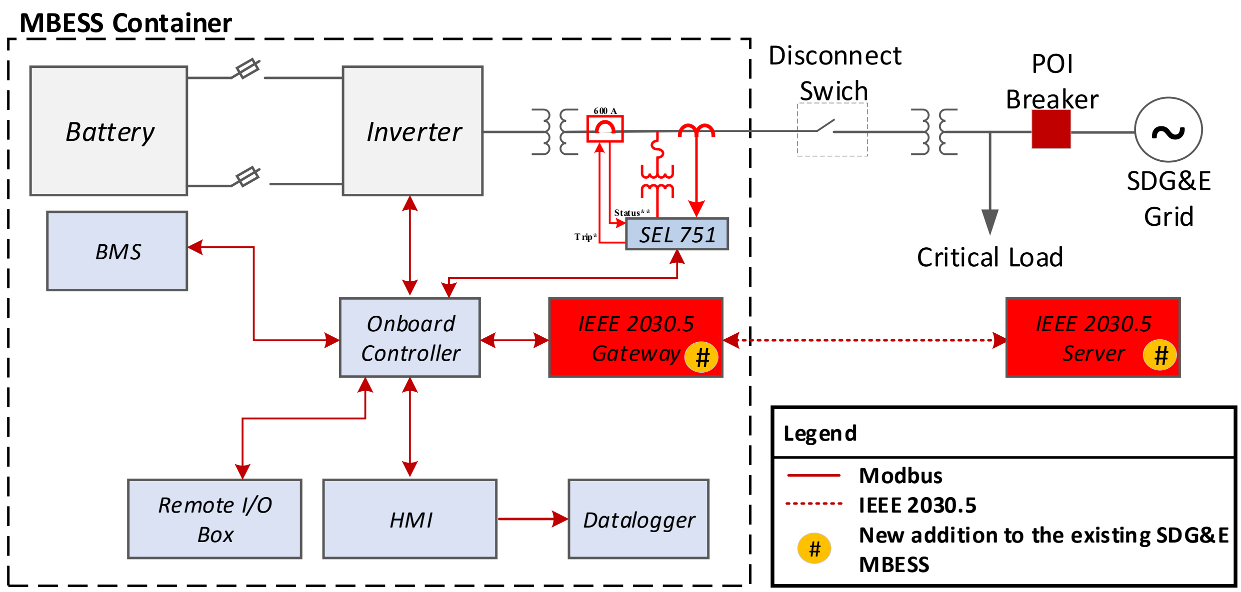
The MBESS is a clean alternative to emergency diesel generators since the storage devices are charged from the grid where the supplied power has a significantly lower emission profile. Using a fully mobile platform enhances the value proposition as it increases the usability of the energy storage system by introducing flexibility in capturing the locational benefits of grid support or customer-specific applications.

The MBESS unit selected for the EPIC project is a single-phase system. It includes an onboard 150 kVA isolation transformer to provide a customer-specific connection for 120/240 V split-phase (3 wires). Figure 0-1 illustrates a simplified schematic of the MBESS for this project. In this project, the existing SDG&E MBESS was upgraded to enable the IEEE 2030.5 communication with the unit by adding a protocol converter/gateway (IEEE 2030.5 to Modbus), as shown in Figure 0-1.

Figure 0-2 presents a picture of the MBESS trailer used for this demonstration. This MBESS is integrated with the IEEE 2030.5 standard (Figure 0-1). Specifically, the IEEE

[9] Power injection increase.

2030.5 server at the ITF sends the commands/schedules to the IEEE 2030.5 gateway located within the MBESS container. This IEEE 2030.5 gateway stores the commands/schedules and sends these commands/schedules to the MBESS local controller at the time of each event. In addition, the MBESS local controller shares the information from sensors/measurements with the IEEE 2030.5 server by using the IEEE 2030.5 gateway as a medium. This is a simplified description of IEEE 2030.5 standard integration with the MBESS.



1. *Figure 0-1. Simplified Schematic of MBESS*

Figure 0-2. MBESS Container Used in the Project (Pictured)

3.2 Control and Monitoring

A robust onboard monitoring and control platform is implemented in the MBESS, which has all the required software associated with the operation and monitoring of the unit. The MBESS general controls are described in the previous EPIC-3, Project 7, Module 2 Final Report. Figure 0-3 presents a sample picture of the home page of the human-machine interface (HMI) of the MBESS. MBESS has two control modes: local and remote. To enable the control of the MBESS through IEEE 2030.5, MBESS was set to remote control. More information regarding the remote-control mode and other features of the SDG&E MBESS can be found in the EPIC-3, Project 7, Module 2 Final Report.

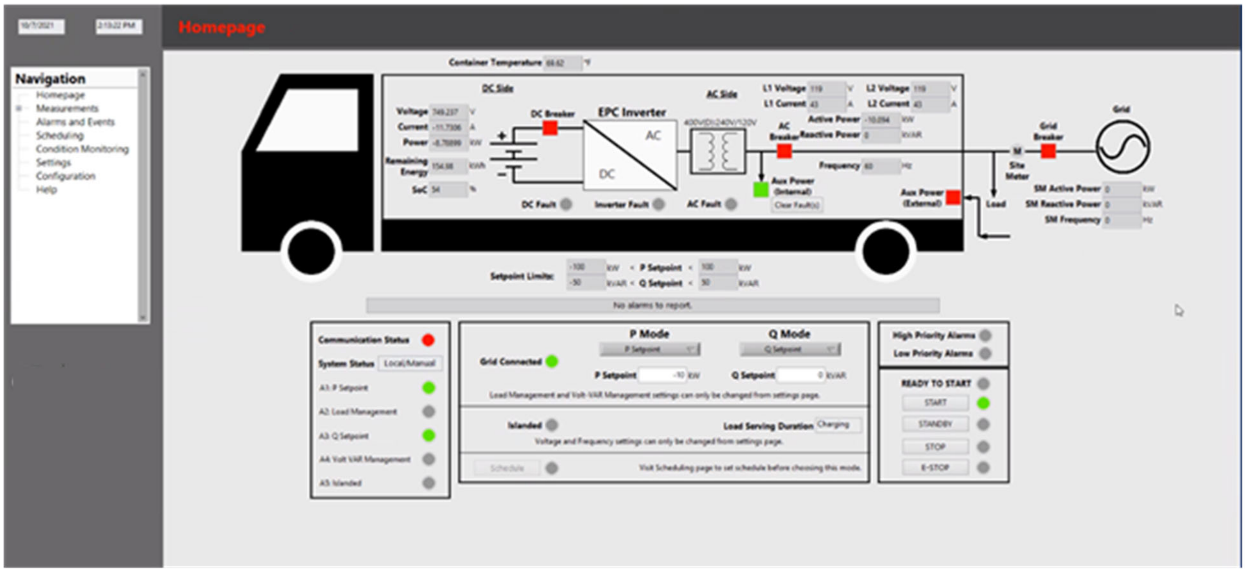


Figure 0-3. MBESS HMI Homepage

The MBESS is integrated into the IEEE 2030.5 server through a CSIP-compliant IEEE 2030.5 gateway. The gateway is responsible for the IEEE 2030.5 communications (server and resource discovery, security, acting on DER controls, and reporting DER data) and for converting IEEE 2030.5 communications to and from the Sunspec Modbus for communication with the MBESS local controller.

A CSIP-compliant IEEE 2030.5 server is used to send and schedule DER controls and monitor the relevant DER data from the MBESS. The server is configured by registering the DER end devices, setting up default DER controls and curve-based DER controls, and sending relevant DER controls as required for each use case.

4. Project Scope Summary

The scope of work focused on performing the first phase of the Operational Flexibility Pilot using the MBESS from EPIC 3, Project 7, Module 2 with the following goals:

- Demonstrate IEEE 2030.5 operational flexibility for DERs within SDG&E's territory, including:
  - Flexibility during grid reconfiguration
  - System output increase
  - Voltage boosting
  - Voltage reduction
- Demonstrate the consequences of communication loss between the IEEE 2030.5 server, gateway, and MBESS local controller.
- Demonstrate additional use cases for EPIC 3's mobile battery energy storage project.

Additionally, throughout this project, the types of DER control management, as defined by "IEEE 2030.5 Implementation Guide for Smart Inverters," were tested, including the following:

- **Immediate controls:** IEEE 2030.5 DER event to change a specific setpoint at a scheduled time for a specific duration. Examples of immediate controls used in this project include DERControl with OpModMaxLimitW, OpModFixedW, and OpModFixedVAR.
- **Default controls:** the controls that cannot be scheduled and have indefinite duration. These settings are not expected to change often. Examples of default-only controls used in this project include DefaultDERControl with OpModMaxLimitW, OpModFixedW, and OpModFixedVAR.
- **Curve control:** This is an IEEE 2030.5 DER event that can be scheduled, which uses a series of (x, y) points to define the behavior of a dependent variable (y) based on the value of an independent variable (x). A default curve may be used in the absence of other active events. This project demonstrated the OpModVoltVar curve control.

Table 0-1 lists the DER controls and modes used in this project with their descriptions.

Table 0-1. IEEE 2030.5 Standard Controls Used in the MBESS

Control/Mode	Abbreviation	Description
Limit Maximum Active Power Injection Control	OpModMaxLimitW	This command makes the MBESS have a specific active power limit.

Control/Mode	Abbreviation	Description
Active Power Injection Setpoint Control	OpModFixedW	This command sets a specific value for the active power injection from the MBESS.
Reactive Power Injection Setpoint Control	OpModFixedVar	This command sets a specific value for the reactive power injection from the MBESS.
Operation in Volt/Var Mode	OpModVoltVar	This command makes the MBESS set its reactive power based on a defined Volt/Var curve.
Default Controls Mode	DefaultDERControl	The operator sets this mode. This mode cannot be scheduled and has an indefinite duration.
Immediate Controls Mode	DERControl	The operator can schedule this mode for a specific time and duration.

4.1 High-level Overview

The project scope includes the major tasks listed in the following subsections.

4.1.1 Task 1: Define Use Cases and Requirements for Integration of IEEE 2030.5 into the Mobile Battery System

The use cases in this task focused on operational flexibility and grid support provided by MBESS through IEEE 2030.5 communication. Clarification between the differences of real-world implementation and the project demonstration is provided to understand the impact of IEEE 2030.5 adoption by the MBESS and the required utility infrastructure.

4.1.2 Task 2: Initial Benefits Analysis

In this task, an initial benefit analysis was performed to identify the benefit areas associated with enabling IEEE 2030.5 communication to MBESS and develop an estimation of the benefits and business case for the demonstration. The benefits were aligned with the identified use cases to assess the value of IEEE 2030.5 communication capabilities for DERs within SDG&E territory.

4.1.3 Task 3: Integrate the IEEE 2030.5 Standard with the MBESS and Testing at ITF

This task was dedicated to adding IEEE 2030.5 communication capabilities to the SDG&E MBESS. To do so, a local IEEE 2030.5 gateway was installed inside the MBESS container and was integrated into the existing MBESS controller. Upon successfully integrating the IEEE 2030.5 gateway to the MBESS controller, the team demonstrated all the desired operational flexibility use cases (identified in Task 1) and tested communication failure scenarios at the ITF. This allowed the team to validate the unit's operation before taking the MBESS to the field.

4.1.4 Task 4: Relocation and Transportation Services

In this task, the project team supported the de-energization and relocation of the MBESS between different sites. This project's demonstration site was Cameron Corners, Campo, CA.

4.1.5 Task 5: Develop a Test Plan for Execution of the Field Demonstration

The team created a detailed test plan to follow for demonstration of the selected use cases at Cameron Corners. This test plan was reviewed and finalized before transporting the MBESS to the field.

4.1.6 Task 6: Perform the Demonstration

Once the unit was successfully energized at Cameron Corners (outcome of Task 4), the test plan developed in Task 5 was used to execute the use cases.

4.1.7 Task 7: Perform Data Analysis

Upon completing the demonstrations, the team focused on organizing and analyzing the data collected. The data analysis was done based on collected test results from various devices and data sources within the system.

4.1.8 Task 8: Revised Cost/Benefits Analysis Based upon Demonstration Results

Using the analyzed data from the site, the team updated the original benefit estimates and created a cost estimate for commercial use of the IEEE 2030.5 standard on DERs within the SDG&E territory.

4.1.9 Task 9: Prepare Findings and Comprehensive Final Report

Using the results from Tasks 7 and 8, the team prepared the project findings, including conclusions, the value proposition for commercial adoption of the demonstrated solution, recommendations on whether to pursue commercial adoption and requirements for pursuing commercial adoption. These findings and more are documented in the comprehensive EPIC 3, Project 7, Module 3 Final Report.

4.1.10 Task 10: Project Management

Throughout the project, a dedicated technical project manager oversaw the project's execution.

5. Project Approach

Various benefits are associated with using the MBESS integrated with the IEEE 2030.5 standard. This section will demonstrate how the IEEE 2030.5 standard was integrated with the existing SDG&E MBESS, the use cases that were demonstrated and their benefits, and the loss of communication scenarios that were investigated while using the IEEE 2030.5 standard.

1. Figure 0-1 provides a conceptual depiction of IEEE 2030.5 standard integration with the MBESS. A CSIP-compliant IEEE 2030.5 gateway was installed inside the MBESS container to accommodate remote control and monitoring of the MBESS from the IEEE 2030.5 server. The IEEE 2030.5 gateway maintains IEEE 2030.5 communications, including security, server and resource discovery, registration, DER controls, and DER data reporting. For monitoring and control, the IEEE 2030.5 data model is converted to Sunspec Modbus for communication with the MBESS local controller. During this project, the IEEE 2030.5 server was located at the ITF and communicated to the IEEE 2030.5 gateway through SDG&E's private LTE network for site testing and the field demonstration at Cameron Corners.

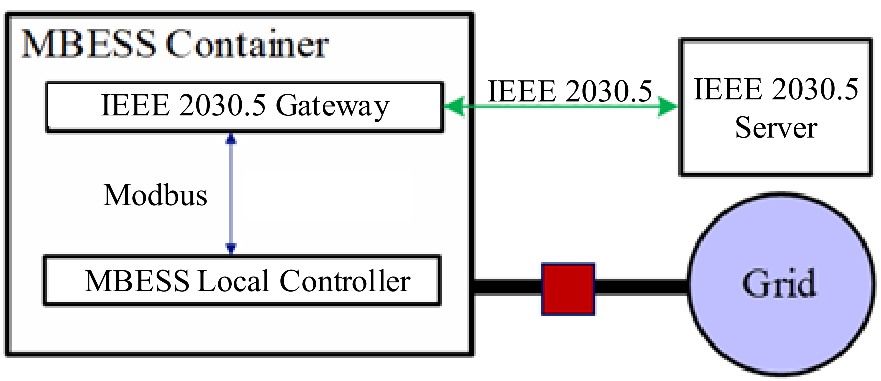


Figure 0-1. IEEE 2030.5 Standard Integration with MBESS (the red box represents the switch between the SDG&E grid and the electrical equipment and battery within the MBESS Container)

All DER controls are entered by the operator on the IEEE 2030.5 server and communicated to the IEEE 2030.5 gateway. The IEEE 2030.5 gateway receives the DER controls, maintains the schedule of active DER controls, and responds to the IEEE 2030.5 server as required by CSIP (e.g., event received, event superseded, etc.). At the time of an event onset, the gateway will set the corresponding command for reverting the unit to the default setting on Sunspec Modbus and send it to the MBESS local controller. Alternatively, the MBESS local controller is responsible for communicating the relevant settings, ratings, and measurements to the gateway using Sunspec

Modbus. The gateway sends the relevant alarms, Mirror Meter Readings (MMR), device capability, DER status, and DER settings to the IEEE 2030.5 server.

Figure 0-2 depicts the installation of the gateway box with the SDG&E modem on the MBESS interior container wall. An eight-pin RJ45 cable is connecting the gateway and the MBESS controller (see Figure 0-2). In addition, Figure 0-3 (a) shows a picture of the IEEE 2030.5 server located at ITF, and Figure 0-3 (b) shows the Modbus gateway connection to the MBESS local controller.

Figure 0-2. Gateway Installation for MBESS Integration with IEEE 2030.5 Standard

(a) *(b)*

Figure 0-3. IEEE 2030.5 Standard Integration with the MBESS: (a) IEEE 2030.5 Standard Server, and (b) Modbus Gateway Connection to MBESS Local Controller

5.1 Use Cases

This project focused on demonstrating the control and monitoring of the equipment at the grid edge using IEEE 2030.5 standard as the main bidirectional communication. The IEEE 2030.5 server used in this project will execute each command specified by the operator but does not host any additional logic. As a result, the implementation of some of the use cases in this project was different from the implementation where a DERMS is present and hosts the required logic. In commercial operation, the DERMS or similar platforms will be integrated into the IEEE 2030.5 server through the Application Programming Interface (API) and execute various optimization functions.

This following section describes each use case and its implementation.

5.1.1 Use Case 1: Flexibility During Grid Reconfiguration

Definition

During abnormal grid conditions which can arise as the result of maintenance requirements or unplanned grid outages, it may be necessary to reconfigure the distribution system which, in turn, may require an Interconnection Customer to reduce or curtail the output of its Generating Facility. In this abnormal grid condition, the connected DER may need to curtail its active power output for the duration of this reconfiguration event, which is the focus of this use case.

Implementation

During a scheduled event in response to a maintenance or planned outage, the portion of the circuit to which the DER is interconnected will be connected to another circuit. In such a case, the IEEE 2030.5 server has the ability to create a scheduled event to adjust the maximum DER outputs for a defined period of time based on the new circuit's capacity and projected circuit loading.[10] Notably, in implementations where the server is integrated into DERMS, the operator will not need to re-enter the schedule on the server. The DERs will receive this event through the IEEE 2030.5 gateway and the DER's active power output at the time of the event will be curtailed.

To demonstrate this use case, the IEEE 2030.5 server, IEEE 2030.5 gateway, and MBESS local controller each need to play a key role, as outlined below:

- IEEE 2030.5 server:
  - Provide the ability for the operator to create a new event to limit the power output of the unit (OpModMaxLimitW)
  - Successfully connect and disconnect the MBESS (opModConnect)
  - Send the scheduled event to MBESS.
  - Monitor the MBESS
- IEEE 2030.5 gateway:
  - Receive the DefaultDERControl and DERControl Event from the IEEE 2030.5 server and stores the relevant data to send to the MBESS local controller at the time of the event.
  - Respond to the IEEE 2030.5 server for DERControls (e.g., acknowledgment of event received).

[10] For purposes of this pilot, SDG&E tested the ability to submit a single schedule to the MBESS but did not specifically schedule the MBESS in response to an actual change in the circuit's capacity or projection of the circuit's loading.

  - Resolve DERControl conflicts through prioritization.
  - Share the relevant scheduled system limits (at the time of the event) with the MBESS local controller.
  - Re-sets the default setpoints to MBESS upon completion of the event.
  - Sends monitoring data from MBESS to the IEEE 2030.5 server.
- MBESS local controller
  - Curtail the active power of the MBESS based on the setpoint received from the gateway, as needed.

5.1.2 Use Case 2: Power Injection Increase

Definition

A customer agrees to modify their active power injection in response to a communication-based request received through the IEEE 2030.5 standard. These requests can be active power injection increases for the DER to a certain level or by allowing their DER to follow a specific predefined pattern provided by a dispatch signal.

Implementation

Upon identifying the need for a DER to inject additional real power into a circuit in order to maintain circuit power flows within available circuity capacity (a "System Output increase" on the feeder), the IEEE 2030.5 server will send the information regarding the capacity increase event to the MBESS. In this project, the IEEE 2030.5 server was only communicating with one DER. As a result, there was no need to identify capacity increase allocation per DER. In an application where the server is communicating with more than one DER, it can accept group controls from the operator or through DERMS and send them to individual end devices. The server does not host any logic to calculate the required capacity increase per device to achieve a required total increased capacity.

To demonstrate this use case, the IEEE 2030.5 server, IEEE 2030.5 gateway, and MBESS local controller each played a key role, as outlined below:

- IEEE 2030.5 server
  - Provided the ability for the operator to create multiple new events to increase the power output of the unit (opModFixedW)
  - Successfully connected and disconnected the MBESS (opModConnect)
  - Sent the scheduled events to MBESS
  - Monitored the MBESS.
- IEEE 2030.5 gateway:
  - Receive the DefaultDERControl and DERControl Event from the IEEE 2030.5 server and stored the relevant data to send to the MBESS local controller at the time of the event

  - Respond to the IEEE 2030.5 server for DERControls (e.g., acknowledgment of event received)
  - Resolve DERControl conflicts through prioritization
  - Share the new active power setpoint (at the time of the event) with the MBESS local controller
  - Re-sets the default setpoints to MBESS upon completion of the event
  - Send monitoring data from MBESS to the IEEE 2030.5 server
- MBESS local controller
  - Adjust the active power of the output of MBESS based on the setpoint received from the gateway.

5.1.3 Use Case 3: Voltage Boosting

Definition

This use case focuses on increasing the voltage along a feeder to address undervoltage issues by injecting reactive power.

Implementation

During an undervoltage (UV) event, the measured voltage at pre-specified metering points is sent to DERMS. DERMS hosts the logic to calculate the reactive power injection required from each DER to address this UV event and send the required setpoints to the IEEE 2030.5 server. The server then shares the setpoint with each DER under its control.

In this project, however, due to the lack of availability of DERMS, instead of calculating the required reactive power based on the measured voltage, the team validated the functionality of the IEEE 2030.5 server, IEEE 2030.5 gateway, and MBESS local controller by manually creating control events to inject a specific reactive power at the output of the MBESS. These events were sent to the IEEE 2030.5 gateway and, in turn, shared with the MBESS local controller at the time of the event to increase the reactive power generation based on the requested setpoint by the IEEE 2030.5 server.

To demonstrate this use case, the IEEE 2030.5 server, gateway, and MBESS local controller each played a key role, as outlined below:

- IEEE 2030.5 server
  - Provide the ability for the operator to create multiple new events to adjust the injected reactive power at the output of the unit (opModFixedVAR)
  - Successfully connect and disconnect the MBESS (opModConnect)
  - Send the scheduled events to MBESS
  - Monitor the MBESS
- IEEE 2030.5 gateway:

  - Receive the DefaultDERControl and DERControl Event from the IEEE 2030.5 server and stores the relevant data to send to the MBESS local controller at the time of the event
  - Respond to the IEEE 2030.5 server for DERControls (e.g., acknowledgment of event received)
  - Resolve DERControl conflicts through prioritization
  - Share the new reactive power setpoint (at the time of the event) with the MBESS local controller
  - Re-sets the default setpoints to MBESS upon completion of the event
  - Send monitoring data from MBESS to the IEEE 2030.5 server
- MBESS local controller
  - Adjust the reactive power of the output of MBESS based on the setpoint received from the IEEE 2030.5 gateway

5.1.4 Use Case 4: Voltage Reduction (Volt/Var)

Definition

This use case focused on using Volt/Var and Volt/Watt curve controls to address the overvoltage issues along the feeder. Note that the MBESS unit under test in this project does not support the Volt/Watt function, and as a result, only Volt/Var was tested in the field.

Implementation

Volt/Watt and/or Volt/Var curve characteristics for each resource are set through the 2030.5 server. The overall control can be implemented as default or scheduled for a specific duration. Upon enabling the curve control, DERs are responsible for following the curve based on the measured voltage.

To demonstrate this use case, the IEEE 2030.5 server, IEEE 2030.5 gateway, and MBESS local controller each played a key role, as outlined below:

- IEEE 2030.5 server:
  - Provide the ability for the operator to define the curve criteria and schedule events for curve control.
  - Successfully connect and disconnect the MBESS (opModConnect).
  - Send the scheduled events to MBESS.
  - Monitor the MBESS.
- IEEE 2030.5 gateway:
  - Receive the DefaultDERControl and DERControl Event from the IEEE 2030.5 server and stores the relevant data to send to the MBESS local controller at the time of the event
  - Respond to the IEEE 2030.5 server for DERControls (e.g., acknowledgment of event received)

  - Resolve DERControl conflicts through prioritization
  - Share the new reactive power setpoint (at the time of the event) with the MBESS local controller
  - Re-sets the default setpoints to MBESS upon completion of the event
  - Send monitoring data from MBESS to the IEEE 2030.5 server
- MBESS local controller
  - Implement the curve characteristics based on the setpoints from the IEEE 2030.5 gateway.
  - During the volt/var event, adjust the reactive power at the output of MBESS following the voltage measurements

5.2 Communication Loss Scenarios

Communication loss between the IEEE 2030.5 server, IEEE 2030.5 gateway, and MBESS local controller is a risk during field deployment. As a result, it is crucial to understand the possible scenarios for the loss of communication and what to expect during each scenario. To this end, the project tested a communication loss between the IEEE 2030.5 server and gateway and between the IEEE 2030.5 gateway and MBESS local controller while the MBESS was energized. Table 0-1 provides an overview of the possible instances when the communication loss event may happen. These instances were demonstrated during this project to understand the potential consequences and how to address them.

Table 0-1. Communication Loss Scenarios

#	Communication Loss Scenario	Sub #	Different Instances of Communication Loss
1.	Communication Loss between the Server and Gateway	1.1.	After the scheduled control starts
		1.2.	After the gateway receives the scheduled control but before the start time
		1.3.	After the gateway receives the scheduled control but before the start time, and communications return before the event duration elapses
2.	Communication Loss between the Gateway and Local MBESS Controller	2.1.	After the scheduled control starts
		2.2.	After the gateway receives the scheduled control but before the start time
		2.3.	After the gateway receives the scheduled control but before the start time, and communications return before the event duration elapses

5.3 Baseline Analysis of the Benefit Areas

As previously detailed in Module 2 of the EPIC project[11], the mobility feature of the MBESS (i.e., being a non-stationary DER), provides the benefit of deploying a battery storage system throughout the year where and when needed. In Module 2, the highlighted benefit areas were improved safety, improved reliability, improved power quality, lower greenhouse gas

[11] Module 2 Final Report: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%202%20Final%20Project%20Report.pdf

emissions,[12] lower operating costs,[13] ability to maintain commercial services dependent on electricity, and the capability to deploy rapidly in disadvantaged communities. In Module 3, the identified benefit areas in Module 2 are extended, as depicted in Figure 0-4, including the IEEE 2030.5 standard as the main means of bidirectional communication.

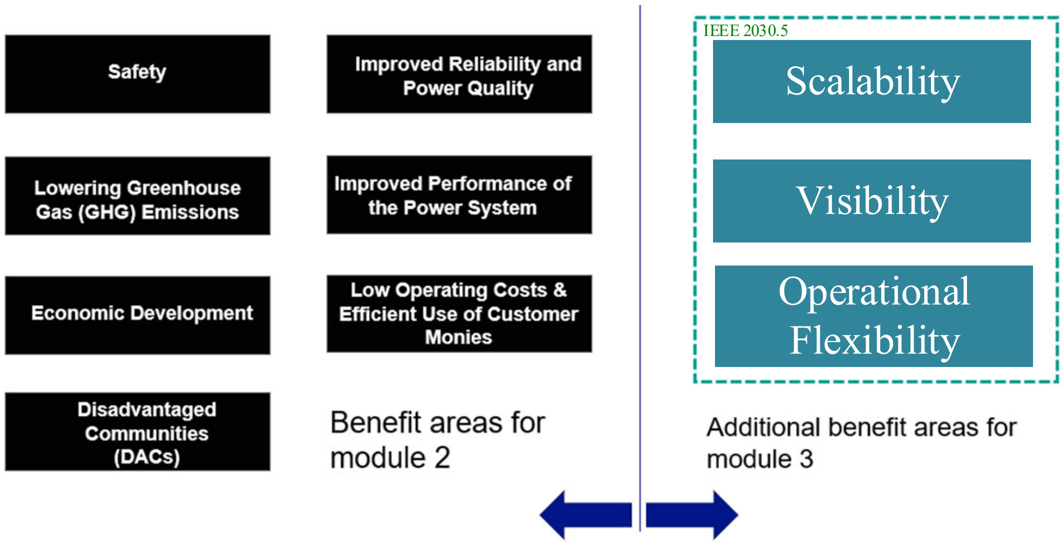


Figure 0-4. Benefit Areas in Module 2 Extended in Module 3

Three main benefit areas from an IEEE 2030.5 communications-enabled MBESS are improved scalability, visibility, and operational flexibility. These benefits arise from enabling bi-directional communication between MBESS and the utility system, which allows for monitoring (hence improved visibility), controls (hence improved operational flexibility), and scalability for future technology adoption. Moreover, the benefits associated with the MBESS integrated with IEEE 2030.5 are as follows:

- **Scalability:**
  - ***Interoperability:*** IEEE 2030.5 provides a standardized communication framework, ensuring interoperability among different vendors' equipment. This interoperability supports the scalability of MBESS integration, allowing utilities to connect and manage a diverse set of devices seamlessly.
  - ***Plug-and-play integration***: With standardized communication protocols, new DERs can be easily integrated into the existing infrastructure, promoting a plug-and-play approach. This simplifies the process of adding more resources, enhancing scalability.
- **Visibility:**
  - ***Real-time data exchange:*** The standard facilitates real-time data exchange between utilities and the MBESS. This improves visibility into the grid's status, enabling utilities to monitor and manage distributed resources effectively.

[12] The grid power used to charge the MBESS has a lower emission profile than the alternative of mobile diesel generators.
[13] The cost of the grid power used to charge the MBESS, including round trip losses, will normally be lower than the cost of diesel fuel that would fuel mobile diesel generators. Note that MBESS has a limited storage capacity while mobile diesel generators are not subject to such limitations provided diesel fuel can be periodically resupplied.

- *Remote monitoring and control:* Utilities can remotely monitor and control the MBESS, enhancing visibility into their performance. This allows for more-informed decision-making and quicker response to grid conditions.

- **Operational flexibility:**
  - ***Demand response integration:*** IEEE 2030.5 supports demand response functionalities, enabling dynamic management of load variations. This flexibility is crucial for optimizing grid operations and responding to changing energy demand patterns.
  - ***Grid stability:*** By providing real-time information on the MBESS, SDG&E can make informed decisions to adjust power flows, manage voltage levels, and use the MBESS resources efficiently.

Table 0-2 below associates the selected use cases with the benefit areas.

Table 0-2. Utility-Controlled MBESS Integrated with IEEE 2030.5 Standard Use Cases Linked to the Benefit Areas

#	Use Case	Description	Benefit Areas[14]
1	Flexibility during Grid Reconfiguration	In a location that is constrained by operational flexibility, a customer can agree to reduce or curtail power during system maintenance or grid outages that involve the system reconfiguration that caused the operational flexibility constraint. The range of adjustability and limits on the number of events will be determined by mutual consent and included in the interconnection agreement.	▪ Operational flexibility ▪ Operational reliability ▪ Operational capacity ▪ Operational safety
2	Increase in Circuit Hosting Capacity	Coordinated dispatchable or scheduled output adjustment in accordance with solicitation requirements or grid service tariff rules. This will mostly be the discharge of stored energy. The customer agrees to the deliverability obligation. Communications must be enabled, which may be less than real-time if the discharge is scheduled ahead of time.	▪ Operational flexibility ▪ Operational capacity
3	Voltage Boosting	Increase voltage that has become lower along a feeder due to distance from a substation and the existence of machine loads. This is achieved with constant or periodic production of reactive power.	▪ Operational flexibility ▪ Operational capacity
4	Voltage Reduction	Reduce voltage in locations that have regular occurrences of high voltage due to reasons beyond the specific customer site.	▪ Operational flexibility ▪ Operational capacity

Additionally, Table 0-3 provides a summary of all MBESS benefit areas, metrics, and outcomes identified and discussed in Modules 1 and 2 of this project. The table was created and populated as part of the Module 1 Final Report. For the sake of consistency, the previous table is preserved in its original format, and additional areas related to Module 3 results have been added.

Table 0-3. Utility-Owned MBESS Metrics and Benefits

Benefit	Description	Criteria and Metrics	Desired Target	Outcome
Safety	The use of an MBESS instead of traditional mobile diesel generators can improve job site safety by reducing the risk, however unlikely, of a fuel spill and	▪ Decrease the potential for a diesel fuel spill through use of an MBESS rather than	▪ Demonstrate that an MBESS can perform the function of a diesel generator so	▪ Based on the results from Modules 1 and 2, it was demonstrated that the use of MBESS prevents any

[14] As specified by Smart Inverter Operation Working Group (SIOWG).

Benefit	Description	Criteria and Metrics	Desired Target	Outcome
	by decreasing ambient noise, allowing for clearer job site communication. [15]	traditional diesel generators. [15] ▪ Calculate the reduction in job site noise pollution by using an MBESS instead of diesel generators. [15]	on-site fuel storage can be reduced.[15] ▪ Calculate a meaningful decrease in job site noise pollution. [15]	fuel spillage while performing similar functions and even beyond compared to a diesel generator. ▪ For more information, refer to footnote 15.
Improved Operational Flexibility	Using a remotely controllable MBESS (through IEEE 2030.5 in this project) provides operational flexibility to system operators to: 1) Increase the capacity of a circuit for seasonal or locational demands (and hence defer certain upgrades). 2) Manage circuit reconfiguration constraints. 3) Coordinated dispatchable or scheduled electricity production in accordance with solicitation requirements or grid service tariff rules.	▪ Remote adjustment of active power based on a control signal form the utility operator. ▪ Distribution system upgrade deferral based on capacity requirements on a circuit for seasonal or locational demands. ▪ The revenue stream from participation in demand response programs and energy markets and providing active power as needed for energy and capacity requirements.	▪ Demonstrate that an MBESS can be controlled for direct active power controls or demand response use cases. ▪ Demonstrate that an MBESS can be controlled remotely by a utility operator to curtail and adjust its active power during a circuit reconfiguration and based on the constraints of a new circuit.	▪ Based on the results from module 3, it was demonstrated that MBESS can be controlled remotely to adjust its active power either for direct setpoints or demand response use cases. ▪ Theoretically, MBESS could be used to defer distribution upgrades associated with the rated power it provides. For example, an MBESS of 500 kW can defer investments needed on a circuit requiring up to 500 kW additional capacity (including cable and switchgear replacement, transformer replacement, etc.).[16]
Improved Visibility and Scalability	Using a remote communication enabled MBESS (through IEEE 2030.5 in this project) provides enhanced visibility for the operators over the field assets. Additionally, it facilitates interconnecting and integrating new assets in a more convenient and scalable fashion.	▪ The ability of MBESS to establish bi-directional communication with the IEEE 2030.5 master platform through the gateway. ▪ The ability of MBESS to send monitoring data on key system status, measurements, and alarms.	1. Demonstrate that an MBESS can communicate with the IEEE 2030.5 master platform provide monitoring information and be controlled remotely	▪ Based on the results from Module 3, it was demonstrated that MBESS can be monitored and controlled remotely for various control functions based on the defined use cases.

[15] From the final report related to Module 1: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%201%20Final%20Project%20Report.pdf. Module 2 final report: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%202%20Final%20Project%20Report.pdf

[16] The distribution deferral pilots conducted to date have not indicated that there is sufficient value in deferral to justify commercial investment in DERs. Given MBESS's comparatively higher cost compared to most DERs, it does not appear MBESS are currently a commercially viable distribution deferral mechanism.

Benefit	Description	Criteria and Metrics	Desired Target	Outcome
		▪ The ability of MBESS to receive control signals for intended use cases and perform accordingly.	based on the control functions specified in Table 3.1.	
Improved Reliability and Power Quality	Currently, diesel generators provide an adequate solution for SDG&E when providing grid support during emergencies. However, because of their emissions, they are limited to emergency functions only. An MBESS can provide emergency backup, supporting reliability. However, it also can support broader grid reliability through peak shaving, load smoothing, voltage and frequency regulation, and prolonging the life of grid equipment.[17]	▪ Ensure that MBESS can act as a backup power source, capable of black starting downstream loads like a diesel generator.[17] ▪ Demonstrate peak shaving and load smoothing abilities.[17] ▪ Calculate the increase in grid infrastructure lifespan based on circuit amperage reductions and corresponding equipment temperature reductions.[17] ▪ Calculate the dollar value of grid equipment lifespan increases.[17] ▪ Calculate the dollar value of grid/circuit upgrade deferrals.[19] ▪ Using the MBESS provides an opportunity for preventing planned and unplanned outages and increasing localized reliability and power quality. ▪ From Module 2, several metrics were defined, including: 1) Avoided the number and duration of PSPS outages. 2) Average load served during the outages. 3) Total supported energy during the outage.	▪ Successfully blackstart and power downstream customer loads, demonstrating PSPS outage mitigation.[17] ▪ Show peak load shaving capabilities and load smoothing thresholds[17] ▪ Grid equipment lifespan extensions are real and meaningful[17] ▪ Value calculations for lifespan increases and grid infrastructure upgrade deferrals demonstrate value to SDG&E[17,,18] ▪ For more information on the targets set for the demonstration of Module 2, refer to footnote 19.	▪ Based on the results from Modules 1 and 2, it was demonstrated that MBESS can successfully perform outage management and other grid support functions to improve reliability and power quality. ▪ For more detailed information on the outcome, please refer to the final reports of Modules 1 and 2.[17]

[17] From the final report related to Module 1. : https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%201%20Final%20Project%20Report.pdf. Module 2 final report: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%202%20Final%20Project%20Report.pdf. Module 2 Final Report: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%202%20Final%20Project%20Report.pdf

[18] The distribution deferral pilots conducted to date have not indicated that there is sufficient value in deferral to justify commercial investment in DERs. Given MBESS's comparatively higher cost compared to most DERs, it does not appear MBESS are currently a commercially viable distribution deferral mechanism.

Benefit	Description	Criteria and Metrics	Desired Target	Outcome
		4) Saving on avoided cost of the outage.		
Improved Performance of the Power System	Improved system operations and performance (i.e., system electrical efficiency) will help reduce electrical losses in the system, such as reductions in resistive losses associated with current flow through the conductors and reductions in transformer electrical losses.[19]	▪ Calculate the peak current reduction for the MBESS deployment. [19] ▪ Determine the percentage of reduction the MBESS is of a full circuit loading.[19]	▪ Visible reduction in circuit loading and current when using MBESS. [19]	▪ For information on the outcome, please refer to the final report of Module 1[19].
Lower Greenhouse Gas (GHG) Emissions	Using an MBESS instead of diesel generators will provide reductions in localized emissions at sites needing grid resiliency. [19]	▪ Calculate the diesel fuel savings (gallons and cost) associated with a switch to MBESS. [19] ▪ Convert diesel savings to yearly metric tons of CO_2e.[19] ▪ Calculate the CO_2e reduction value on California's Cap and Trade market. [19] ▪ From Module 2, the metrics defined included the annual reduction of CO_2 based on the number/duration of served outages (and hence kWh served) and the difference between diesel-supplied vs. MBESS-supplied outages.	▪ Show a reduction in diesel fuel consumption for grid resiliency support. [19] ▪ Determine the value of emissions reductions on California's Cap and Trade market. [19] ▪ From Module 2, the desired target was to demonstrate a reduction of CO_2 based on the projected number of outages supplied by MBESS.	▪ Based on the results from Modules 1 and 2, it was demonstrated that MBESS can successfully reduce the emission for outage management use cases where MBESS is used as a replacement for diesel generators. Further reduction can be achieved by charging MBESS from a 100% clean resource such as solar or wind. ▪ For more detailed information on the outcome, please refer to the final reports of Modules 1 and 2.[20]
Lower Operating Costs and More Efficient Use of Customer Monies	Using an MBESS to support grid upgrade deferrals provides real value to SDG&E, money that would otherwise be spent on infrastructure upgrades. Because of the mobile nature of an MBESS, strategic deployment based on SDG&E's grid needs assessment can push out capital upgrades, which would save or defer use of ratepayer dollars. This value can be calculated and can be factored into the lifecycle cost of an MBESS for SDG&E. Ideally. It could	▪ Calculate the 10-year lifecycle cost of an MBESS purchase vs. a diesel generator rental model currently employed by SDG&E. Include upfront costs of the MBESS purchase, ongoing and yearly costs, and potential revenue streams from other MBESS functions such as grid upgrade deferrals and CAISO market functions. [20]	▪ Demonstrate a greater ROI for an MBESS vs. a diesel generator. [20] ▪ Demonstrate positive value from partial participation in CAISO market functions. [20]	▪ Based on the results from Modules 1 and 2, it was demonstrated that MBESS provides a financially advantageous investment provided that the unit is used properly and based on stacked use cases to generate revenue (e.g., from Module 2, an IRR of 33% and Benefit to Cost Ratio of 2.03 is calculated).

[19] From the final report related to Module 1: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%201%20Final%20Project%20Report.pdf. Module 2 final report: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%202%20Final%20Project%20Report.pdf. Module 2 Final Report: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%202%20Final%20Project%20Report.pdf

Benefit	Description	Criteria and Metrics	Desired Target	Outcome
	make MBESS a more financially advantageous investment for SDG&E to meet its grid resiliency needs than the more traditional diesel generators.[20]			▪ For more detailed information on the outcome, please refer to the final reports of Modules 1 and 2.[20]
Economic Development	Should SDG&E choose to procure additional MBESS to support grid resiliency and grid infrastructure upgrade deferrals, this will generate a local market for these units. Not only will it draw awareness to such a product and its flexibility, but it will also attract jobs associated with the supply, setup, operation, and maintenance of the MBESS.[22]	▪ Calculate the number of MBESS needed to fully defer SDG&E's planned grid upgrades between 2022 and 2030.[20] ▪ Calculate the value of local market investment required to procure MBESS for grid upgrade deferrals.[20, 21] ▪ Based on Module 2, the following metrics were defined: 1) Affected businesses/communities to assess the project's impact on affected communities and their local businesses 2) Determined the population within a 1-mile radius of the CRC to evaluate the expected number of people that would have access to the CRC during an outage 3) Determined the number and type of businesses within one block around the CRC that would be visited.	▪ Generate a significant local market investment in MBESS technology.[20] ▪ Provide financial and business gains associated with serving the population during the outage.	▪ Based on the results from Modules 1 and 2, it was demonstrated that MBESS provides additional economic development opportunities. ▪ For more detailed information on the outcome, please refer to the final reports of Modules 1 and 2.[22]
Disadvantaged Communities (DACs)	The CPUC has encouraged EPIC program administrators to seek projects that benefit disadvantaged communities, including rethinking the location of clean energy technologies to benefit burdened	▪ An MBESS can operate in a disadvantaged community and show investment in these communities. The project may achieve GHG benefits that support state goals and	▪ Demonstrate SDG&E's increased ability to support GHG reductions in DACs through the deployment of an MBESS in their operations and	▪ Based on the results from modules 1 and 2, it was demonstrated that MBESS provides additional benefits for DACs, including: 1) Outage duration reduced in DACs.

[20] From the final report related to Module 1: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%201%20Final%20Project%20Report.pdf. Module 2 final report: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%202%20Final%20Project%20Report.pdf. Module 2 Final Report: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%202%20Final%20Project%20Report.pdf

[21] The distribution deferral pilots conducted to date have not indicated that there is sufficient value in deferral to justify commercial investment in DERs. Given MBESS's comparatively higher cost compared to most DERs, it does not appear MBESS are currently a commercially viable distribution deferral mechanism.

Benefit	Description	Criteria and Metrics	Desired Target	Outcome
	communities. Furthermore, specific project benefits may have a direct benefit to the local community (i.e., reduced source emissions when the source is physically located in the disadvantaged community, such as using a mobile battery instead of a diesel generator. GHG emission reductions due to electrical savings are attributed to the generation source, which may not be in the disadvantaged community).[22]	may reduce emissions from sources located within the disadvantaged community. [22]	reduction in generator runtime hours when MBESS is deployed for resiliency purposes. [22]	2) Avoided cost of using diesel genset in DACs. 3) avoided GHG emissions by not using diesel gensets at DACs. ▪ For more detailed information on the outcome, please refer to the final reports of Modules 1 and 2.[22]
Incremental Benefits of a Mobile Solution	When compared to the traditional resiliency solution (a diesel generator), an MBESS solution will accrue incremental and stacked benefits by being relocated to a variety of sites and performing a variety of functions, minimizing MBESS idle time and providing a variety of benefits to SDG&E. ROI and long-term benefits have been quantified in the other benefit areas above. [22]	▪ Demonstrate increased flexibility in MBESS deployment vs. traditional diesel generators.[22] ▪ Evaluate additional potential value generation opportunities for MBESS vs. traditional diesel generators.[22] ▪ Identify any additional benefits associated with using an MBESS over diesel generators.[22] ▪ Based on module 2, the following metrics were identified: 1) The incremental benefits achieved with the mobile battery over the appropriate diesel generator alternative. 2) The costs associated with a mobile battery and the appropriate diesel generator alternative. 3) Incremental return on investment (ROI) by considering incremental benefits and incremental costs.	▪ Increased flexibility of deployment.[22] ▪ Additional functionality successfully demonstrated by an MBESS.[22] ▪ Quantify any additional benefits.[22]	▪ Based on the results from Modules 1 and 2, it was demonstrated that MBESS provides additional benefits compared to a diesel generator, such as grid support applications (peak shaving, market participation, power quality improvement, etc.), which leads to additional benefits to the utility and customers. ▪ For more detailed information on the outcome, please refer to the final reports of modules 1 and 2.[22]

[22] From the final report related to Module 1: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%201%20Final%20Project%20Report.pdf. Module 2 final report: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%202%20Final%20Project%20Report.pdf. Module 2 Final Report: https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%202%20Final%20Project%20Report.pdf

5.4 Description of Pre-Commercial Demonstration

5.4.1 Location/Transportation

The field test demonstration for this project was performed at SDG&E's existing microgrid site located at Cameron Corners near Campo, California. The aerial view of the location is depicted in Figure 0-5.

Figure 0-5. Aerial View of the Field Test Location at Cameron Corners, Campo, CA

The transportation route of the MBESS from SDG&E's ITF to the demonstration site at Cameron Corners is shown in Figure 0-6. The distance traveled from the ITF to the demonstration site is around 80 miles. Figure 0-7 shows pictures of the MBESS during the use case demonstration at the field test location.

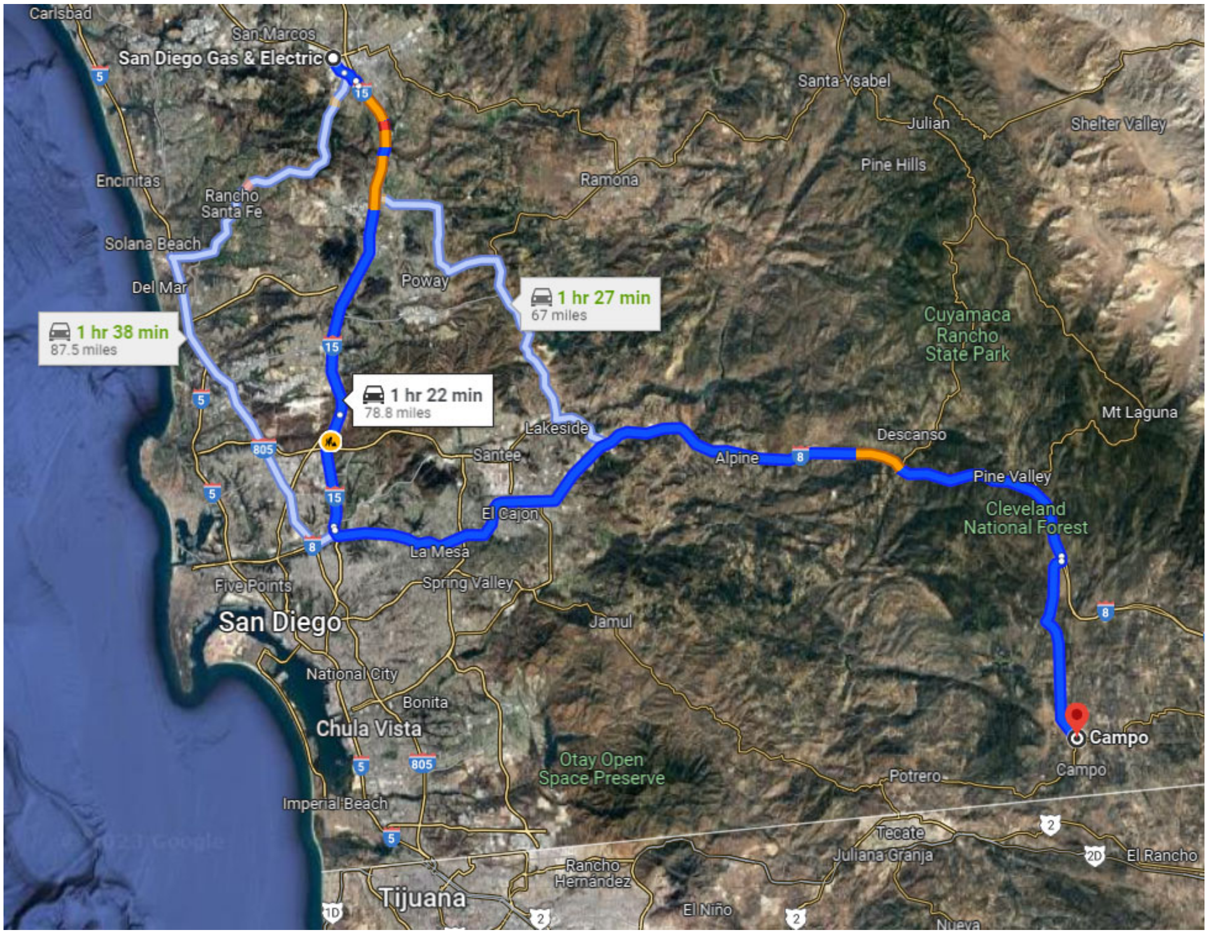


Figure 0-6. Path for Transporting the MBESS from the ITF to the Demonstration Site at Cameron Corners

Figure 0-7. Pictures of the MBESS at Cameron Corners during the Use Case Demonstrations

5.4.2 Use Case Demonstration Approach

Before transporting the MBESS to Cameron Corners for field demonstration, all the use cases and loss of communication scenarios were tested at the ITF to validate the operation of the MBESS, the successful integration of the IEEE 2030.5 gateway to the MBESS local controller, and the successful communication between the IEEE 2030.5 server and gateway over a private LTE network. Upon completion of site testing, the MBESS was transported from the ITF to Cameron Corners for the field demonstration of the use cases.

5.4.3 Equipment Requirements

The following equipment was used during the demonstration:

- **MBESS:** 100 kW/250 kWh MBESS with an integrated IEEE 2030.5 gateway to enable remote monitoring and control of the unit through the IEEE 2030.5 server.
- **Permanent connection box:** This is required on the utility/customer side to establish an interconnection point to the MBESS at the demonstration site.
- **Cam-Lok cables:** A set of 400 A Cam-Lok cables was needed to connect MBESS with the permanent connection box. Proper Cam-Lok cables are located inside MBESS to accelerate the interconnection process.
- **Auxiliary cables:** A set of auxiliary cables to connect to the 120/240 V auxiliary input. These cables are located inside the MBESS terminal box.
- **IEEE 2030.5 server:** The IEEE 2030.5 standard server is located at the to send commands for monitoring and controlling the MBESS in the field.

Notably, there were minimal equipment requirements for interconnecting the MBESS to utility/customer facilities, considering the fully integrated design of MBESS.

5.4.4 Software Requirements

A CSIP-compliant IEEE 2030.5 server is required from the utility to send and schedule DER controls and monitor the relevant DER data from the MBESS.

5.4.5 Supporting SDG&E Infrastructure and Data Requirements

Based on the defined use cases for the MBESS and the required remote control of the unit for the demonstration, a private LTE connection from the IEEE 2030.5 server at the ITF to the MBESS in the field was established.

5.4.6 Site Testing at the ITF

The site testing performed at the ITF included a demonstration of operational flexibility use cases and loss of communication scenario testing of the MBESS while operating in remote control mode. The second part was to perform the use case identified in the ITF with the MBESS integrated with the IEEE 2030.5 standard.

Table 0-4 depicts the details of the use case demonstrations at the ITF. Specifically, Table 0-4 provides the details related to the DERControl mode, objective, duration, and date of the tests.

Table 0-4. MBESS Integrated with IEEE 2030.5 Standard Use Cases Demonstrated at the ITF

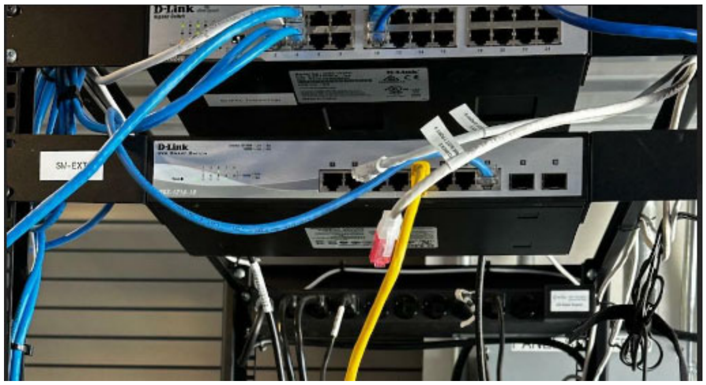
#	Use Case	Objective	Duration	Pass/Fail	Date
1	Flexibility during Grid Reconfiguration	Confirm the flexibility of the MBESS during grid reconfiguration through the IEEE 2030.5 server (DERControl: OpModMaxLimitW). Note that events are scheduled one at a time.	55 min	☒/☐	07/06/2023
2	Capacity Increase	Confirm the flexibility of the MBESS during grid reconfiguration through the IEEE 2030.5 server (DERControl: OpModMaxLimitW). Note that events are scheduled one at a time.	45 min	☒/☐	07/06/2023
3	Voltage Boosting	Confirm voltage boosting by the MBESS through the IEEE 2030.5 server (DERControl: OpModMaxFixedVAR).	45 min	☒/☐	07/06/2023
4	Voltage Reduction	Confirm voltage reduction with Volt/Var curve by the MBESS through the IEEE 2030.5 server (DERControl: OpModVoltVar).	30 min	☒/☐	07/06/2023

The communication loss between the server and gateway is emulated in Figure 0-8 (a) and (b), an ethernet cable disconnection and reconnection. Also, the communication loss between the gateway and MBESS local control is emulated in Figure 0-9 through disconnection from the MBESS Modbus.

Table 0-5. MBESS Integrated with IEEE 2030.5 Standard Communication Loss Scenarios Effects Demonstrated at the ITF

#	Use Case	Objective	Duration	Pass/Fail	Date
1	Communication Loss between Server and Gateway	Test the effect of communication loss between the server and gateway during a use case demonstration with an MBESS integrated with the IEEE 2030.5 standard. The use case selected here is the capacity increase use case. Moreover, three different times are tested in this communication loss scenario: communication loss between the server and gateway (1) after the scheduled control starts, (2) after the gateway receives the scheduled control but before the start time, and (3) after the gateway receives the scheduled control but before the start time, but then communications return before the event duration elapsing.	55 min	☒/☐	07/06/2023
2	Communication Loss between Gateway and MBESS Local Controller	The objective is to test the effect of communication loss between the gateway and MBESS local controller during a use case demonstration with an MBESS integrated with the IEEE 2030.5 standard. The use case selected here is the capacity increase use case. Moreover, three different times are tested in this communication loss scenario: communication loss between the server and gateway (1) after the scheduled control starts, (2) after the gateway receives the scheduled control but	45 min	☒/☐	07/06/2023

#	Use Case	Objective	Duration	Pass/Fail	Date
		before the start time, and (3) after the gateway receives the scheduled control but before the start time, but then communications return before the event duration elapsing.			



(a)

(b)

Figure 0-8. (a) Communication Loss Between Server and Gateway Emulation by Disconnecting the Ethernet Cable, (b) Reconnection of the Ethernet Cable to Emulate Communication Restoration

Figure 0-9. Modbus Gateway Disconnection from MBESS Local Controller to Emulate the Communication Loss Scenario

5.4.7 Field Demonstration

Figure 0-10 presents a simplified schematic of the setup used during the field demonstration at Cameron Corners. The MBESS connects to a tap box (including a disconnect switch) at the SDG&E site, which is then connected to the 12 kV distribution system through a step-up transformer.

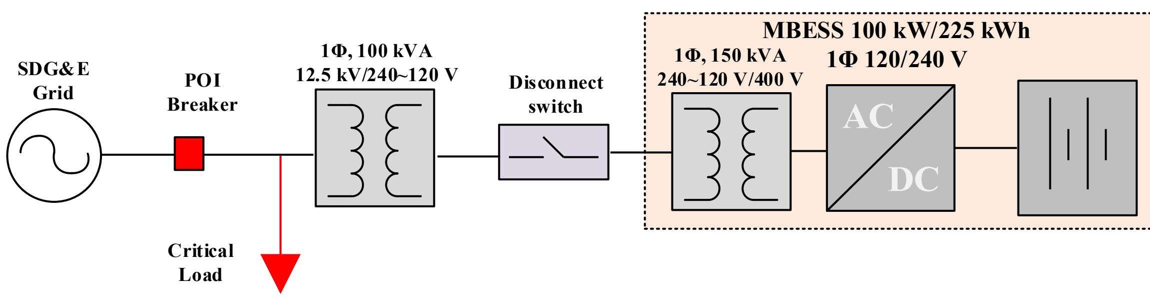


Figure 0-10. Setup of Cameron Corners Site Use Cases Demonstration

Figure 0-11 depicts the network diagram of the MBESS integrated with the IEEE 2030.5 standard. As seen in this figure, the communication between the IEEE 2030.5 server and MBESS was through a private LTE network. This communication was used to control and monitor the unit.

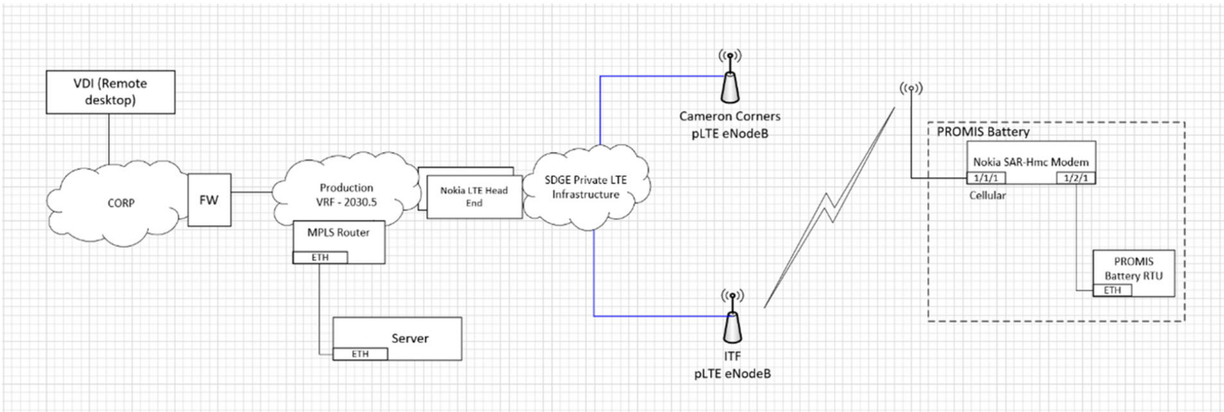


Figure 0-11. Network Block Diagram for the Field of the MBESS Using IEEE 2030.5 at Cameron Corners (PROMIS is Another Name for the MBESS)

Before initializing the demonstration, the team followed the subsequent steps to energize the MBESS and prepare the setup:

1. Connect the Cam-Lok cables from the MBESS output terminal box to the disconnect switch, as shown in Figure 0-10 above (see Figure 0-12 from the site), and ensure the disconnect switch is open initially.
2. Follow the MBESS step-by-step procedures in [5] for post-transportation inspection and confirm that the unit is ready to be energized.
3. Energize the MBESS unit and check the system status/measurements from the HMI.
4. Confirm that the communications between the server located at the ITF and the gateway are established.
5. Verify that the system data are being logged correctly by the MBESS and the IEEE 2030.5 server.

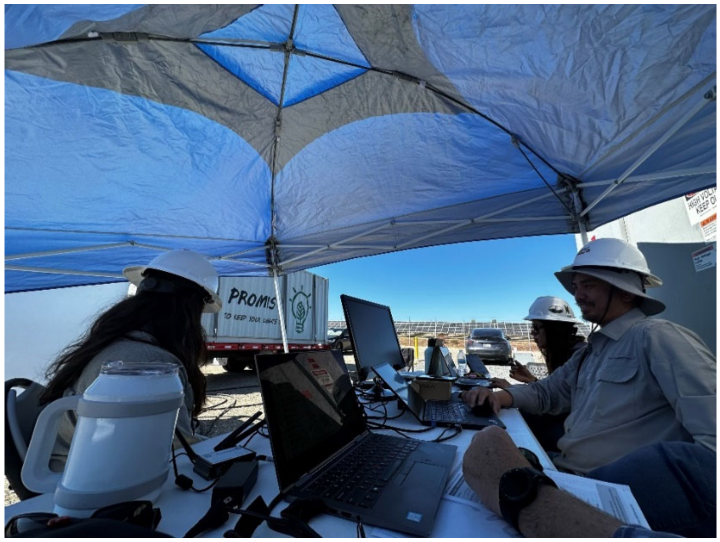


Figure 0-12. Picture Taken during the Field Test Demonstration at Cameron Corners

Table 0-6 depicts the details of the use case demonstrations in the field. The team successfully demonstrated all the use cases at Cameron Corners.

Table 0-6. MBESS Integrated with IEEE 2030.5 Standard Use Cases Demonstrated in the Field

#	Use Case	Objective	Duration	Pass/Fail	Date
1	Flexibility during Grid Reconfiguration	Confirm the flexibility of the MBESS during grid reconfiguration through the IEEE 2030.5 server (DERControl: OpModMaxLimitW). Note that events are scheduled one at a time.	32 min	☒/☐	09/19/2023
2	Capacity Increase	Confirm the flexibility of the MBESS during grid reconfiguration through the IEEE 2030.5 server (DERControl: OpModMaxLimitW). Note that events are scheduled one at a time.	16 min	☒/☐	09/19/2023
3	Voltage Boosting	Confirm voltage boosting by the MBESS through the IEEE 2030.5 server (DERControl: OpModMaxFixedVAR).	23 min	☒/☐	09/19/2023
4	Voltage Reduction	Confirm voltage reduction with Volt/Var curve by the MBESS through the IEEE 2030.5 server (DERControl: OpModVoltVar).	20 min	☒/☐	09/19/2023

6. Project Results

The following section provides the results associated with integrating the MBESS with the IEEE 2030.5 standard.

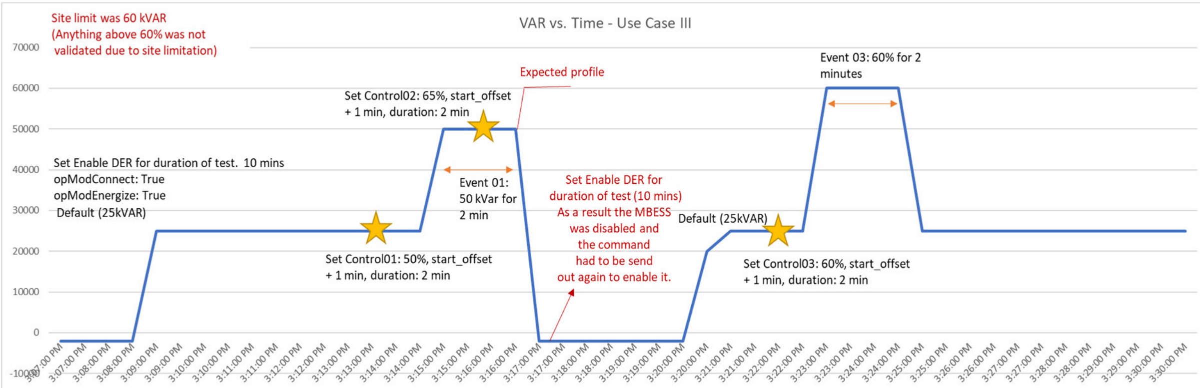
6.1 Results Discussion

6.1.1 Results Construction Sample from Data Collected from a Use Case Demonstration

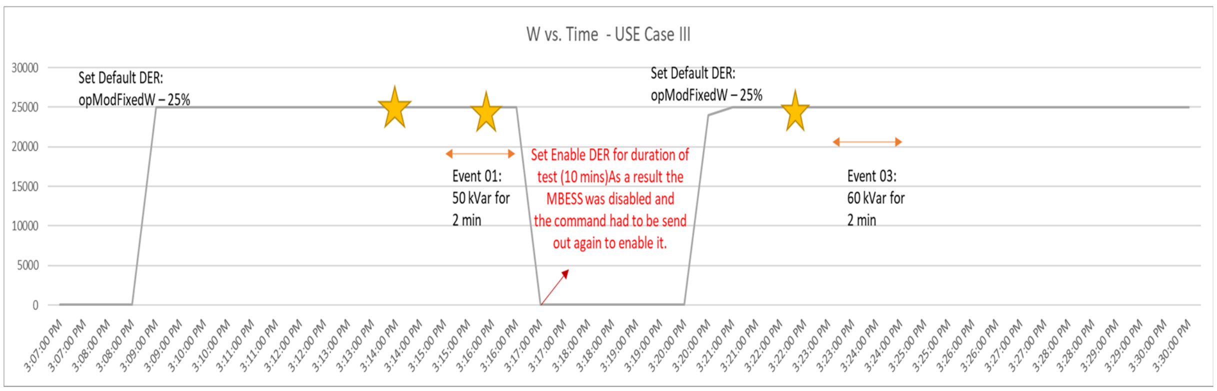
The data collected from the test, either in the field or the ITF, are plotted against the recorded duration of the specific use case. For instance, Table 0-1 shows data collected from Use Case 3, "Voltage Boosting," demonstration at the field on 09/19/2023 from 3:07:00 PM–3:30:00 PM. Table 0-1 depicts the MBESS active power, MBESS reactive power, and MBESS terminal voltage. This use case aims to demonstrate the capability of using the MBESS with the IEEE 2030.5 standard integration to boost the voltage with reactive power injection. Plotting the time vector versus the three quantities of the MBESS (i.e., active power, reactive power, and terminal voltage vs. time in Figure 0-1) will validate that the MBESS capability in boosting voltage will be a schedulable DER. The same process is repeated to plot the results related to all use cases and communication loss scenarios.

Table 0-1. Sample Date Collected from Use Case 3 "Voltage Boosting" from the Field Test Demonstration

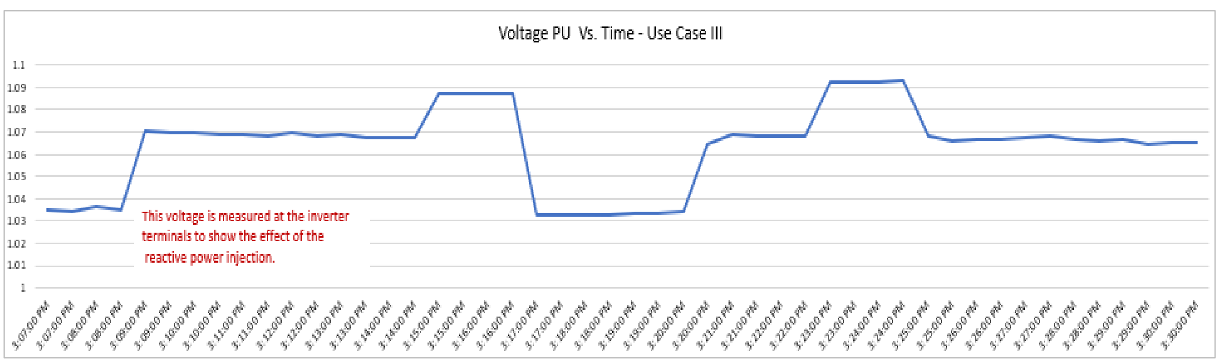
Time	Q (kVar)	P (kW)	V [%]
3:07:00 PM	-2	0	103.450
3:08:00 PM	-2	0	103.625
3:09:00 PM	25	25	107.050
3:10:00 PM	25	25	106.950
↓	↓	↓	↓
3:24:00	60	25	109.325
↓	↓	↓	↓
3:27:00 PM	25	25	106.850
3:28:00 PM	25	25	106.700
3:29:00 PM	25	25	106.650
3:30:00 PM	25	25	106.550



(a)



(b)



(c)

Figure 0-1. Results of Sample Use Case 3, "Voltage Boosting," at the Field Demonstration: (a) Reactive Power Profile, (b) Terminal Voltage Profile, and (c) Active Power Profile

6.1.2 Use Case 1: "Flexibility during Grid Reconfiguration" Results

Figure 0-2 depicts the active power profile of the MBESS during the whole demonstration of Use Case 1 at Cameron Corners. At 1:49:00 PM, the MBESS is set to default mode with an active power injection of 75 kW. Note that the base 100% active power is selected to be 100 kW. Then, at the time instant 1:53:00 PM, an event scheduled for 3 minutes ahead was sent to the MBESS to limit the active power to 50 kW for a 2-minute duration. This event should occur between 1:56:00 PM and 1:58:00 PM in Figure 0-2.

However, at the site, upon opening the POI breaker at the time instant 1:54:00 PM, the upstream breaker tripped in the temporary distribution panel installed for testing. This caused the MBESS to miss the time window for the pre-set event (as seen in Figure 0-2 between 1:54:00 PM–2:06:00 PM). Therefore, it was decided to avoid opening the POI breaker in the next steps. The operator continued the use case testing to validate the successful MBESS response to the opModMaxLimW command. After the re-energization of MBESS with the default 75 kW active power injection at 2:06:00 PM, the MBESS receives two scheduled events of limiting the active power to 50 kW at 2:12:00 PM–2:14:00 PM and 25 kW at 2:18:00 PM–2:19:00 PM (Figure 0-2). Note that the limiting event at the 50 kW event was sent to the MBESS at 2:09:00 PM, and the limiting event at the 25 kW event was sent at 2:16:00 PM. Finally, at the conclusion of the 2030.5 event, the default setting of the MBESS reverted back to 100 kW.

Use case 1 demonstrates that the MBESS with integrated IEEE 2030.5 standard can provide grid flexibility during a reconfiguration of events using the opModMaxLimW command. Additionally, the MBESS properly responds to a single scheduled control event, and after completion of the schedule, the smart inverter returns to the DefaultDERControl.

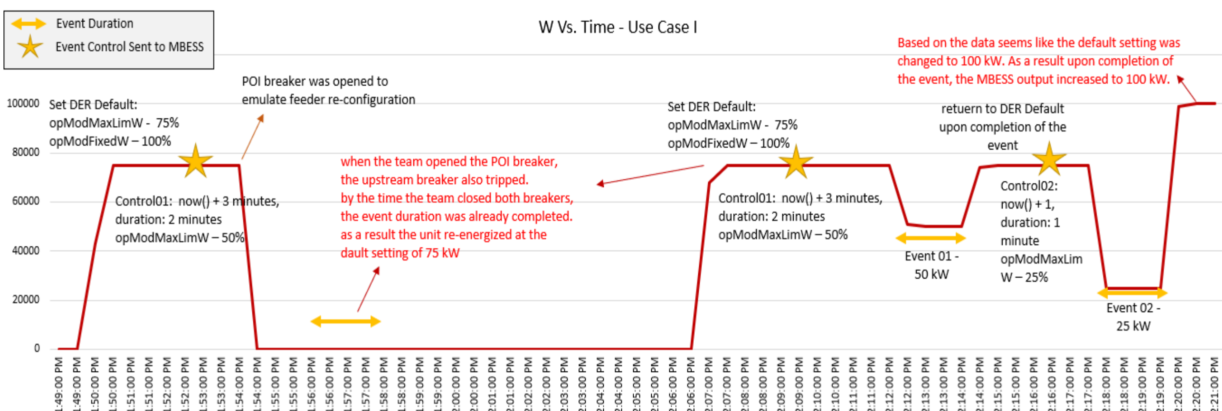


Figure 0-2. Use Case 1 "Flexibility During Grid Reconfiguration" Active Power Profile

6.1.3 Use Case 2: "Capacity Increase" Results

Figure 0-3 depicts the active power profile of the MBESS during the use case 2, "Capacity Increase,"[23] demonstration at Cameron Corners. Initially, at 2:26:00 PM, the MBESS operates at default mode with 25 kW active power injection, as Figure 0-3 shows. After that, at 2:28:00 PM, a request to increase the active power to 50 kW using opModFixedW for two minutes is sent to the MBESS. Therefore, Figure 0-3 shows that

[23] The term "Capacity Increase" is used as shorthand for an "increase in active power injection." The injection of power onto a circuit does not change the circuit's thermal rating.

the active power is 50 kW from 2:30:00 PM–2:32:00 PM. At 2:30:00 PM, a request to increase the active power to 75 kW (i.e., Event 2) for three minutes ahead with a duration of two minutes was sent. Then, at 2:31:00 PM, Event 3, which increased the active power to 100 kW for five minutes ahead with a duration of two minutes, was sent. Please note that both Events 2 and 3 were sent to MBESS during Event 1, and the output of the unit was increased to 50 kW.

Afterward, at time instant 2:32:00 PM, Event 1 completes, and the MBESS goes back to the default 25 kW injection mode. As can be seen from Figure 53, at the time instants 2:33:00 PM and 3:36:00 PM, Events 2 and 3 start as expected, respectively. Note that, due to power limitations in the site (cable used for this test), the active power was set to a maximum of 85 kW instead of 100 kW in Event 3.

This field test confirms the MBESS capability in performing capacity increase use case through the opModFixedW command from IEEE 2030.5. Additionally, the MBESS properly responds to multiple scheduled control events, and after completion of each event, the smart inverter returns to the DefaultDERControl.

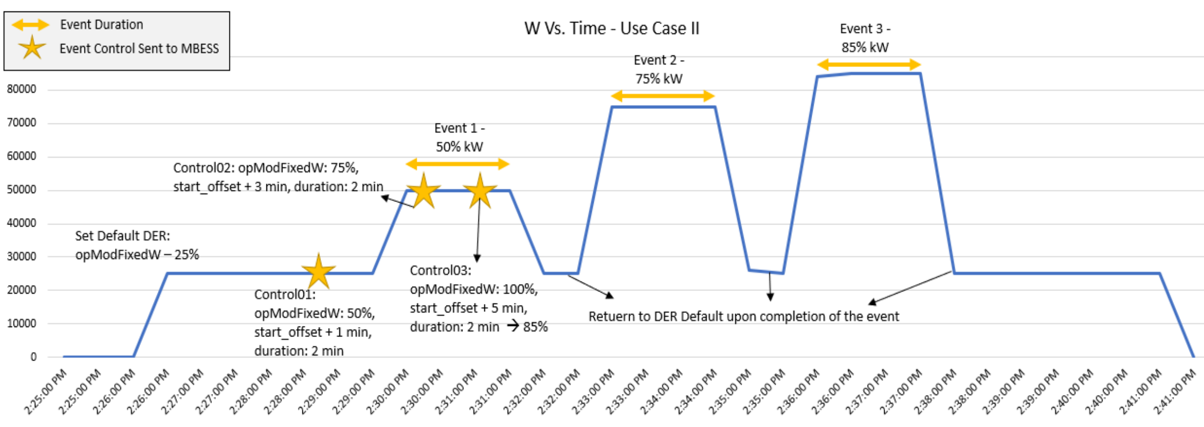
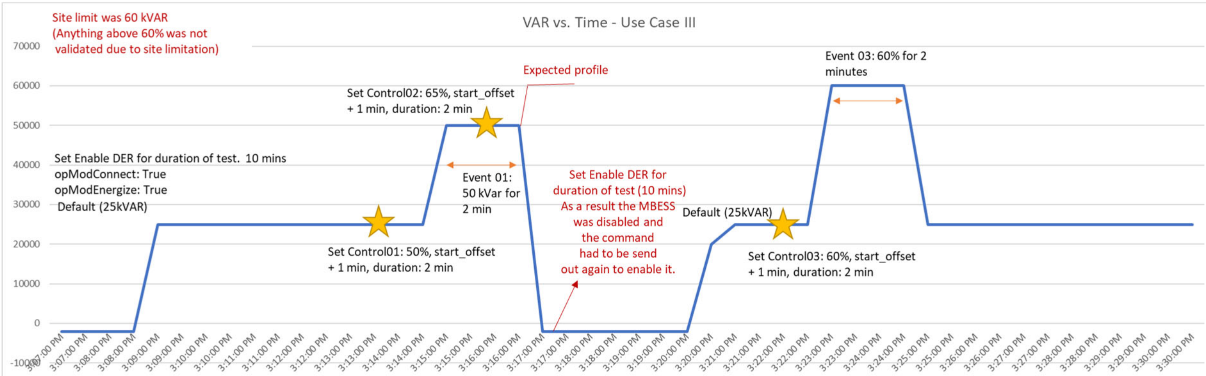


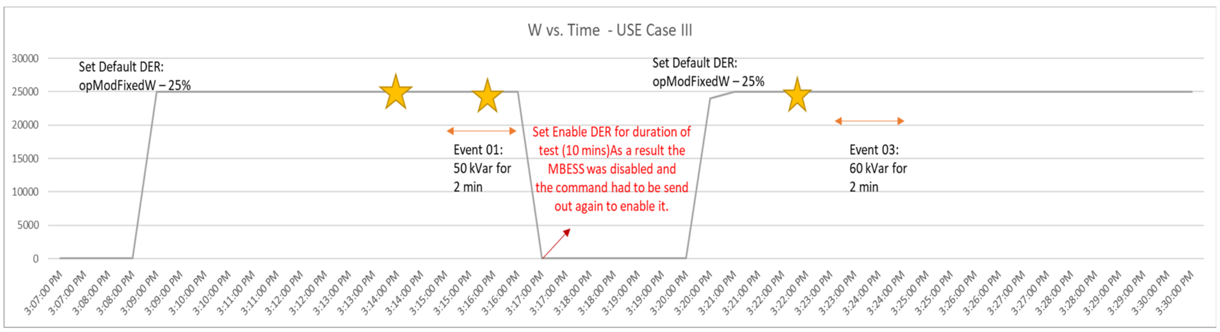
Figure 0-3. Use Case 2 "Capacity Increase" Active Power Profile

6.1.4 Use Case 3: "Voltage Boosting" Results

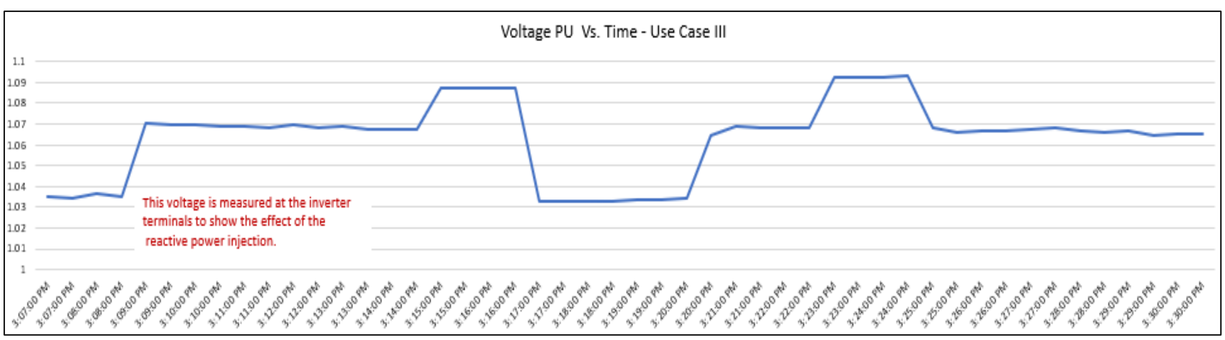
Notably, in real-world implementation, the voltage measurements received by the IEEE 2030.5 server and gateway will be shared with the DERMS. The DERMS will host the logic to calculate the reactive power required based on the voltage drop and will share the Q setpoint with the IEEE 2030.5 server, which, in turn, will send the setpoint to the DERs. However, since this project's scope did not cover the upstream integration of the DERMS and the IEEE 2030.5 server, the team only sent the opModMaxFixedVar command to the MBESS through the server located at the ITF. Figure 0-4 shows Use Case 3's reactive power, voltage, and active power profiles during the field test demonstration at Cameron Corners. At the time instant 3:08:00 PM, the MBESS is enabled by setting the opModConnect and opModEnergize to "True" for a 10-minute duration by the IEEE 2030.5 server located at the ITF. The opModMaxFixedVar and opModFixedW of the unit are set to 25% (inject) and 25% active power delivery, respectively. Figure 54 (a) and (b) show that the unit was successfully energized and operated- at the default values. Furthermore, using the IEEE 2030.5 server, at 3:13:00 PM, an event is scheduled for one minute ahead to increase the reactive power to 50 kVar for two minutes. As a result, the reactive power is increased in Figure 0-4 (a) at the time instant 3:14:00 PM to 50 kVar. Another schedule was sent at 3:16:00 PM for one minute ahead to increase the reactive power to 65 kVar. However, before initiating this event, the MBESS was disabled at 3:17:00 PM. At 3:20:00 PM, the opModConnect and opModEnergize were set to “True” again by the IEEE 2030.5 server. As a result, the MBESS was enabled again and followed the pre-set default settings for active and reactive power, as Figure 0-4 (a) and (b) show. At 3:22:00 PM, an alternative schedule was sent one minute ahead to increase the reactive power of the MBESS to 60 kVar. As Figure 0-4 (a) shows, following the scheduled event at 3:23:00 PM, MBESS reactive power increased to 60 kVar and lasted for two minutes. Upon the event’s completion, the unit returned to the default kVar setpoint of 25% (25 kVar). Figure 54 (c) illustrates the voltage at the inverter terminal (internal to the MBESS unit) during the duration of the test. This figure shows that voltage closely follows the reactive power injection. In conclusion, this use case demonstrates that the MBESS, with IEEE 2030.5 capabilities, can use the opModMaxFixedVar command to increase its reactive power injection to address voltage drops along the feeder.



(a)



(b)



(c)

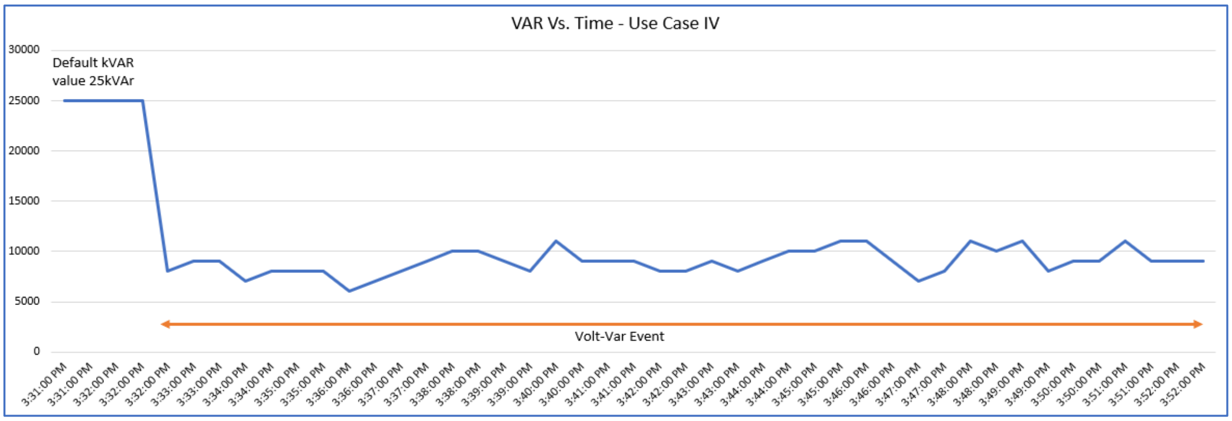
Figure 0-4. Use Case 3 "Voltage Boosting": (a) Reactive Power Profile, (b) Terminal Voltage Profile, and (c) Active Power Profile

6.1.5 Use Case 4: "Voltage Reduction (Volt/Var)" Results

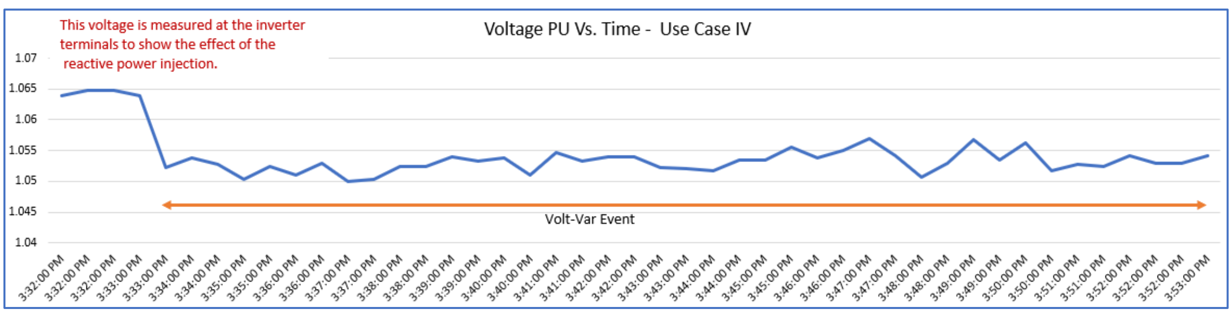
Figure 0-5 shows the use of the Volt/Var curve of the MBESS with an integrated IEEE 2030.5 standard. Specifically, Figure 0-5 (a) depicts how the reactive power changes at 3:32:00 PM from the default 25 kVar to supplying reactive power in a method that decreases the terminal voltage in Figure 0-5 (b). Notably, the reference point for the MBESS to perform Volt/Var is at its inverter terminal, and Figure 0-5 (b) shows the voltage measured at the AC side of the inverter.

Also, the active power for this use case's duration was set at 25 kW (Figure 0-5 (c)). This use case concludes that the reactive power of the MBESS can be set to follow a specific Vol/Var curve to reduce the terminal voltage through IEEE 2030.5 standard use.

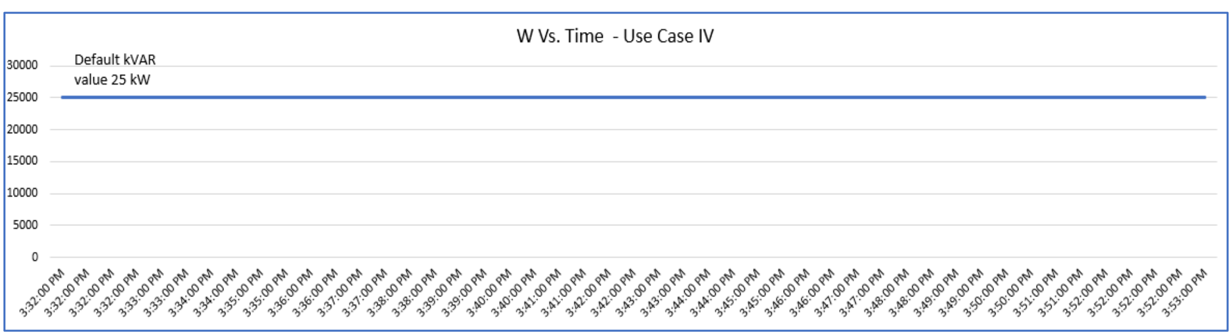
This use case confirmed that the MBESS can accept the volt-var curve settings from the IEEE 2030.5 server and adjust its reactive power based on the voltage measurements to follow the curves and maintain the voltage.



(a)



(b)



(c)

Figure 0-5. Use Case 4 "Voltage Reduction (Volt/Var)": (a) Reactive Power Profile, (b) Terminal Voltage Profile, and (c) Active Power Profile

6.1.6 Communication Loss Scenario 1: "Communication Loss between Server and Gateway" Results

The observed behavior of the Modbus gateway, server, and MBESS performed as expected in Figure 0-6. The Modbus gateway did not perform a watchdog reboot with a loss of network connection in less than two minutes. However, extended loss of communication (> 2 minutes) triggered the watchdog to reboot the gateway (per the settings), which in turn caused the MBESS controller to go to local mode which is a production mechanism of the MBESS. Below are key observations from this test, all of which were expected system behaviors:

- The Modbus gateway handled a temporary loss of network communication lasting less than two minutes without restarting itself.
- The Modbus gateway handled a loss of network communication lasting longer than two minutes by performing its programmed recovery mechanism of rebooting (restarting) itself.
- All DER controls were processed (received, started, completed) by the Modbus gateway at the expected times before the gateway reset, regardless of the communication status with the server.
- The MBESS reverted to local mode after restarting the Modbus gateway.
- The server will be inoperable and will not receive any data from the Modbus gateway due to the loss of network communication.
- The loss of communication event resulted in the loss of meter data for that given time frame.

Figure 0-6 shows the active power measured at the output of the MBESS during the loss of communication between the gateway and server.

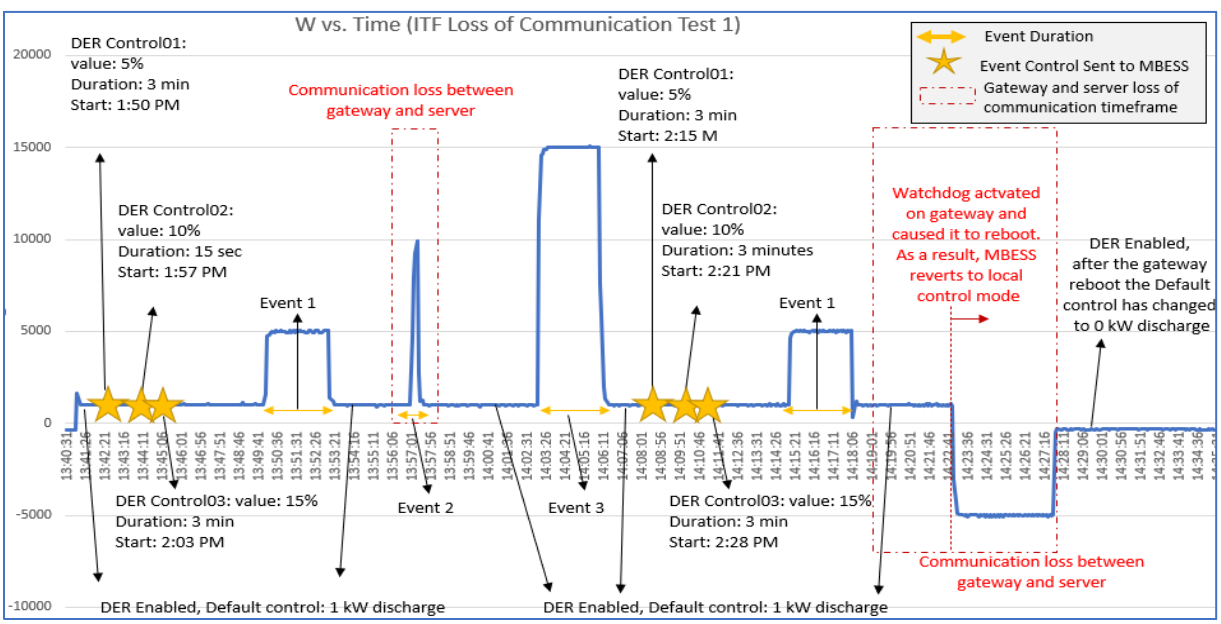


Figure 0-6. Communication Loss Scenario 1: Active Power Profile at MBESS Output during Server and Gateway Connection Loss at the ITF

6.1.7 Communication Loss Scenario 2: "Communication Loss Between Gateway and MBESS Local Controller" Results

The observed behavior of the Modbus gateway, server, and MBESS performed as expected in Figure 0-7. The MBESS local controller returned to local mode after losing network communication. Once set to remote mode, the MBESS could accept and process DER controls.

- The MBESS reverted to local mode upon losing connection to the Modbus gateway. This behavior is expected.
- To restore the MBESS's operation, an enable command must be sent and processed by the MBESS local controller.
- The enabling of remote mode from local mode is currently handled remotely through the vendor's technology. To accept and conform with DER controls, the MBESS must operate under remote mode.
- The loss of communication event resulted in the loss of meter data for that given time frame.

Figure 0-7 shows the power output of the MBESS during the gateway and local controller communication loss test at the ITF.

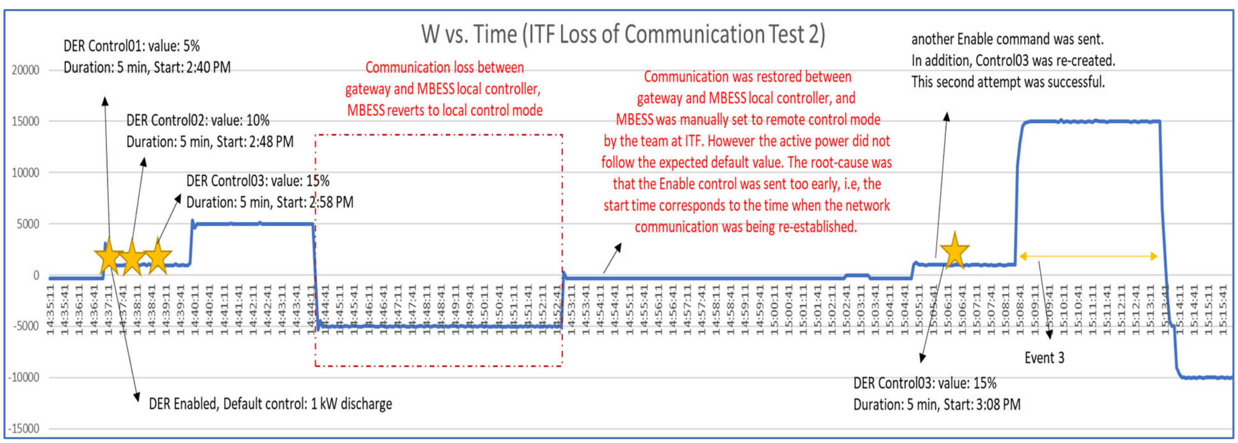


Figure 0-7. Communication Loss Scenario 2: Active Power Profile at MBESS Output during Gateway and MBESS Local Controller Connection Loss at ITF

6.2 Commercialization Cost Estimates

The following is an outline of cost elements associated with the commercialization of IEEE 2030.5:[24]

- Development and integration of an IEEE 2030.5 server platform
    - This includes the IEEE 2030.5 software application, database server, and associated server infrastructure to integrate into existing infrastructure.

- Integration of an IEEE 2030.5 Gateway with a DER
    - If not using a native IEEE 2030.5 client, the integration of IEEE 2030.5 Gateway will incur costs. This includes the development and integration of the 2030.5 Gateway to communicate with and translate IEEE 2030.5 data through the DER's communications protocol.

- Network infrastructure and data usage for IEEE 2030.5 Gateway and IEEE 2030.5 server platform communication.
    - If using cellular communication, costs include the cellular modem, but ultimately, the data usage for each DER as it transmits IEEE 2030.5 data. Otherwise, hardware equipment that is associated with integration into an Ethernet network is required.

- Ongoing maintenance and upgrade costs for the above platforms.

[24] The MBESS 2030.5 communication protocol pilot was not intended to, and did not, estimate what these costs may be, or which entities would bear which portion of these costs.

7. Findings

The demonstration of these cases at the Cameron Corners field site shows the capability of the IEEE 2030.5 server and 2030.5 gateway to work with a legacy inverter on the MBESS to perform the Operational Flexibility using the IEEE 2030.5 standard. Specifically, the successful use cases demonstrated (1) flexibility during grid reconfiguration, (2) capacity increase, (3) voltage boosting with fixed reactive power injection, and (4) voltage reduction with Volt/Var curve mode. In addition, various communication loss scenarios were demonstrated at the ITF. These communication loss scenarios included (1) communication loss between the IEEE 2030.5 server and IEEE 2030.5 gateway and (2) communication loss between the IEEE 2030.5 gateway and MBESS local controller. These communication losses were demonstrated at different times. For instance, communication loss was initiated before the scheduled event started, after the scheduled event started before the event started, and returning before the planned event time elapsed. The results of this project indicate that the MBESS with the IEEE 2030.5 integrated standard will pave the way to include further developments recommended by California Rule 21 and facilitate the monitoring and control of stationary as well as portable DERs in the field.

Findings Discussion

This project demonstrated that the IEEE 2030.5 Operational Flexibility use cases can be successfully performed using the 2030.5 server, 2030.5 gateway, and SDG&E's 4G LTE communications infrastructure. Also, the project demonstrated the IEEE 2030.5 standard can be integrated successfully with the MBESS. Also, through this IEEE 2030.5 standard integration, the MBESS can perform the following use cases: flexibility during grid reconfiguration, capacity increase, voltage boosting with fixed reactive power injection, and voltage reduction with Volt/Var curve mode. This integration enhances the scalability, visibility, operational flexibility, and power quality that the MBESS provides. In addition, since this project focuses on bidirectional communication implementation on the MBESS (i.e., the IEEE 2030.5 standard server and gateway), several realistic communication loss scenarios were studied. These communication loss scenarios include communication loss between the server and gateway and communication loss between the gateway and MBESS local controller. The solution provided (i.e., the MBESS integrated with the IEEE 2030.5 standard) showed successful use case deployment even during communication loss occurrences. Furthermore, as potential next step of this project is including a DERMS action to deliver optimized operation from the perspective of the upper network.

Updated Value Proposition

The updated value proposition achieved with the MBESS integrated with IEEE 2030.5 standard can be described as follows:

Improved Scalability

For flexible resources such as MBESS, the addition of IEEE 2030.5 communication capability supports future scalability for adding other mobile energy storage systems to SDG&E's service territory. For instance, as the utility integrates more MBESS units into its asset portfolio and moves toward owning, operating, and maintaining a fleet of MBESS, it becomes more important to minimize the efforts associated with the integration of a new unit to the 2030.5 control platform (such as DERMS). The IEEE 2030.5 communication enables higher scalability and as a result, faster adoption of new MBESS. DERMS will be an essential utility platform for monitoring and control of DERs, mitigating DER-related operational issues, optimizing grid performance, and capturing new benefits. The increasing scale of DER assets (especially BTM DERs) to be integrated over time highlights the importance of platform scalability. Using a standard framework for communication within all DERs improves the overall interoperability and plug-and-play integration of the assets, which in turn leads to improved scalability for the platform.

Improved Interoperability

IEEE 2030.5 provides a standardized communication framework, ensuring interoperability among different vendors' equipment. This interoperability supports the scalability of resource integration, allowing utilities to connect and manage DER devices seamlessly.

Enhanced Plug-and-Play Integration

With standardized communication protocols, new DER can be easily integrated into the existing infrastructure, promoting a plug-and-play approach. This simplifies the process of adding more resources, enhancing scalability.

Improved Visibility

By enabling a standard communication framework and requiring the DER assets to adhere to that are the key steps to establish the communication between the utility and DER assets, initially for monitoring purposes and enhanced visibility. Monitoring MBESS as a non-stationary utility asset is even more critical than stationary assets from a security and operational perspective. Since the schedule of operation, field staff, physical location and interconnection point might change, the importance of having remote monitoring and visibility is even more highlighted. The operator's visibility toward MBESS in the field (status, availability, measurements, KPIs) leads to operational awareness in the first step. It is eventually the base for decision-making and asset control in the field.

Improved Real-time Data Exchange

The standard facilitates real-time data exchange between utilities and DER, including MBESSs. This improves visibility into the grid's status, enabling utilities to monitor and manage distributed resources more effectively.

Improved Remote Monitoring and Control

Utilities can remotely monitor and control DER, including the MBESS, enhancing visibility into their performance. This allows for proactive decision-making and a quicker response to grid conditions.

Enhanced Operational Flexibility

The ultimate goal for utilities in regard to DER is to leverage their benefits for enhanced grid operations through aggregating and controlling them for different use cases. This is essential while the utility intends to maximize the benefits from DER by stacking its use cases and applications and covering different use cases on a seasonal and locational basis. A standard communication framework that allows for DER integration into utility platforms provides aggregation and control capability over DER assets in the field. This leads to enhanced operational flexibility by managing DER connect/disconnect, controlling their active/reactive power output, and aggregating them for an optimum operation for specific use cases. The operator can use this flexibility to mitigate grid constraints and/or optimize grid operation.

Demand Response Integration

IEEE 2030.5 supports demand response functionalities, enabling the dynamic management of load variations. This flexibility is crucial for optimizing grid operations and responding to changing energy demand patterns.

Improved Grid Stability

By providing real-time information on DER, utilities can make more informed decisions as to the use of the DER. This includes adjusting power flow, managing voltage levels, and ensuring efficient use of the DER.

8. Conclusion

This project successfully demonstrated the Operational Flexibility use cases performed using an IEEE 2030.5 server, IEEE 2030.5 gateway, SDG&E's 4G LTE network and a MBESS with its legacy inverter. In addition, the MBESS's capability to perform several Operational Flexibility use cases was successfully demonstrated. These use cases involved using the IEEE 2030.5 standard as the main bidirectional communication. The successful use cases demonstrated through the IEEE 2030.5 standard use were (1) flexibility during grid reconfiguration, (2) capacity increase, (3) voltage boosting with fixed reactive power injection, and (4) voltage reduction with Volt/Var curve mode. Furthermore, the robustness of the MBESS integrated with the IEEE 2030.5 standard was tested with two communication loss scenarios. These scenarios included (1) communication loss between the server and gateway and (2) communication loss between the gateway and MBESS local controller. Additionally, it was demonstrated that for DERs without inherent 2030.5 communication capability, a protocol converter/gateway can be added locally to enhance the capabilities of the DER and accommodate the IEEE 2030.5 communication.

9. Recommendations

The objective of SDG&E's project was to demonstrate operational flexibility use cases using the IEEE 2030.5 standard with an MBESS in the field. Four use cases focused on CA Rule 21 Phase 3 advanced functions, while two use cases tested the system behavior during communication loss. Based on the successful demonstration of these use cases, it is recommended that SDG&E continue with integrating DERs into their control and monitoring infrastructure using the IEEE 2030.5 protocol and that the IEEE 2030.5 server should be integrated into systems such as DERMS and/or ADMS to further enhance SDG&E's ability to deploy and operate MBESS. In terms of management of the IEEE 2030.5 server, it is recommended that the requirements and policies for DER interconnection are formalized.

Some issues for consideration include:

- Registration and identification of DERs (e.g., in-band, out-of-band methods) Group management policies and prioritization.
- Topology-based groups (e.g., substation, feeder, service point, etc.)
- Non-topology-based groups (e.g., tariff-based, area-based, etc.)
- Consideration of Default DER controls (when no scheduled control is active)
- Default polling and posting rates, etc.
- For DERs that do not support the IEEE 2030.5 protocol, it is recommended to consider adding IEEE 2030.5 gateways that can provide the conversion to a protocol that the DER supports.
- Future exploration of an increased amount of scheduling values.

10. References

[1]. https://www.cpuc.ca.gov/rule21
[2]. https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%201%20Final%20Project%20Report.pdf
[3]. https://www.sdge.com/sites/default/files/EPIC-3%20Project%207-Mobile%20Battery-Module%202%20Final%20Project%20Report.pdf
[4]. https://sunspec.org/wp-content/uploads/2019/08/CSIPImplementationGuidev2.103-15-2018.pdf
[5]. "PROMIS Energization Sheet: Transportation Inspection and Checklist," 2021

Appendix A: Standards and Guidelines

#	Name	Definition
1	ANSI	American National Standards Institute
2	ANSI C37/IEEE	Surges withstand capabilities, whenever applicable
3	ANSI C57/IEEE	Transformer Standards, whenever applicable
4	ANSI Z535	Product Safety Signs and Labels
5	ANSI/IEEE C2	National Electric Safety Code
6	Cal/OSHA	California Occupational Safety and Health Administration
7	CFC	California Fire Code
8	Electric Tariff Rule 21	Generating Facility Interconnections
9	IEEE 1547	IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems
10	IEEE 1881	Standard Glossary of Stationary Battery Terminology
11	IEEE 2030.5	California default communications protocol for residential distributed energy resource (DER) integration applications
12	IEEE 519	IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
13	NEC	National Electric Code
14	NEMA	National Electrical Manufacturers Association
15	NESC	National Electric Safety Code
16	NFPA 704	Standard System for the Identification of the Hazards of Materials for Emergency Response
17	NFPA 855	Standard for the Installation of Stationary Energy Storage Systems *Applicable in the event of adoption by contract execution
18	UL 1642/IEC 62133	Applicable sections related to battery cell safety, where applicable
19	UL 1741	Standard for Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources
20	UL 1778	Underwriters Laboratory's Standard for Uninterruptible Power Systems (UPS) for up to 600V AC

#	Name	Definition
21	**UL 9540/9540A**	Standard for Energy Storage Systems and Equipment
22	**42 United States Code (U.S.C.)**	Noise Control Act of 1972

Appendix B: Metrics for Measuring Success or Failure

SDG&E presented the following metrics specific to SDG&E to measure the success or failure of the OpFlex Pilot:

1. Test completion: Evaluate whether all planned tests were completed, both at SDG&E's Integrated Test Facility (ITF) and the two field locations.
    - Tests were conducted at the ITF and one field location. Although SDG&E initially planned for two field locations, one of them experienced an equipment failure one month prior to the scheduled testing. Despite this setback, the single field location proved sufficient to validate the system. The selection of two locations was a precautionary measure to ensure the continuity of testing in the event of an issue at one site.

2. Equipment installation and integration: Assess the successful completion of hardware installation by the end of Q1 2023 and the integration of the IEEE 2030.5 server and IEEE 2030.5 gateway within the production architecture.
    - The equipment, including IEEE 2030.5 server, was installed at SDG&E's Integrated Test Facility, utilizing SDG&E's production communications system. The IEEE 2030.5 gateway was installed in the battery container which was located at the ITF and later in a remote field location.

3. Test plan development and execution: Examine the collaboration between SDG&E and team executing the test plan at the ITF and the field locations.
    - The collaboration between SDG&E and the team executing the test plan at the ITF and the field locations was highly effective. The project successfully achieved its objectives within the planned timeframe.

4. MBESS performance: Assess the performance of the effectiveness of the MBESS equipped with IEEE 2030.5 functionality as the chosen DER in alleviating circuit operational flexibility constraints under scenarios chosen as test cases.
    - MBESS demonstrated effective performance. For detailed information and specific inquiries, please refer to the report.

5. Communication protocol and profile evaluation: Analyze the benefits and challenges associated with the IEEE 2030.5 protocol and the CSIP profile, including their impact on MBESS performance and Operational Flexibility.
    - After the anticipated integration issues had been resolved, the system worked as expected. Please see report for details.

6. Private LTE system performance: Evaluate the effectiveness of SDG&E's private LTE system for communications during field testing and its suitability for implementation in the context of IEEE 2030.5 related applications.

- Private LTE performance was excellent. Please see report for details.

The following metrics were developed in consultation with the Commission's Energy Division staff and agreed to by the utilities, and provided as Attachment A in each of the Supplemental Advice Letters (PG&E AL 6612-E-C, SCE AL 4017-E-B, and SDG&E AL 4806-E-B). However, as SDG&E previously noted, there are several metrics among the Joint IOU Metrics that are not applicable in a retrospective analysis and evaluation of SDG&E's OpFlex Pilot.

<u>Over-Arching Metrics</u>

1. Pilot adequately tests systems and scenarios to cover the DER Operational Alternatives discussed in Proposal F-1, such as limiting or eliminating exported energy, modifying advanced inverter functions, monitoring and reporting, and other functionality that supports grid operations.
    a. Yes.

2. Value engineering opportunities are considered throughout the process of piloting OpFlex DER operational alternatives.
    a. Yes, please see report for discussion of the use of EPIC project funding for completion of the OpFlex Pilot.

3. Diversity, Equity, and Inclusion are considered in the creation and piloting of the systems to implement Proposal F-1 - such as ensuring that specific communities will not be disproportionately affected by curtailments, etc.
    a. Yes. By using mobile batteries, any area in SDG&E's service territory can be supported.

<u>Demonstrate the Ability to Integrate Participating Generating Facilities into IOU Control Systems</u>

4. DER locations and capabilities can be modeled in IOU systems.
    a. Yes, this capability exists in the Distribution Management System model.

5. DER systems can be provisioned on IOU systems based on IOU's technical requirements.
    a. Yes, DER systems can be provisioned on IOU systems based on IOU technical requirements.

6. DER systems can provide status and telemetry to IOU systems as prescribed.
    a. Currently, telemetry is available only through the use of the SCADA system. Status and telemetry functionalities can be integrated into a future DERMS that supports the IEEE 2030.5 standard.

7. DER systems are interoperable with IOU systems.
    a. This requirement can be further explored with the use of a future DERMS that supports the IEEE 2030.5 standard.

8. IOU systems have near real time visibility of the grid and states for a select number of strategically located DERs (at maximum 1 minute granularity).
    a. Current and future communications systems have this capability. Furthermore, this capability can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

<u>Demonstrate the Ability to Control Participating Generating Facilities</u>

9. IOU can send control signals via IEEE 2030.5 for control commands, limits, or schedules to DER systems.
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

10. DER systems can receive the IEEE 2030.5 control signals from IOU and adhere to the commands.
    a. This capability can be further explored through the use of future DERMS.

11. IOU can send multiple control schedules to DER systems.
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

12. DER systems are capable of adhering to multiple control schedules, including responding properly to as-needed DER operational schedule changes.
    a. This capability can be further explored through the use of future DERMS.

13. DER systems can respond to control commands within 30 seconds (or prescribed response times).
    a. These response time requirements will be determined by SDG&E's Electric Distribution Operations (EDO) team. Response time requirements will inform the necessary technical requirements.

14. Fail-safes for loss of communications or hardware failures are sufficient to avoid potential issues for the grid.
    a. This will need to be explored further in future DERMS that supports the IEEE 2030.5 standard.

15. Control system uptime is similar to existing SCADA uptime metrics for reliability, including the control system Availability (Availability (%) = (Total Operational Time / Total Time) * 100); Mean Time Between Failures (MTBF) (MTBF = Total Operational Time / Number of Failures); Mean Time To Repair (MTTR) (MTTR = Total Downtime / Number of Failures), etc.
    a. These uptime requirements will be determined by SDG&E's Electric Distribution Operations (EDO) team. Uptime requirements will inform the necessary technical requirements.

16. Contractual obligations are in place for DER systems to adhere to technical requirements for OpFlex mitigation (as necessary).
    a. Technical requirements will be specified in any OpFlex Constraint mitigation contracts SDG&E enters into with DER providers.

17. IOU systems can generate and implement DER management scenarios to support OpFlex objectives based on DER states, capabilities, and forecasts. When necessary, this can include temporarily overriding other DER control objectives such as market-based objectives from either the Distribution System Operator (DSO) or Independent System Operator (ISO).
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

18. IOU systems can determine when abnormal conditions are relieved and revert DER operations to default operations.
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

Identify Triggers for OpFlex DER Operational Alternatives (Curtailment, Increased Generation, etc.):

19. IOU System can identify or forecast abnormal switching scenarios and update DER constraints in near real-time (at maximum 1 minute granularity).
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

20. IOU System can adequately forecast the impacts of changing DER import/export in relation to grid conditions.
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

21. Automation of trigger identification can be scaled across the system.
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

22. Informational systems are updated to provide the OpFlex capabilities of any particular facility.
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

Develop Methodology to Calculate DER Management Scenario Characteristics and Allocate Actions Appropriately (Curtailment, Increased Generation, etc.)

23. A process is developed to determine the amount of curtailment, increased generation, etc. required at each generating facility during an OpFlex event (circuit reconfiguration, etc.).

   a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

24. Automation is developed to determine the amount of curtailment, increased generation, etc. required at each generating facility during an OpFlex event to be able to scale system wide.
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

25. System-generated curtailment/generation set points do not create additional issues for the grid.
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

26. System-generated curtailment/generation set points are not overly restrictive to DER system customers based on grid behavior.
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

27. Functional requirements involved in the DER management scenarios are recorded for future discussion.
    a. This will be a requirement of the future DERMS with 2030.5.

28. Develop Operational Processes to Implement OpFlex DER Operational Alternatives:
    a. Appropriate processes would be developed to support a DERMS that supports the IEEE 2030.5 standard.

29. Develop engineering tools to analyze switching scenarios with various operational alternative capabilities of facilities.
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

30. Develop processes for Operators and Engineers to dispatch new settings to facilities.
    a. Appropriate processes would be developed to support a DERMS that supports the IEEE 2030.5 standard.

31. Mitigation processes are in place and are adequate when facilities do not respond or inadequately respond to utility commands.
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

Demonstrate Ability to Monitor and Report on OpFlex DER Operational Alternative Success

32. IOU systems can determine when DER management scenarios do not achieve objectives and record information regarding why.
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

33. IOU systems have the capacity to store data on the characteristics, such as the length and operational alternatives executed, of the DER management scenarios during abnormal conditions for the purpose of reporting and/or using this data to assess the impacts of the scenarios.
    a. This requirement can be further explored with the implementation of a future DERMS that supports the IEEE 2030.5 standard.

<u>Evaluation Metrics--Reflect on Lessons Learned and Assess the Potential for Scaling Proposal F-1</u>

34. Lessons learned: key lessons learned from the pilot are identified.
    a. For a comprehensive discussion of key findings and recommendations, please refer to the full report. In summary, it has been observed that mobile batteries can be effectively deployed using existing production communication infrastructure for Op Flex use cases. However, challenges related to the required sizes and availability of these batteries may arise and will need to be addressed.
    b. The deployment of mobile batteries for Op Flex, utilizing the IEEE 2030.5 standard, necessitates the involvement of multiple employees equipped with various tools and skillsets. The tasks of moving, connecting, testing, and operating the batteries are complex and require significant time and teamwork. The pilot has demonstrated that with proper coordination, these operational challenges can be successfully managed. The necessary collaboration among team members is achievable, ensuring the effective use of mobile batteries in real-world scenarios.

35. Stakeholder feedback: Collect feedback from relevant stakeholders, including utility personnel, DER owners, and regulators, to gain insights into the pilot's effectiveness, areas for improvement, and the value proposition for future use of IEEE 2030.5 in the context of Operational Flexibility.
    a. For this use case, there is a need for various mobile batteries of different sizes and State of Charge (SOC) to be available. Trained personnel are required and need to be available to operate the battery. Sufficient space is required to park the multiple MBESS with EVSE available for all MBESS. Any future work in this space will likely be informed by feedback from DER owners with whom SDG&E may contract to provide Op Flex Constraint mitigation and from regulators.

36. Scalability: The potential and appropriateness of utilizing future EPIC-funded projects and/or GRC funds to expand the functionalities necessary for Proposal F-1 and scale up the pilot's results is assessed.

    a. Future EPIC-funded projects and/or GRC-authorized funding will need to be allocated to build and operationalize an enterprise Distributed Energy Resource Management System within SDG&E's Electric Distribution Operations team that supports the functionalities necessary for Proposal F-1. Additionally, funds will likely be required for other stakeholders who will need to perform work to ensure the enterprise DERMS becomes fully operational and possess the functionality contemplated within the Joint IOU Metrics. This includes the development of necessary infrastructure, training of personnel, and integration with existing systems to support the expanded functionalities envisioned in Proposal F-1.

37. Additional DER operational alternatives that could assist in operationalizing and scaling proposal F-1 are considered for future testing.
    a. The next step for SDG&E involves the development and integration of an enterprise Distributed Energy Resource Management System within our existing Network Management System. This integration is pivotal for enhancing our grid management capabilities, enabling more efficient, reliable, and resilient operations. The enterprise DERMS will facilitate advanced coordination and optimization of utility-owned DERs and DERs with whom SDG&E may contract to provide distribution services, thereby supporting the scalability and operational flexibility required for Proposal F-1. This initiative will also necessitate comprehensive planning, resource allocation, and collaboration with various stakeholders to ensure successful implementation and operationalization.

38. Documentation and dissemination: Ensure that the learning outcomes, benefits, and challenges are well-documented through reports, technical papers, and input to standards development.
    a. This report, along with the dissemination of this work through the forum of EPIC, will play a pivotal role in ensuring that the lessons learned are effectively shared with a broad range of stakeholders.