FLOW BATTERIES North America

BATTERY COUNCIL INTERNATIONAL

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Sumitomo Electric USA

October 27-29 | Chicago, IL | Renaissance Chicago Downtown

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Marc Newmarker

Principal Engineer - Advanced Clean Technology

San Diego Gas & Electric

October 27-29 | Chicago, IL | Renaissance Chicago Downtown

$16.7B

2023 revenue

~300K

Miles of transmission and distribution lines

~40M

Consumers

20 YRS

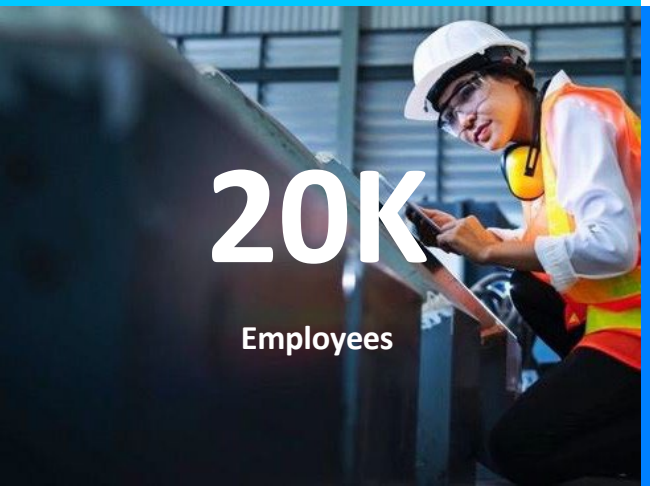
Outperforming peers on comparative total returns

$87B

In total assets (2023)

SEMPRA™

Together, we are making a bigger impact



20K

Employees

One of the largest regulated utility customer base in the U.S.

3

Growth platforms

100+

Years of history in the energy industry

Building North America's premier energy infrastructure company

SEMPRA

San Diego Gas & Electric

Providing Clean, Safe, Reliable Energy

More than an energy company, we're a people company

San Diego Gas & Electric is an innovative energy company that provides clean, safe, and reliable energy to better the lives of the people we serve in San Diego and southern Orange counties.

3.7 MILLION CONSUMERS

We distribute energy service to 3.6 million people through 1.49 million electric meters and 905,000 natural gas meters in San Diego and southern Orange counties.

4,600+ EMPLOYEES

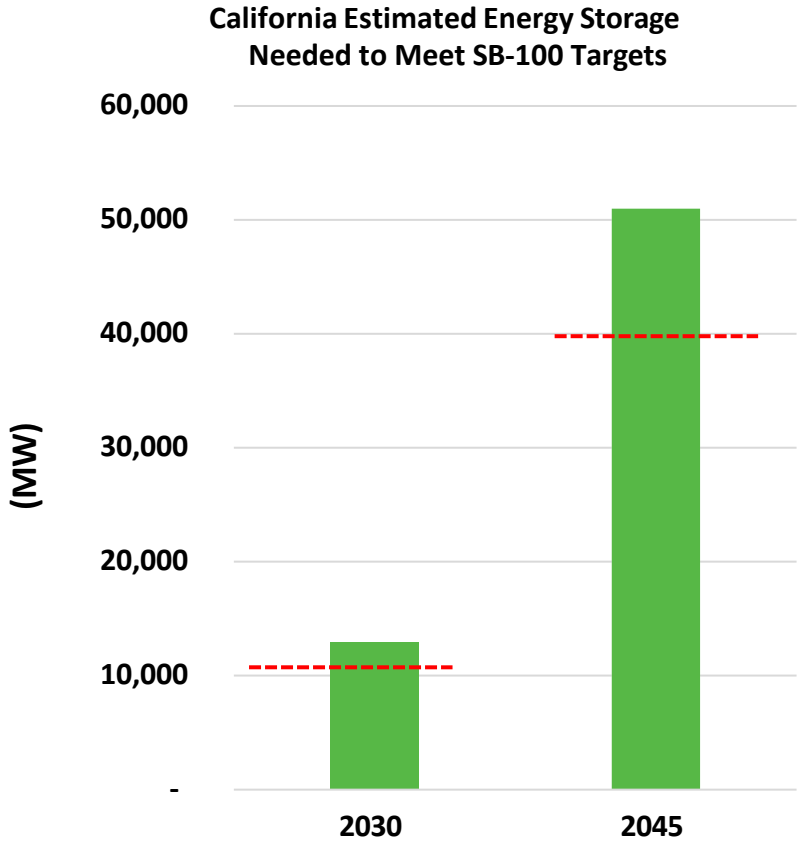
We employ more than 4,600 people who work every day to deliver the energy our customers need.

4,100 SQUARE-MILE SERVICE AREA

We supply power to a population of 1.4 million business and residential accounts in a 4,100 square-mile service area spanning 2 counties and 25 communities.

Significant Energy Storage Needed to Meet California Climate Goals

- Sizable generation retirements expected across the west will require significant energy storage over next 10-20 years to meet the state's climate goals
- Statewide, expected average annual growth ~8GW of solar, and ~2GW of battery storage, beginning in 2023 to support electrification[1]
- SDG&E's projected regional electricity consumption expected to double from 2020 to 2045, primarily driven by transportation electrification[1]
- SDG&E's projected regional electric net peak demand grows by 85% from 2020 to 2045[1]



1. SDG&E Path to Net Zero Study Estimates

Note: Includes 38 MMT case from IRP and CEC SB100 Core scenario. CARB Scoping Plan being updated, as are CPUC IRPs.

SDG&E Existing Utility Owned Storage

In Operation | Under Construction

Project/Location	MW / MWh	COD
In-Service Energy Storage Projects (~443.1 MW)		
Borrego, Canyon Crest, Ortega Hwy, Borrego Springs	5.6 MW / 11 MWh	2012-2015
Escondido	30 MW / 120 MWh	2017
El Cajon	7.5 MW / 30 MWh	2017
Miguel VRF	2 MW / 8 MWh	2017
Miramar Top Gun	30 MW / 120 MWh	2021
Kearny	20 MW / 80 MWh	2022
Ramona Air Attack Base	0.5 MW / 2 MWh	2022
Fallbrook	40 MW / 160 MWh	2023
Westside Canal	231 MW / 924 MWh	2023
Melrose	20 MW / 80 MWh	2023
Pala-Gomez Creek	10 MW / 60 MWh	2023
Boulevard, Clairemont, Paradise, Elliot	39 MW / 180.5 MWh	2023
Borrego Microgrid Expansion	7 MW / 17 MWh	2025
Cameron Corners	0.5 MW / 4 MWh	2025*
Under Construction Energy Storage Projects (40 MW)		
Fallbrook 2.0	30 MW / 120 MWh	2024
Santee	10 MW / 40 MWh	2024
Total	**~483.1 MW**	

Sumitomo Electric Introduction

Parent Company:

Sumitomo Electric Industries, Ltd.

- Founded in **1897**
- Headquartered in Osaka, Japan
- Employees worldwide: **290,000**
- **Net Sales: $29B**

US Subsidiary:

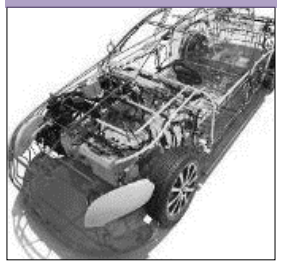
Sumitomo Electric U.S.A (SEUSA)

- Established in 1971
- Headquartered in Torrance, CA
- US based employees: **58**
- **Net Sales: $42M**

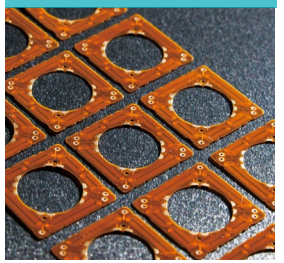
Environment & Energy

Info-communications

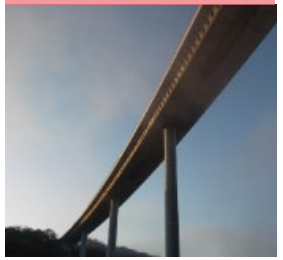
Automotive



Electronics



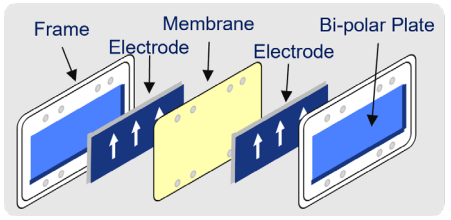
Industrial Materials

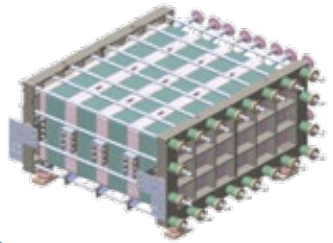


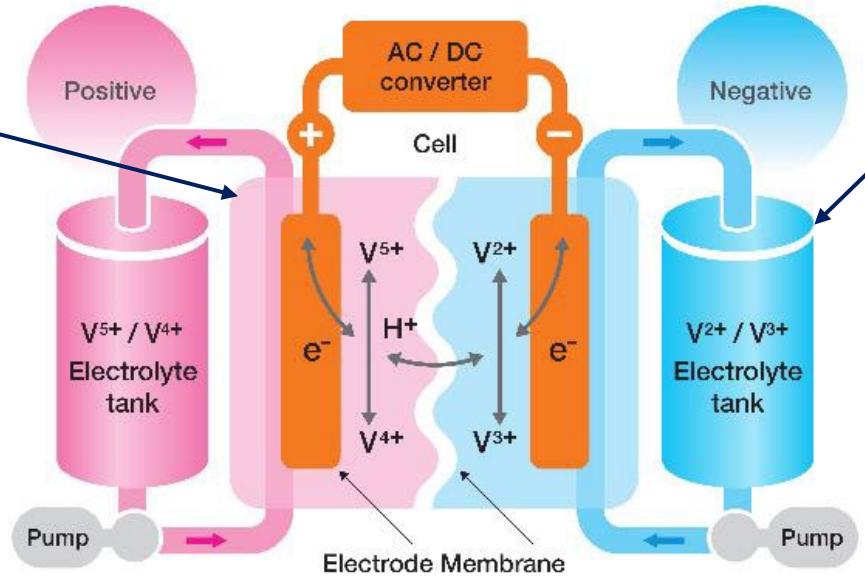
Conversion rate: 151.41 JPY to USD.
Figures are as of the fiscal year that ended March 31, 2024.

Sumitomo Electric's Vanadium Redox Flow Battery Technology

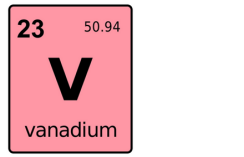
Key Component 1
Battery Cell Stack







Key Component 2
Vanadium Electrolyte



Positive Reaction

$V^{4+} \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftarrows}} V^{5+} + e^-$

Negative Reaction

$V^{3+} + e^- \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftarrows}} V^{2+}$

- ✓ Vanadium electrolytes in positive and negative are always circulating by pumps in order to make redox reaction in cell stack.
- ✓ Flow battery can be charged and discharged through this redox reaction.
- ✓ The redox reaction do NOT deteriorate the electrolyte, so the electrolyte can be used semi-permanently.

Sumitomo Electric: Installation Record Worldwide

John Cockerille
1.7MWh *C&I*

Nippon PS
750kWh *C&I*

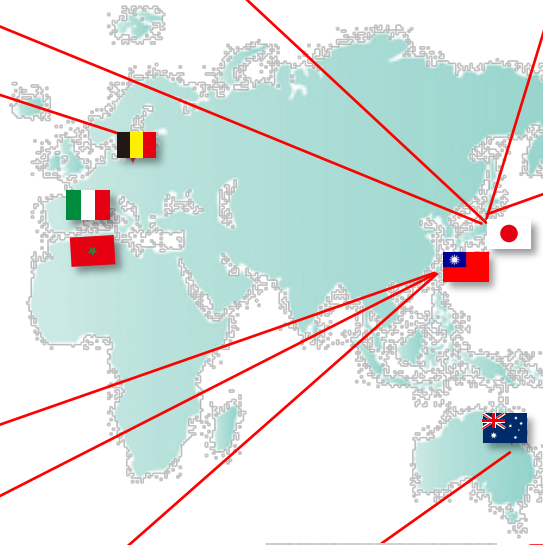
Kashiwazaki IR Energy
8MWh Wholesale Market

Hokkaido Electric Power (HEP)
51MWh *Grid Balancing (wind)*

HEP
60MWh *Dispatch*

52 MW

190 MWh



SUMITOMO ELECTRIC
Connect with Innovation

ITRI
3MWh
Electrolyte Production

National Lab.
750kWh
VPP

Taiwan Power
750kWh
Multiuse

Energy Queensland
750kWh
Electrolyte Production

San Diego Gas & Electric (SDGE)
8MWh
Wholesale Market

SDGE
4MWh
Wholesale Market, Microgrid

Miguel Substation Project Outline

Multi-use operation of VRFB system on the distribution grid of SDG&E to prove economic value & potential for the use on electric grids.

- ✓ **Capacity**:
  8MWh (2MWx4h, Max 3MW)
- ✓ **Location**:
  SDG&E, Miguel S/S (CA, USA)
- ✓ **Use Cases**:
  - Distribution line applications such as peak-shaving, peak-cut
  - Operation in CAISO market
  - Microgrid
- ✓ **Project Partners**:

CALIFORNIA Governor's Office of Business and Economic Development

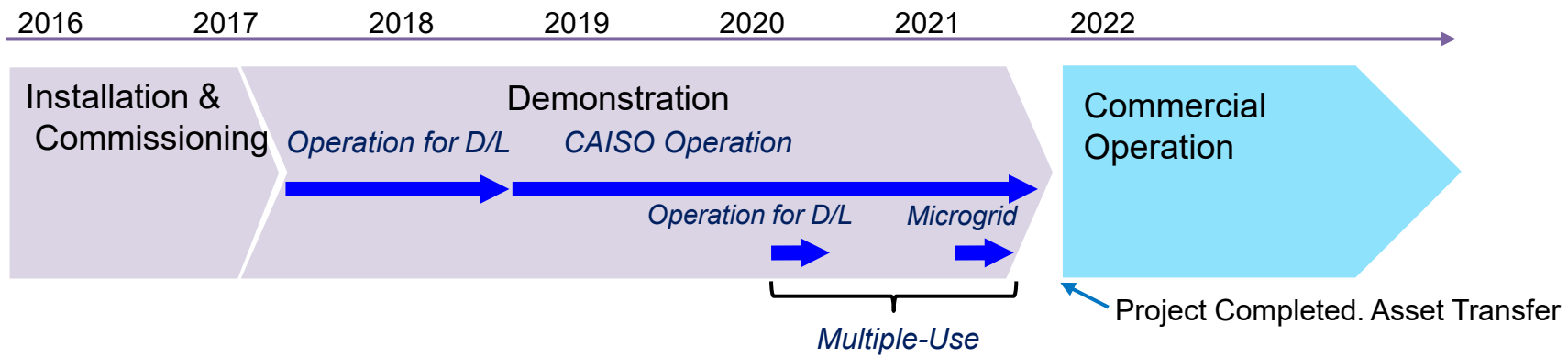
SDGE

NEDO

SUMITOMO ELECTRIC

Demonstration Period

Step	Item	Contents, Target
1	Distribution	✓ Confirm basic control function in distribution line ✓ Peak Shaving, Peak Shift, Capacity Firming, Voltage Control, and so on.
2	CAISO Market	✓ Energy Market, Ancillary Service ✓ Bidding algorithm study for revenue improvement
3	Multi-use, Microgrid	✓ Multi-use for distribution and CAISO operation ✓ Multi-use for CAISO operation in normal and microgrid operation in emergencies



Beyond Pilots

99% Operational Availability over final 2-yrs of demonstration period

California Flow Battery System

Capacity	8MWh (2MW x 4h)
Operator	San Diego Gas and Electric
Application	CAISO Market, Peak Shaving, Microgrid
Demonstration	2017 – 2022
LTSA	20-yrs
Support	NEDO, California Go-Biz

NEDO New Energy and Industrial Technology Development Organization

CALIFORNIA Governor's Office of Business and Economic Development

SDG&E Executed option to Purchase 2022

California LDES Flow Battery System

Capacity	4MWh (0.5MW x 8h)
Customer	*San Diego Gas and Electric*
Application	CAISO Market, Microgrid
Operation	2025~
LTSA	20-yrs

SDG&E Cameron Corners

Long Duration Energy Storage for Community Microgrid

This facility is designed to establish a community microgrid in conjunction with the adjacent photovoltaic generation system, ensuring energy supply during Public Safety Power Shutoff (PSPS) events (intended to provide coverage up to three days) as a part of SDG&E' s wildfire mitigation program. Under normal condition, the system operates in the CAISO market.

The system consists of two 250 kW battery modules (totaling 0.5 MW and 4 MWh with eight-hour duration), which are connected in series on the DC side to the PCS.

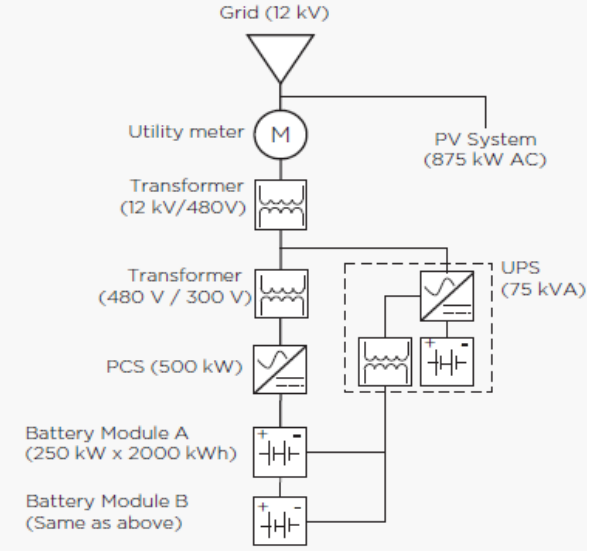
Project Overview

- Capacity: 4 MWh (0.5 MW × 8 h)
- Rated Power: 0.5 MW
- Location: Cameron Corners, California, US
- Operation Start: 2025 (Commercial Operation)
- Use Cases: CAISO operation, Community microgrid with black start capability
- Grid Connection: 12 kV
- Battery Footprint: 38.7 × 42.3 ft² (11.8 × 12.9 m²)
- Elevation: Above 2,500 ft (approx. 800 m)

Battery Specification

- DC Voltage Range: 480 - 780 V
- Battery Enclosure: 20 ft Container (LQ: Low Cube)
- Tank Type: 40 ft Container (HQ: High Cube)
- HVAC: Forced Air
- Aux. Power Supply: 208 VAC
- Certification: UL 9540A, UL 1973

SLD Overview



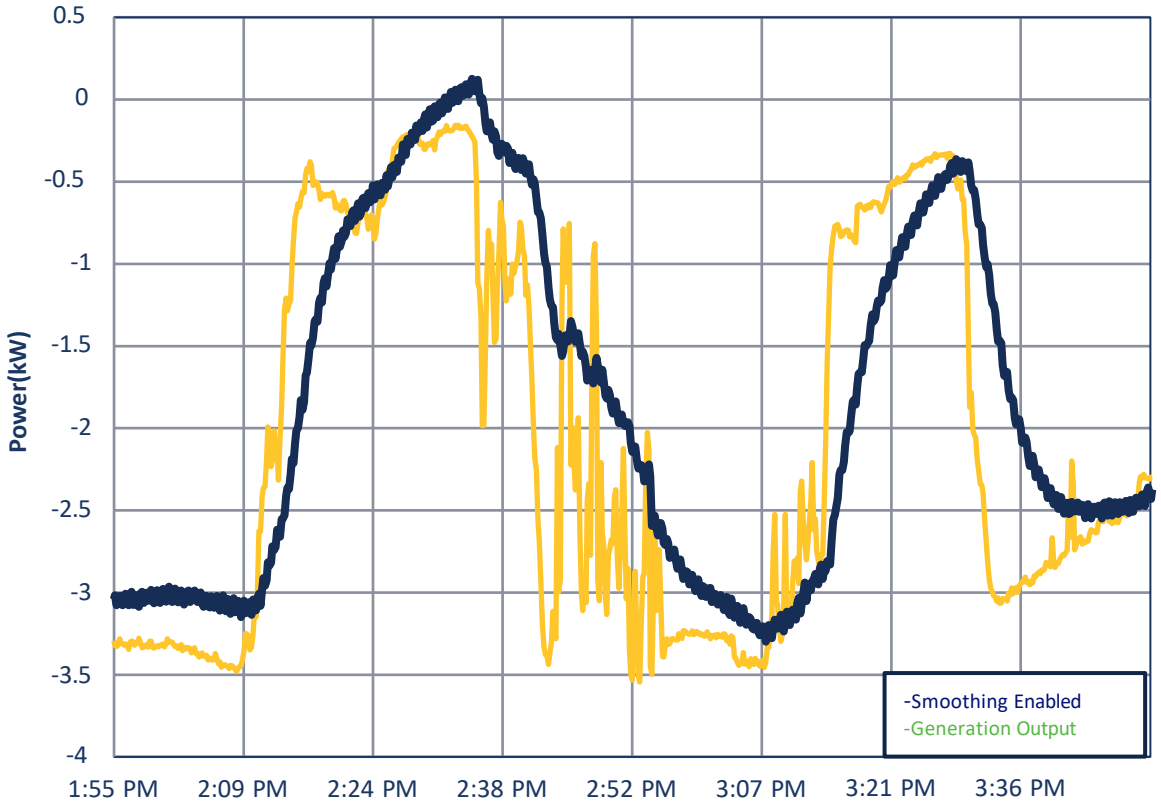
Moderator Led Q&A

Moderator Q&A

- Can you describe the results of the various use cases tested at the Miguel project?
    - Ideally providing specific examples

Capacity Firming/PV Smoothing Operation

Smoothing intermittencies caused by fluctuating power output



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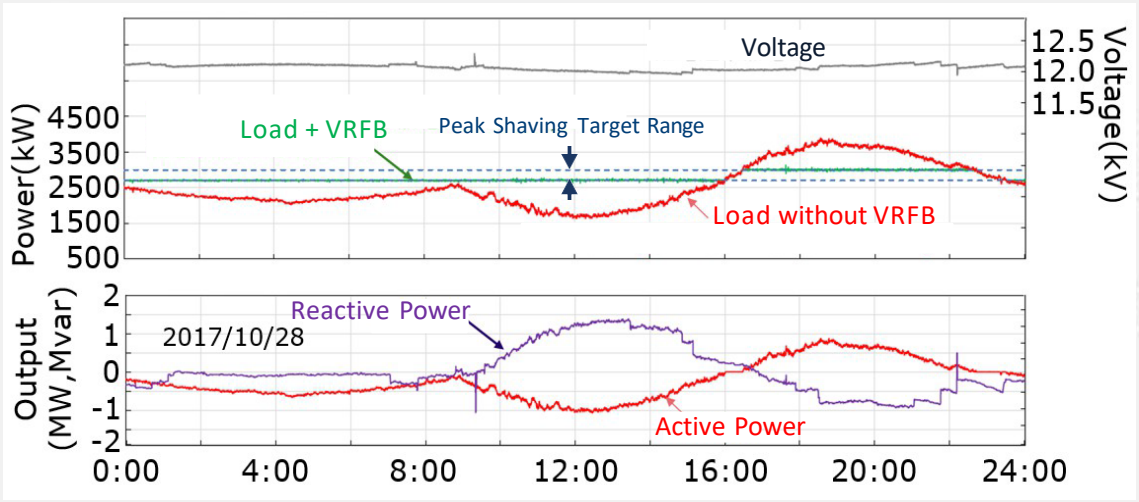
Capacity Firming/PV Smoothing Operation

Distribution Network

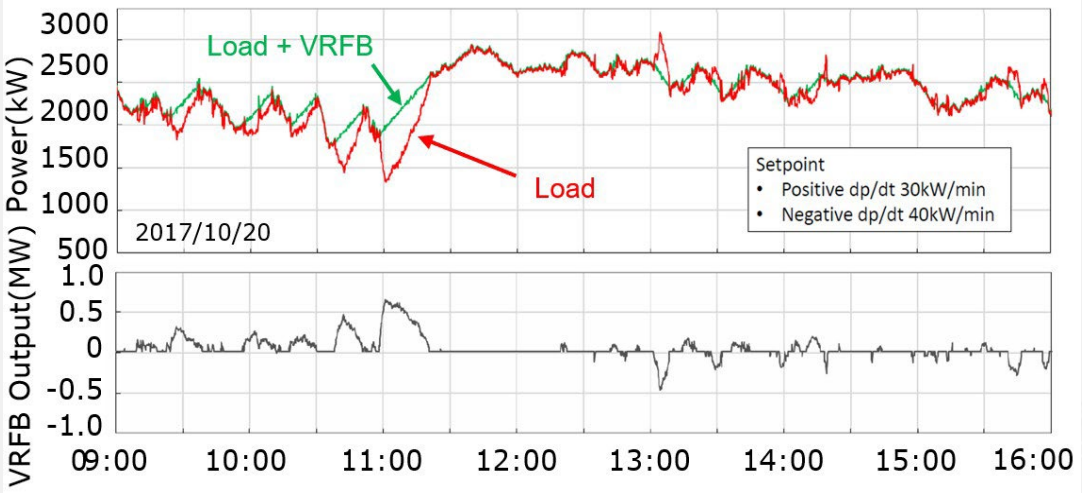
Peak shaving / Base loading

Reduce infrastructure investment and O&M costs.



Renewable Firming

Fluctuations in renewables can be suppressed.



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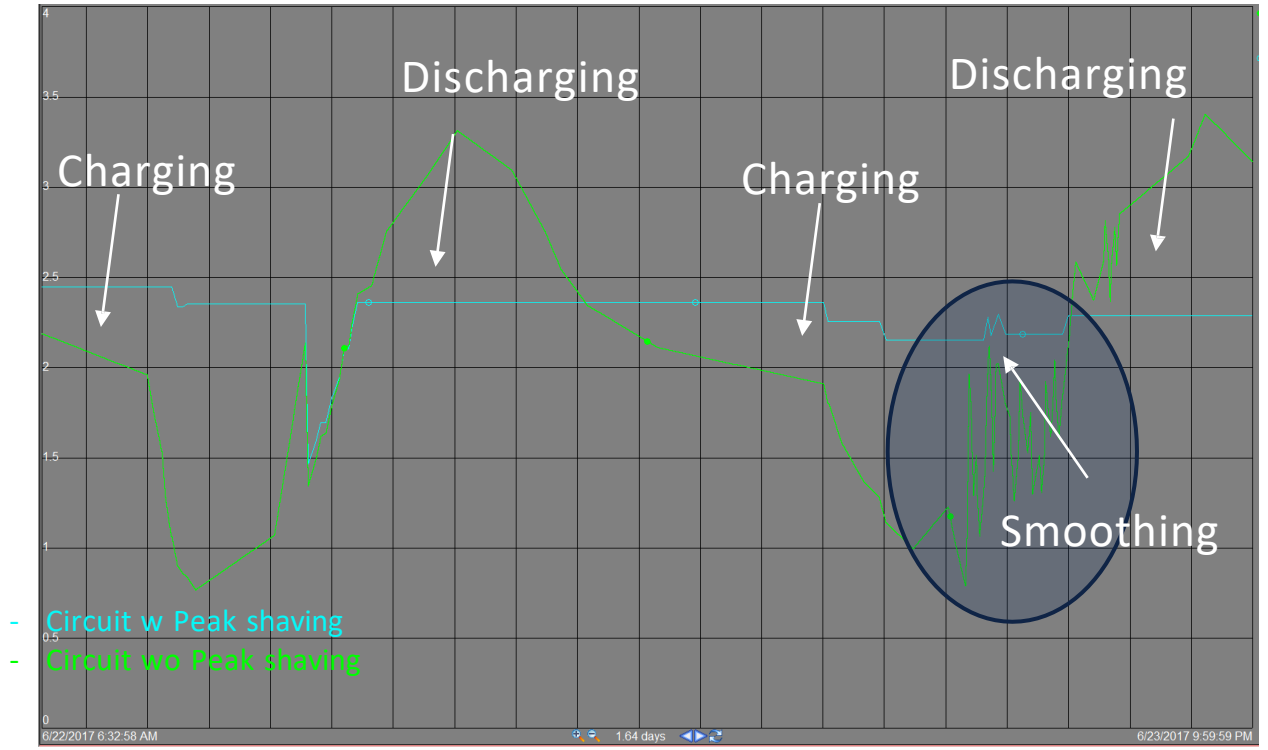
Capacity Firming/PV Smoothing Operation

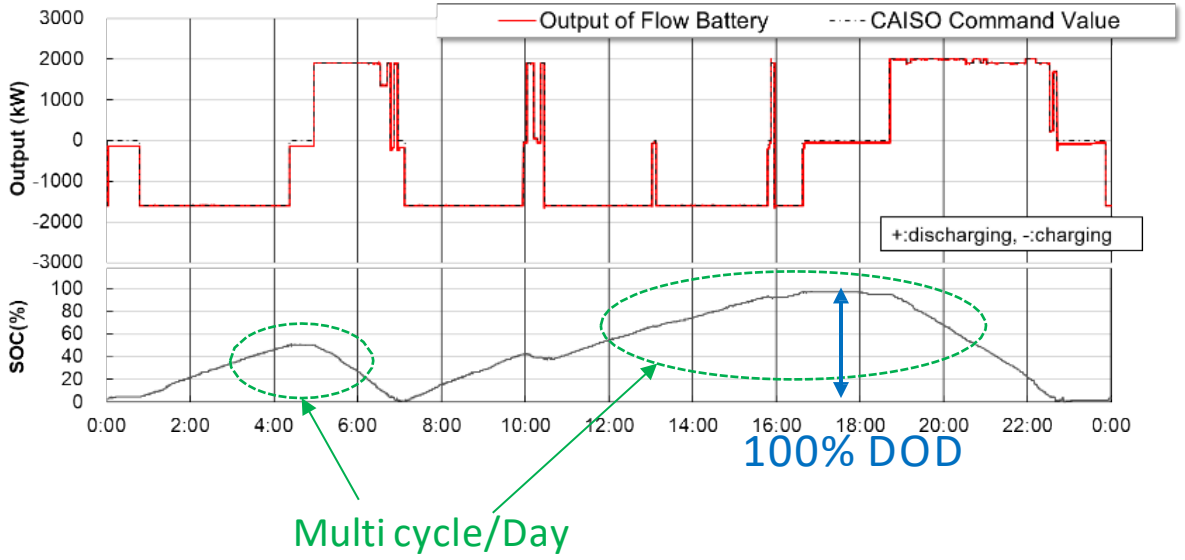
- Data of June 22nd - 23rd 2017
- Peak Shaving & Base Loading (flatten the load curve of feeder and reduce loading at substation)
- Smoothing with high-speed communications



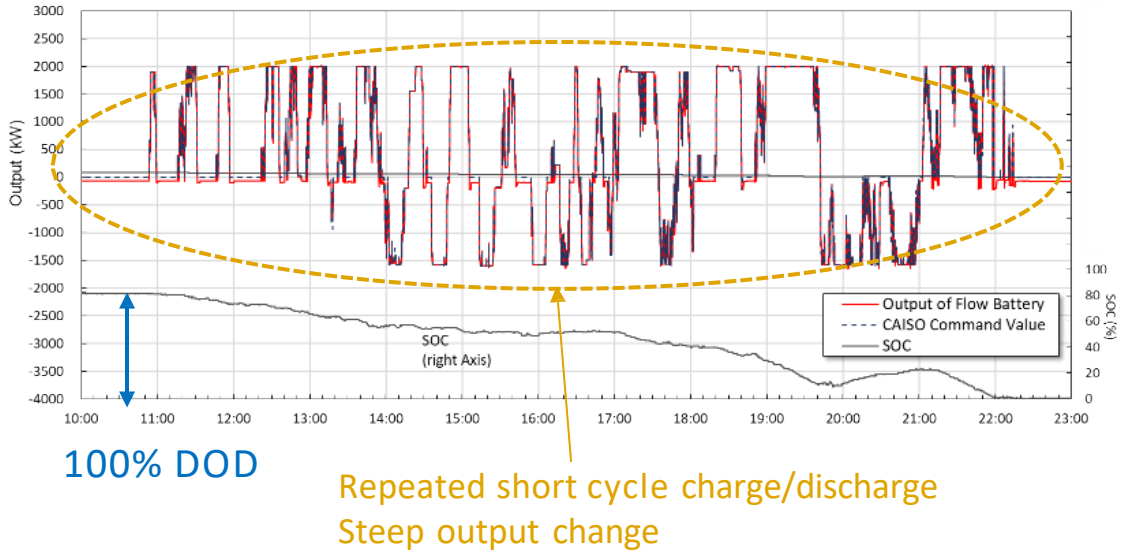
Market Participation

- Dec.2018 CAISO operation started with Energy market only
- Jun. 2019 Operation in both Energy and AS market was started
- Aug.2021 CAISO operation study is completed

*Typical operation in **Energy Market***



*Typical operation in **Ancillary Service***



**Due to confidentiality, Market Revenue cannot be displayed*

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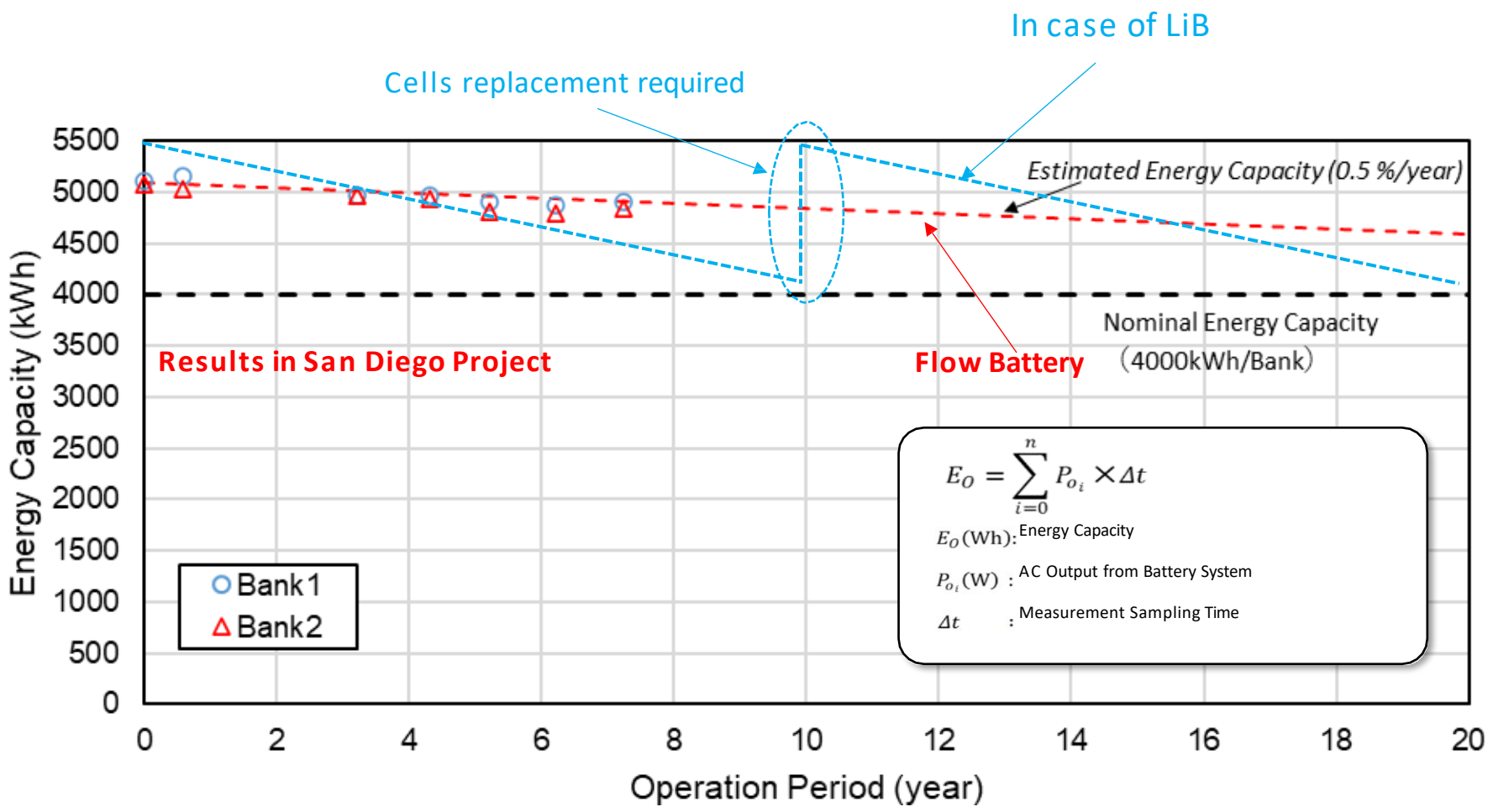
Moderator Q&A

- Can you speak to overall performance, degradation, or other key indicators?

Minimal Observed Degradation Miguel Substation



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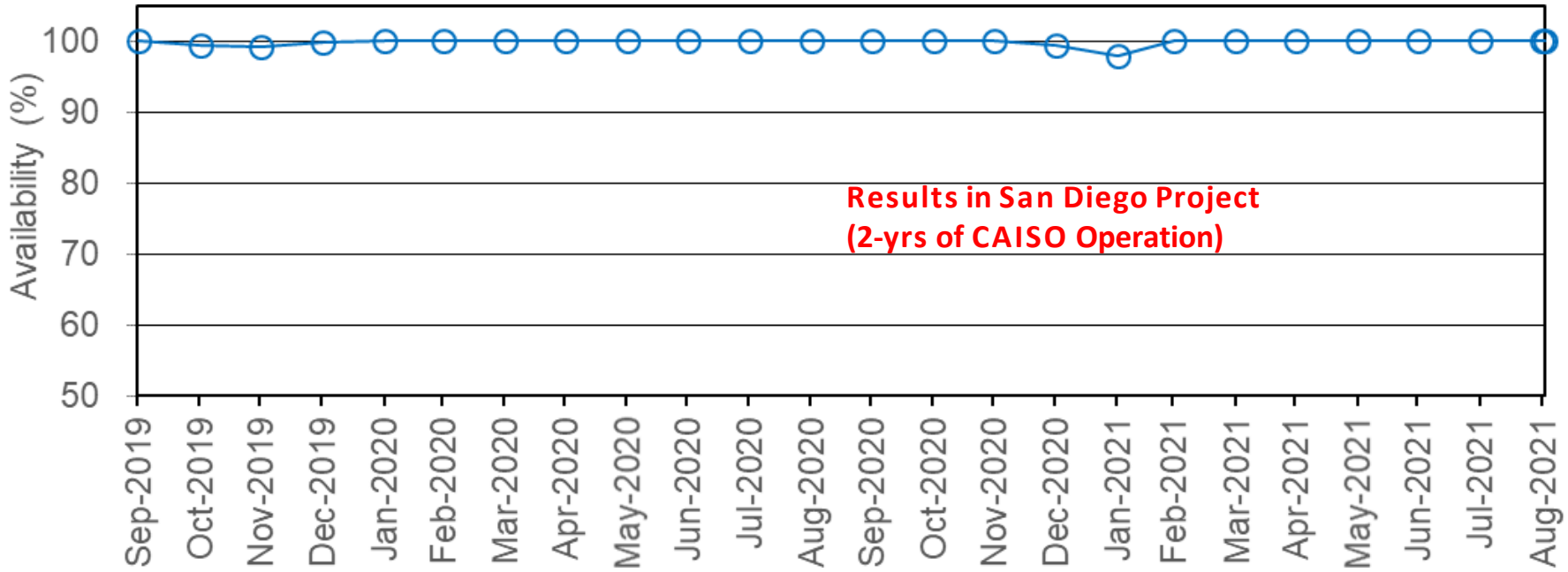
High Availability Miguel Substation

- ✓ The system kept high availability during CAISO operation.
  (99% over 2 year period)
- ✓ The data includes unexpected stoppage by PCS and Battery components.

Availability = B / (A-D)

A	Total Time Frame (Jun.2019~Aug.2021)	19368 hour
B	CAISO Operation	15883 hour
C	Unscheduled Down Time Due to Battery	166 hour
D	Others (Scheduled Down Time, Unscheduled Down Time due to other than battery system)	3320 hour



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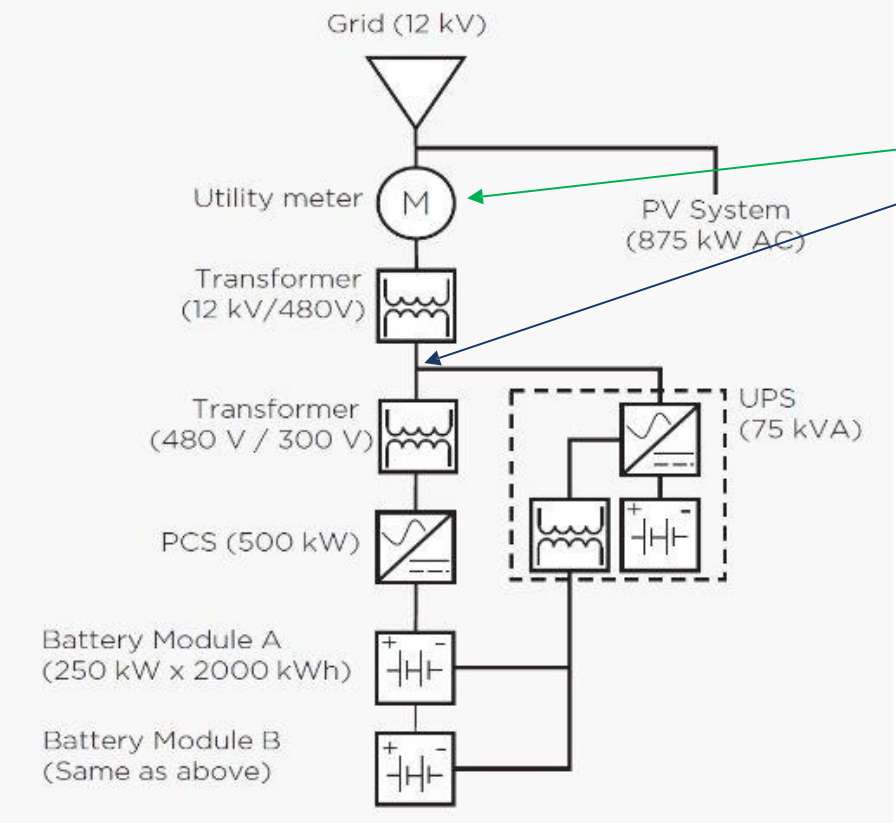
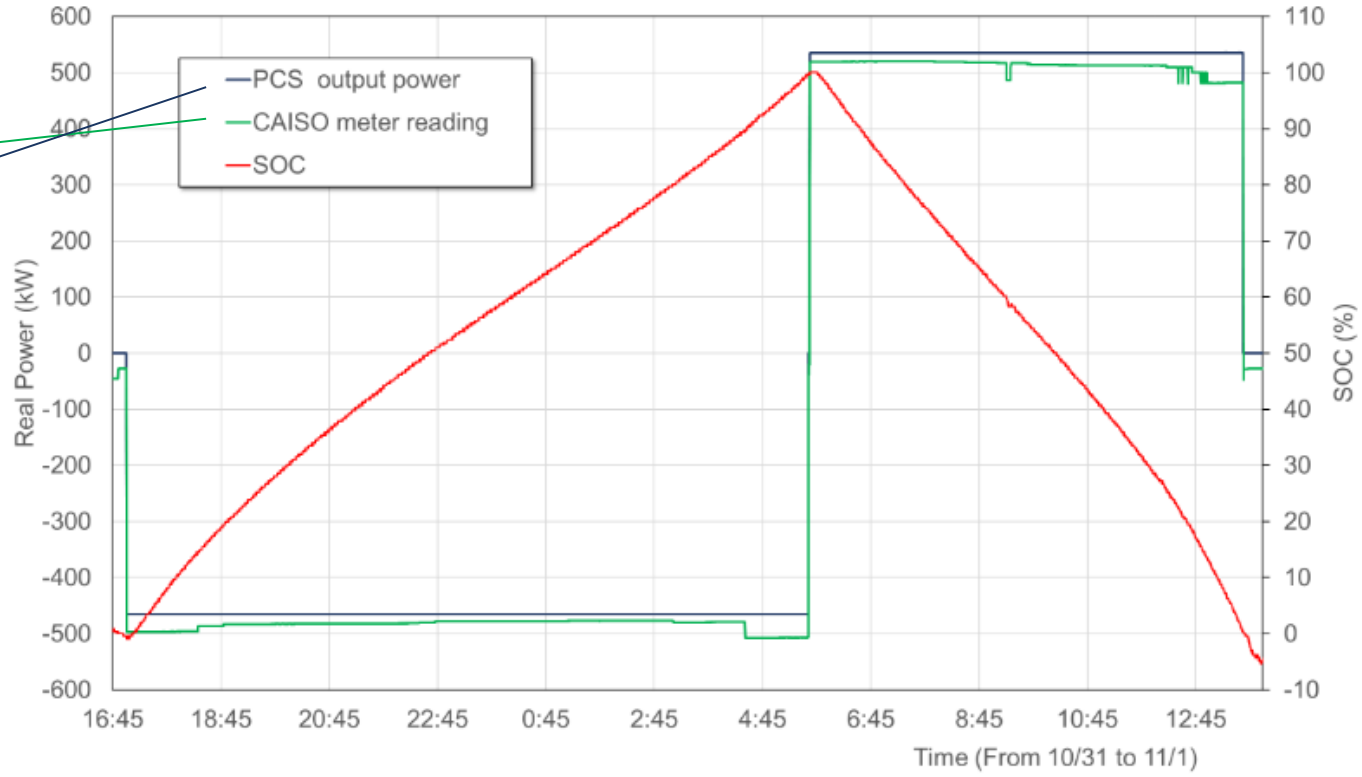
Charging/Discharging Test Cameron Corners Microgrid





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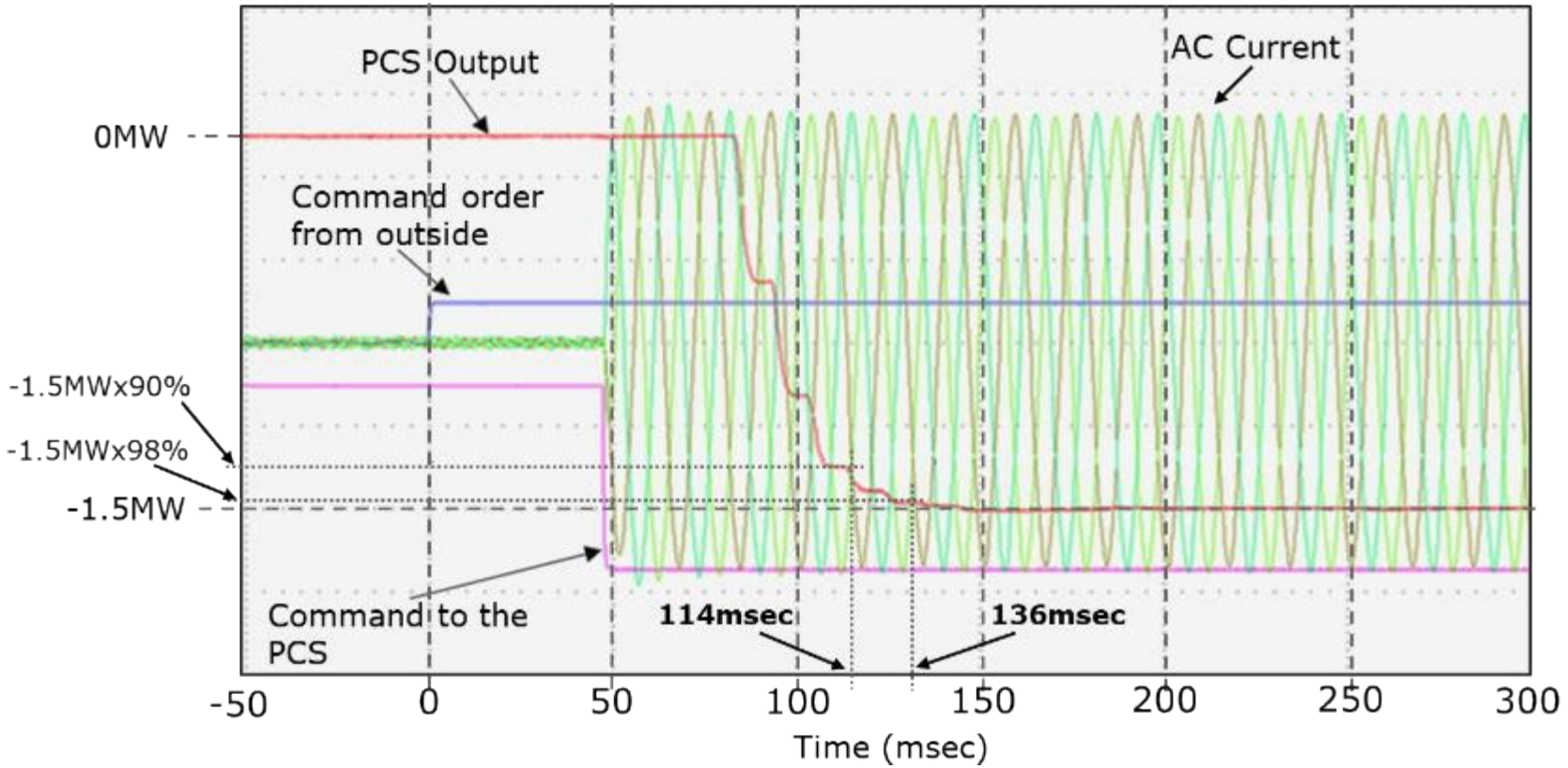
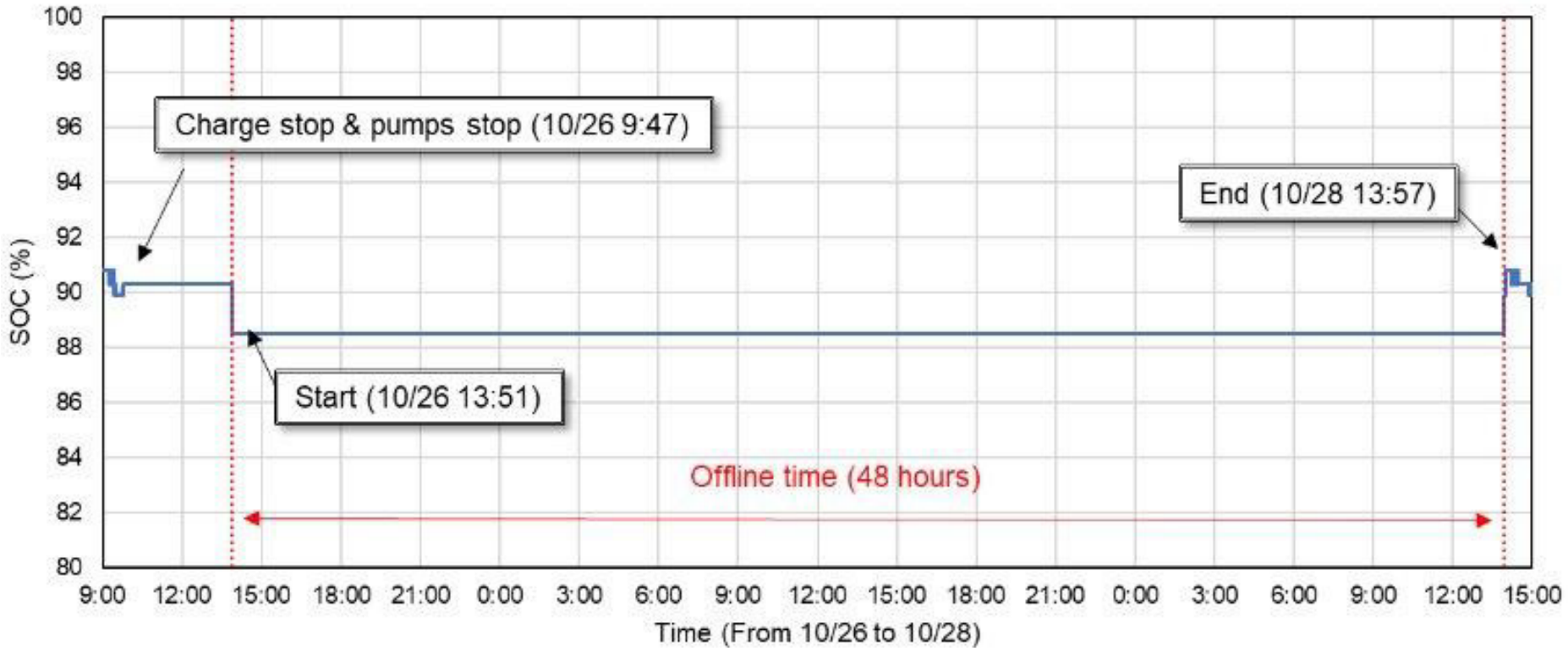
Response Time
Miguel Substation

- ✓ Response time depends on latency and PCS response.
- ✓ Response time tested during commissioning was less than 200msec.
- ✓ Battery itself can respond in less than 0.1msec.



No SoC Decrease During System Downtime Cameron Corners Microgrid



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CAISO Resource Adequacy Requirements

- CAISO Tariff Appendix K – Ancillary Service Requirement Protocol (ASRP)

- CAISO monitors
  - actual real power level (MW);
  - high limit, low limit and rate limit values
  - in-service status indication confirming availability of Regulation service.
  - Resource Ramp Rate when operating as Generation (MW/min);
  - Resource Ramp Rate when operating as Load (MW/min);
  - The maximum instantaneous ability to produce or consume Energy in MW;
  - The maximum capability to provide Energy as expressed in MWh over a fifteen (15) minute interval

- Requirements for Certification
  - the rated capacity of 500 KW or greater
  - Minimum Governor Performance
    - 5 percent droop ;
    - +/- 0.036 Hz deadband;
    - Power output changes in one second for any freq deviation outside of the deadband;
  - Minimum Frequency Responsive Device Performance
    - frequency $\leq$ 59.92 Hz, the resource must reach ten (10) percent of its awarded spinning capacity within eight (8) seconds;
    - The resources must change the power it delivers or consumes in one (1) second if system frequency is less than or equal to 59.92 Hz
  - Respond to dispatch within one (1) minute
  - Full power charge or discharge within ten (10) minutes

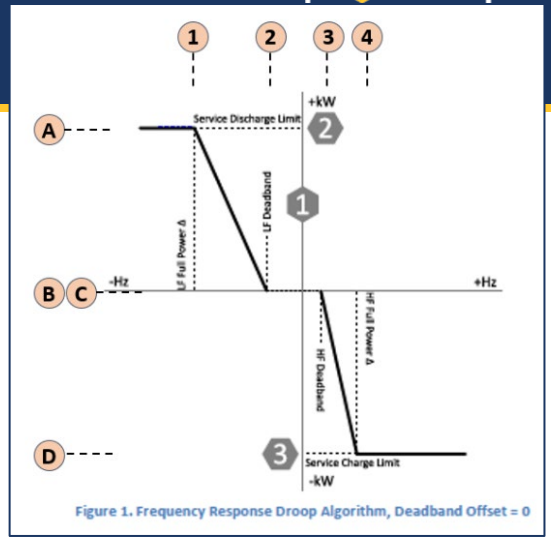

Figure 1. Frequency Response Droop Algorithm, Deadband Offset = 0

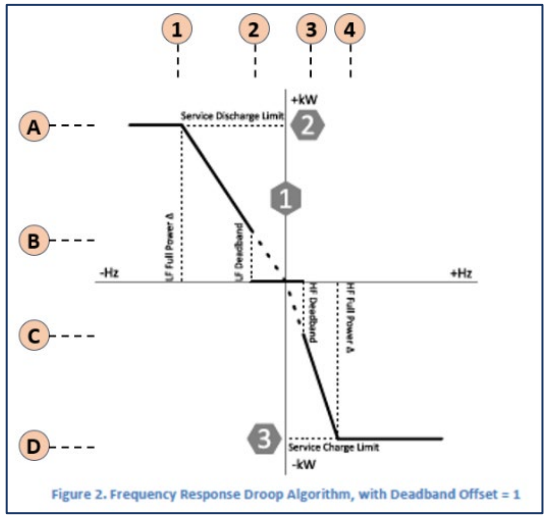

Figure 2. Frequency Response Droop Algorithm, with Deadband Offset = 1

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Moderator Q&A

- You mentioned this system was also intended to demonstrate microgrid operation, can you expand on that a bit more and show any relevant data
- *Microgrid aspect added to the project in 2021*

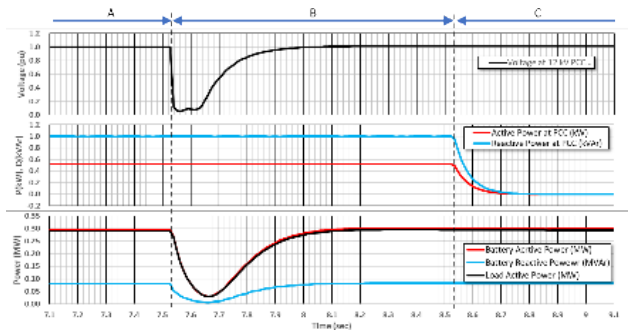
Microgrid Boundary

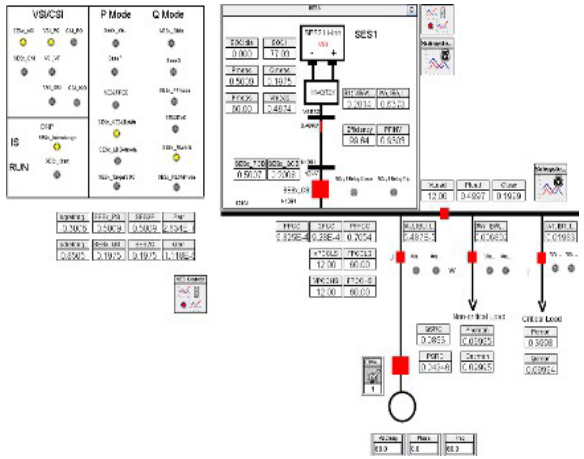
- ✓ The microgrid included 66 customers over 1.5 miles of distribution

Dynamic Testing

Selection of Microgrid Area

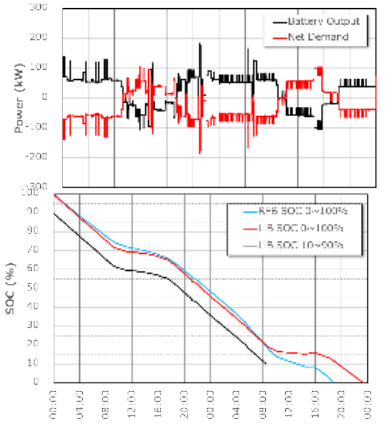
- Simulation using actual distribution network constants and load data by grid simulator (RTDS)
- Control parameter setting by transient response simulation of black start and seamless transition





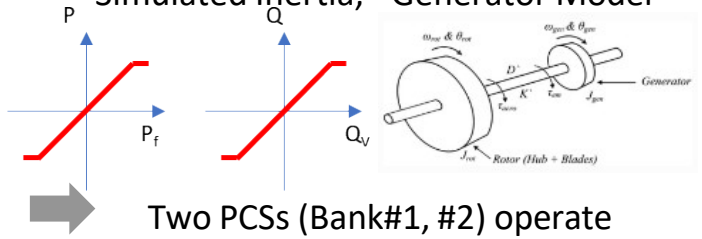
Duration Consideration

- Simulation of flow battery modeling
- Calculations of duration using actual load data for selected microgrid areas



Voltage Source Parallel Operation

Apply the following algorithm to PCS
- Simulated Inertia, - Generator Model



Two PCSs (Bank#1, #2) operate independently of voltage source

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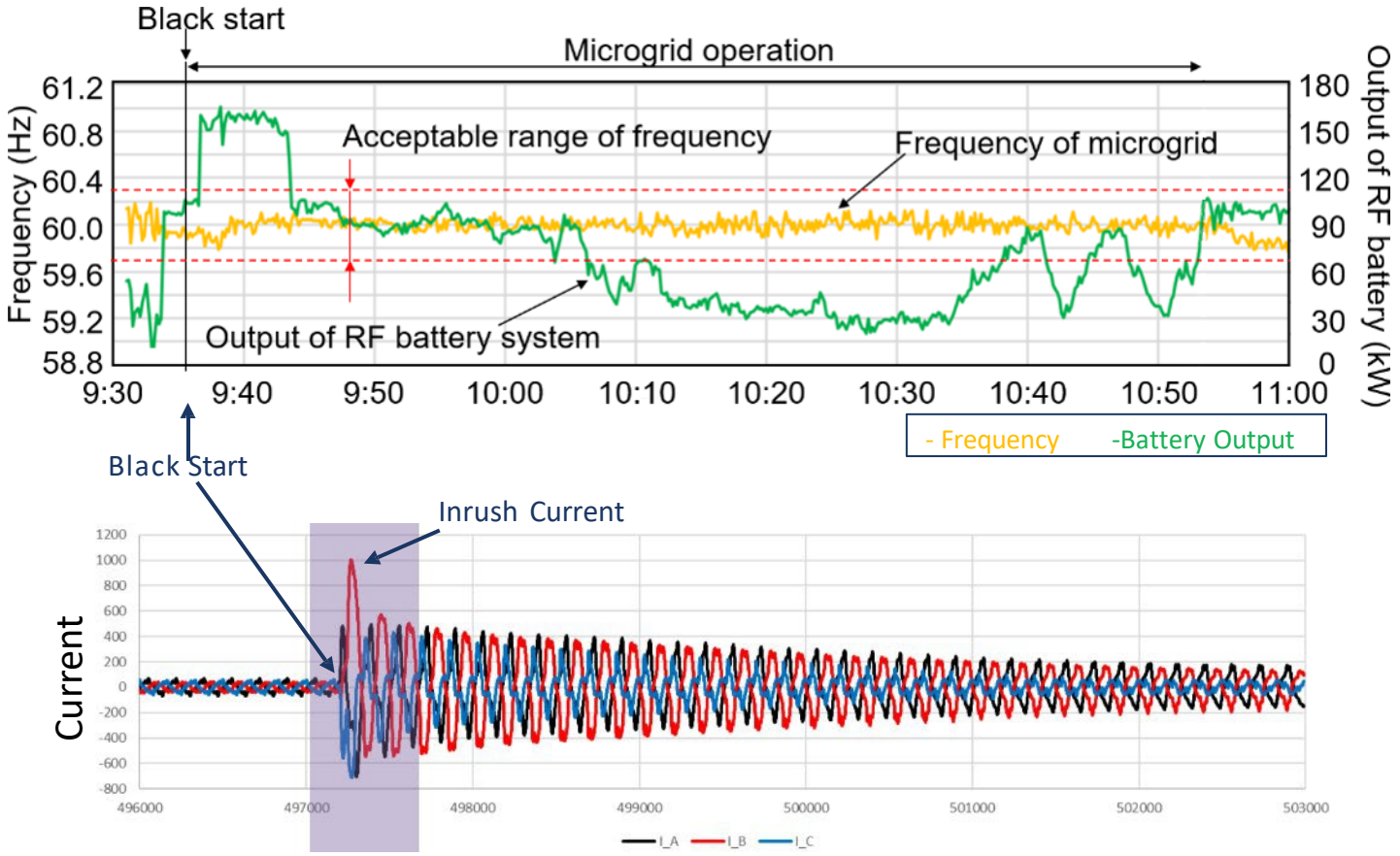
Microgrid Black Start



First 35 cycles after black start

Black start procedure

- Measurement point battery site
- Inrush
- IEEE 1547
  - Delay reconnection after steady-state voltage and frequency

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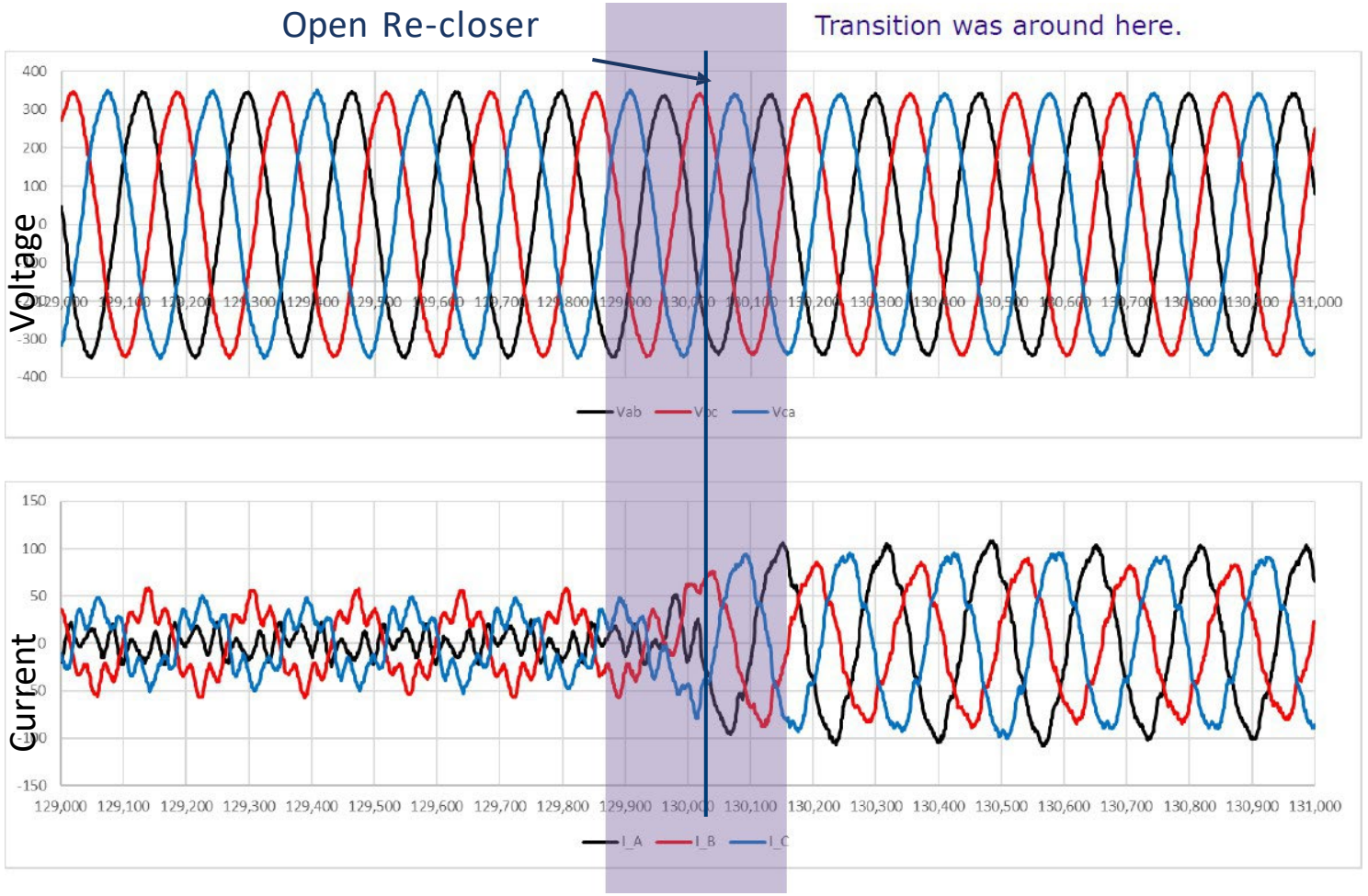
Seamless Transition



- Successful transition to microgrid without service interruptions
- (No voltage or frequency excursions outside of IEEE 1547 guidelines

Seamless Transition

- Battery voltage rms = 240v

  voltage peak = 339v
- Voltage remains steady
- Current increases to pickup load

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Microgrid Operations
Low and High PV Penetrations

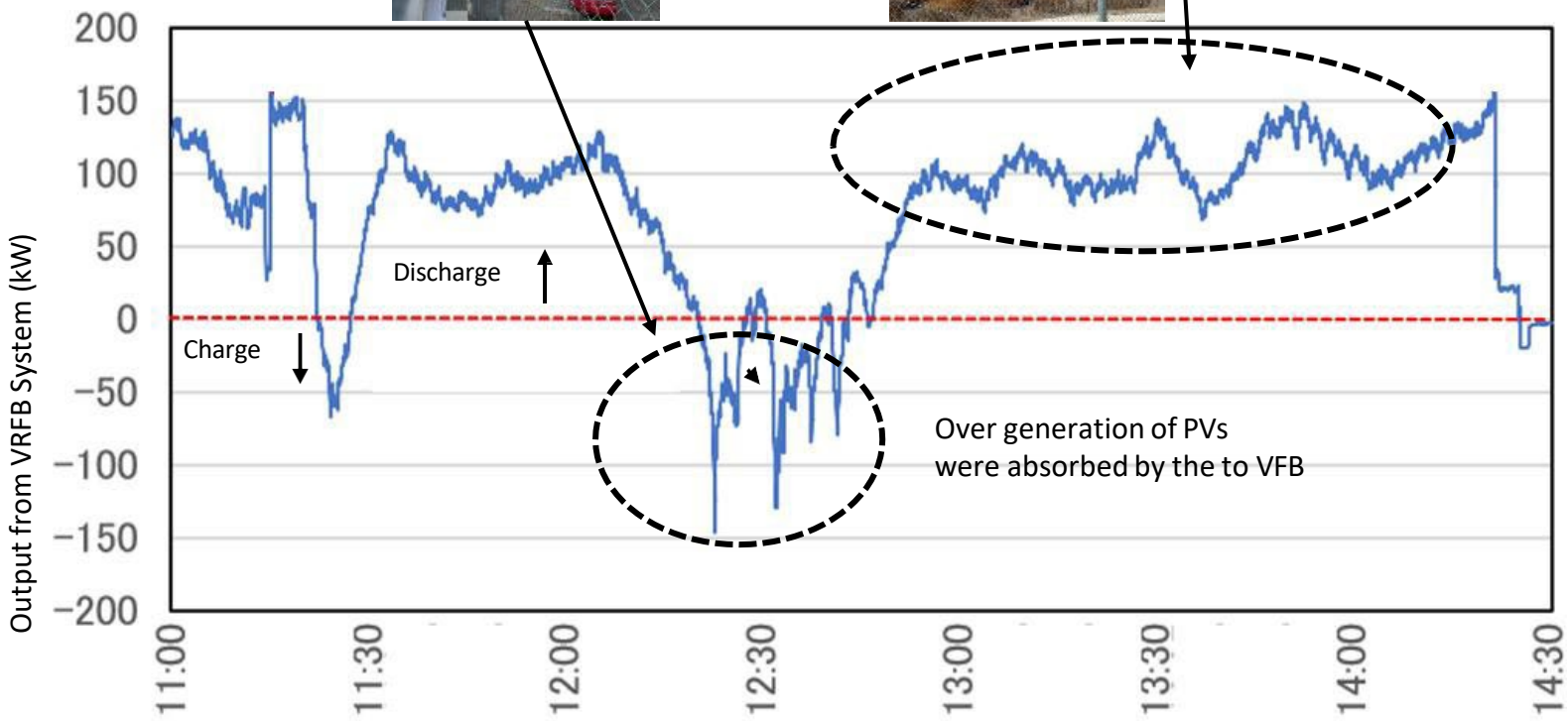
Advantages of a Battery as Island Master

- ✓ Surplus power cannot be absorbed when generators are used as voltage source

- ✓ **In a microgrid with storage batteries as the voltage source, Solar energy can be used effectively without the need for output limitation even in the event of PV over generation**

Sunny

Cloudy



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Thank you!

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