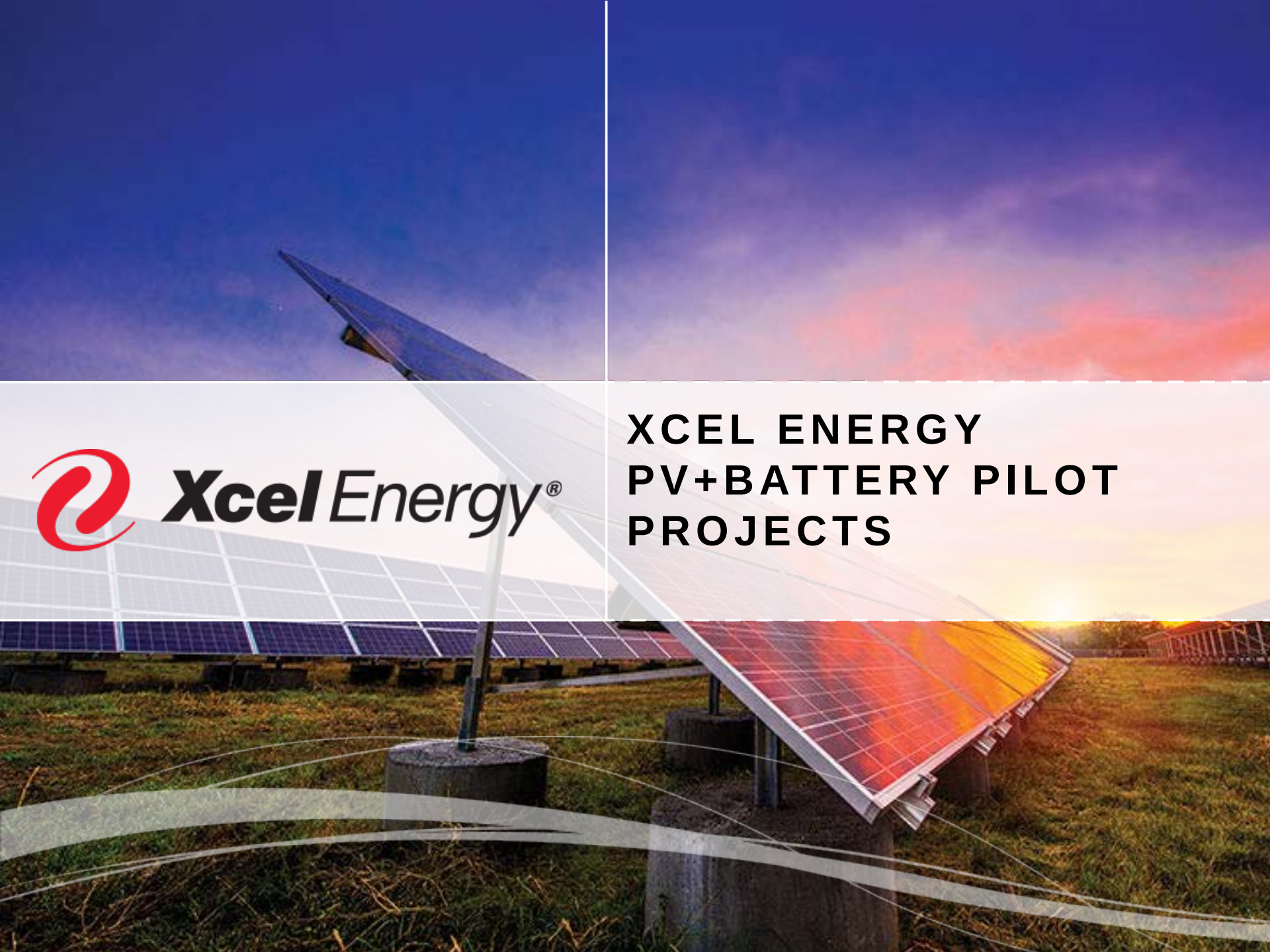


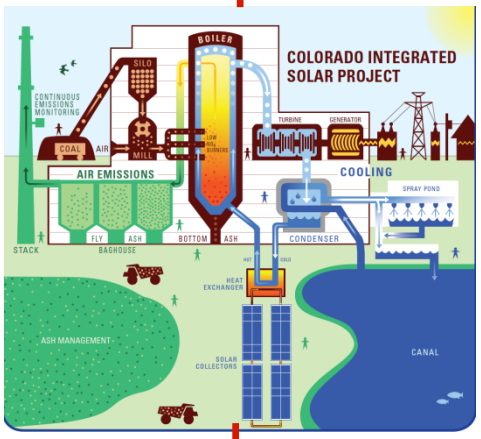
Xcel Energy®

XCEL ENERGY PV+BATTERY PILOT PROJECTS

INNOVATIVE CLEAN TECHNOLOGY (ICT) PROJECTS

2009 Colorado Solar Integration Project

(Grand Junction, Colorado)



Parabolic trough solar plant with turbine capacity 2 MW

2012 Community Energy Storage Project

(Aurora, Colorado)

- 25kW/50kWh Sodium-Nickel-Chloride BESS
- ΣPV = 19.5 kW

2015 Panasonic Project

(Denver)

- 1MW/2MWh Li-Ion BESS
- ΣPV = 1.5MW
- Microgrid

2015 Stapleton Project

(Denver)

- Six utility-sited BESS
- Six BTM BESS
- High PV feeder

PANASONIC PROJECT

PEÑA STATION/PANASONIC PROJECT

3.376 kVA PV on feeder

Denver International Airport Parking Lot at 61st and Peña Rail Stop
1.6 MWdc Carport Solar PV System

S&C Electric Company
Islanding Switch

Panasonic Technology & Business Solutions Center
Anchor Load plus 259 kWdc Rooftop Solar PV System

Xcel Energy Transformer

Younicos Y.Cubes
1 MW / 2 MWh Battery Energy Storage System

Project Partners

Panasonic

DEN

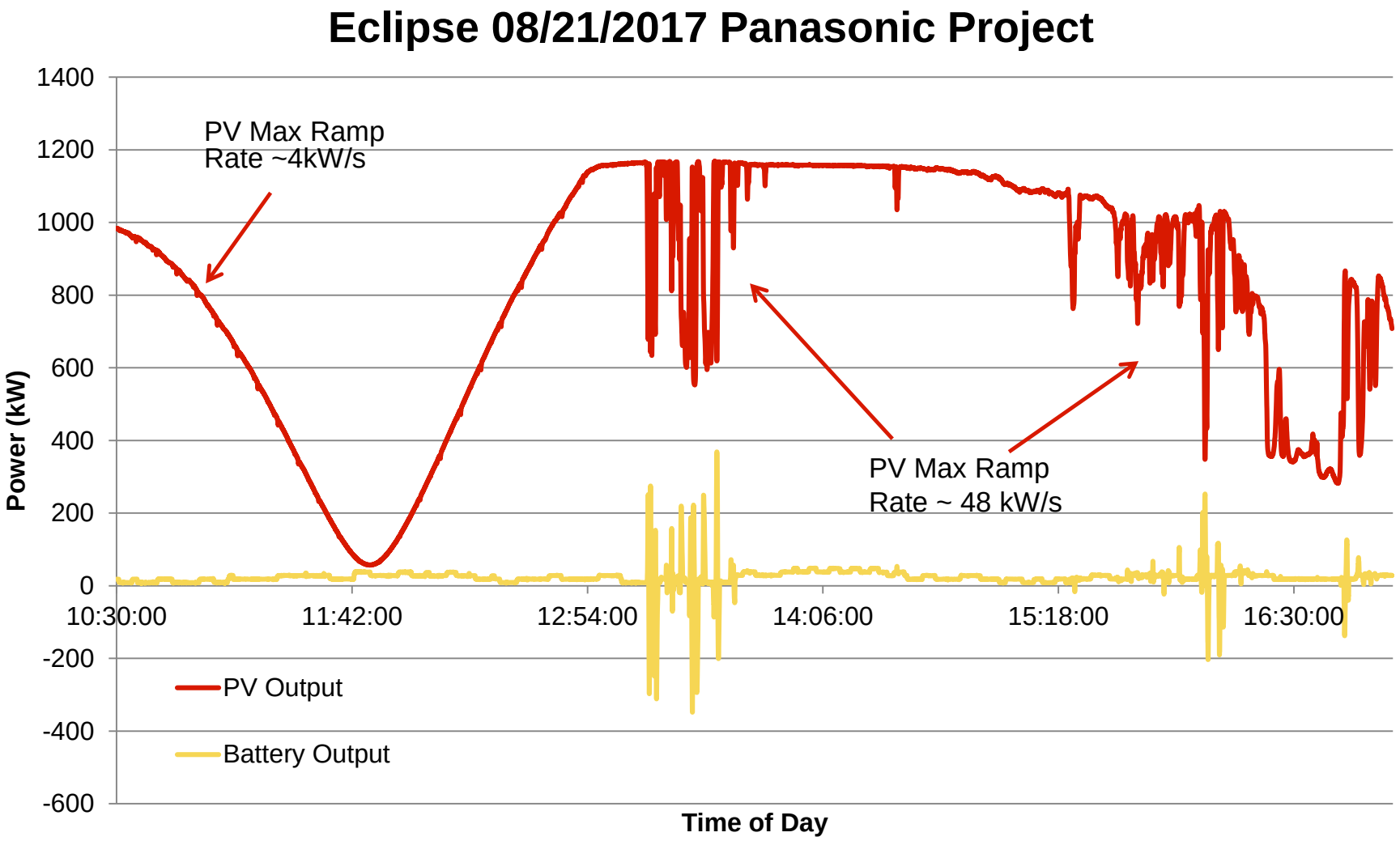
Younicos

Xcel Energy®

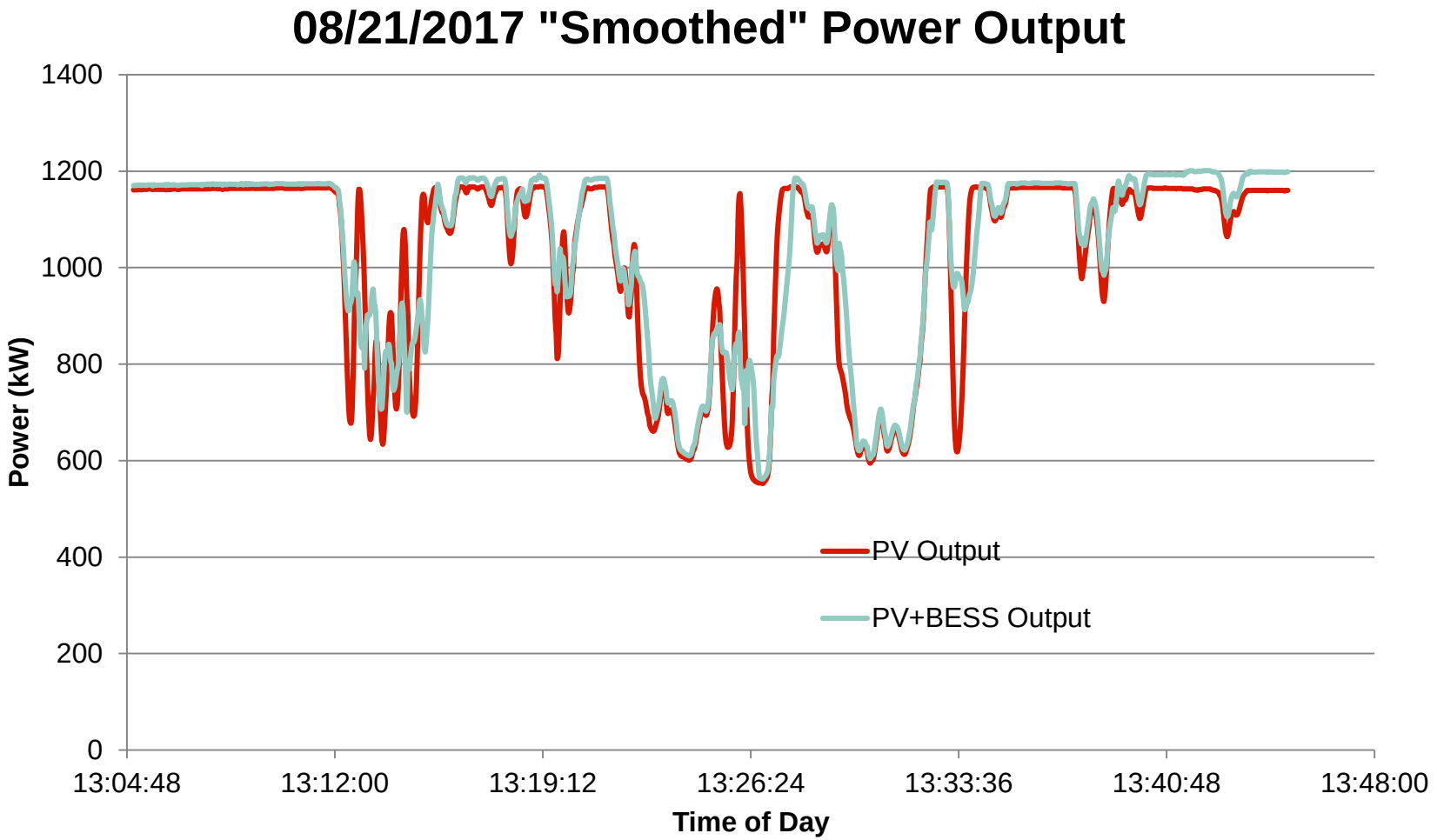
PANASONIC PROJECT OBJECTIVES

- Microgrid/Islanding of Panasonic building
- Peak Demand Reduction
- Energy Arbitrage
- Frequency Response
- Voltage Regulation
- PV smoothing/Ramp Rate Limiting

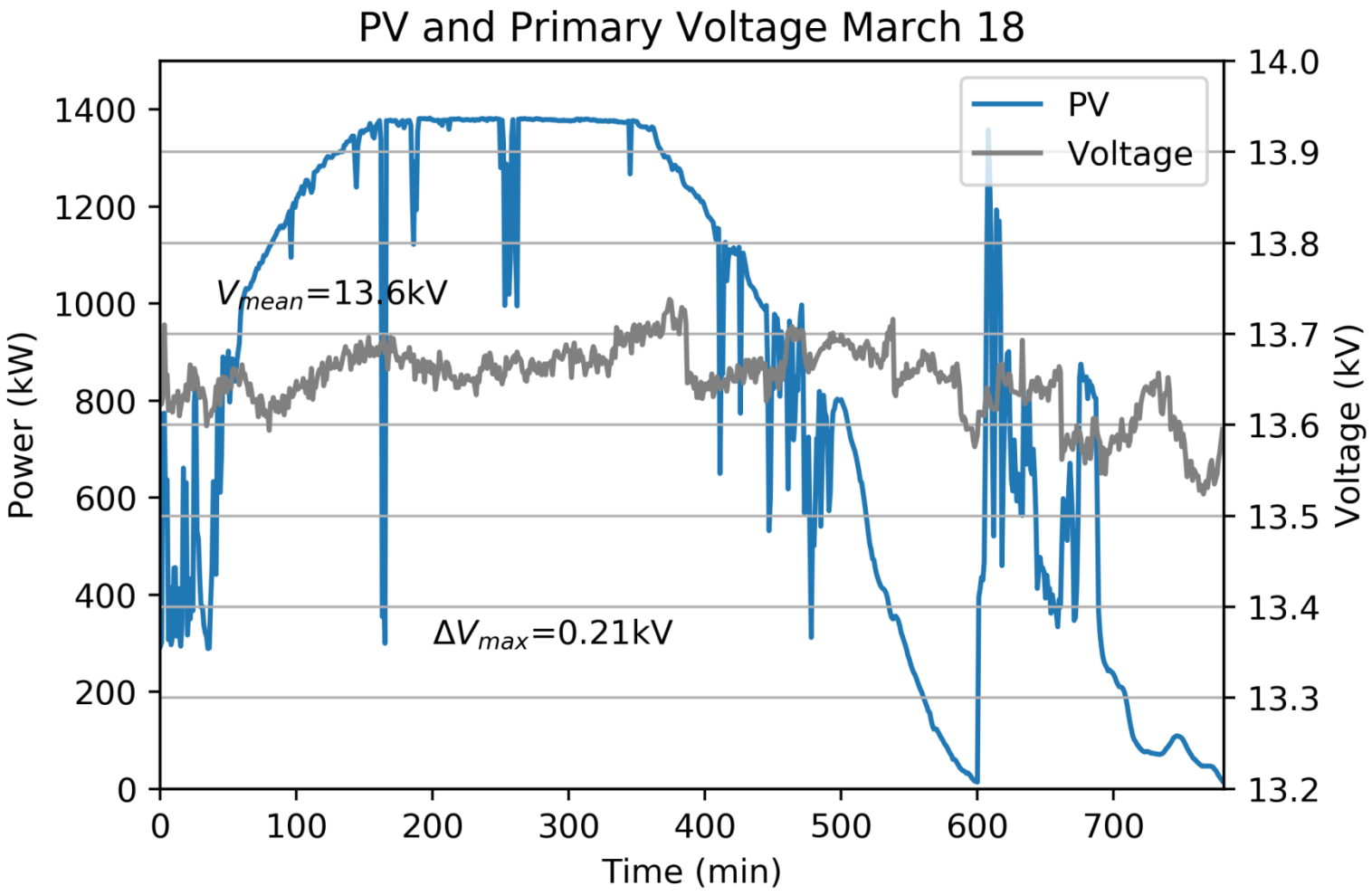
PANASONIC PROJECT RAMP RATE ON 8/21/17 ECLIPSE



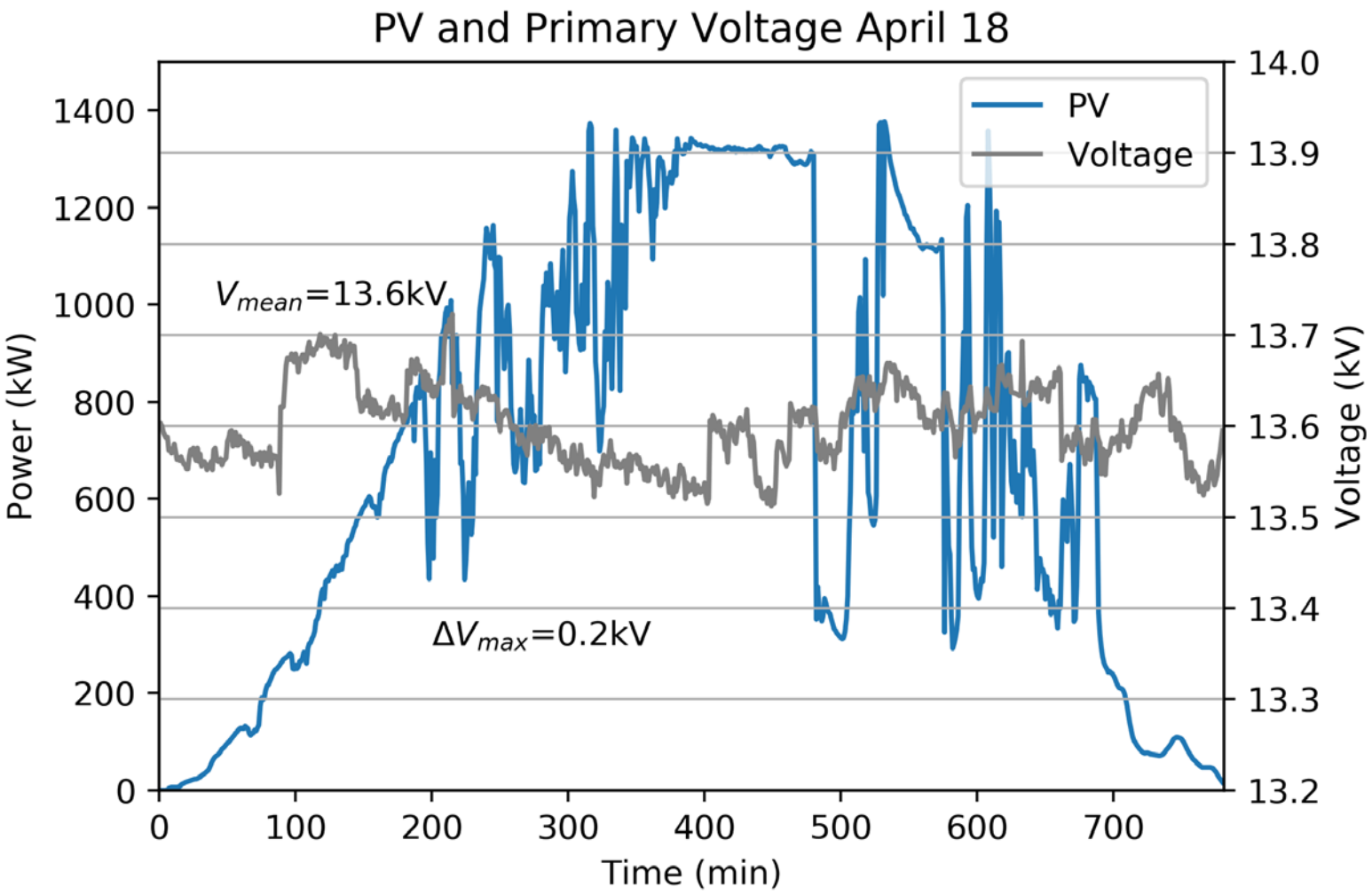
PV “SMOOTHED” OUTPUT 8/21/17



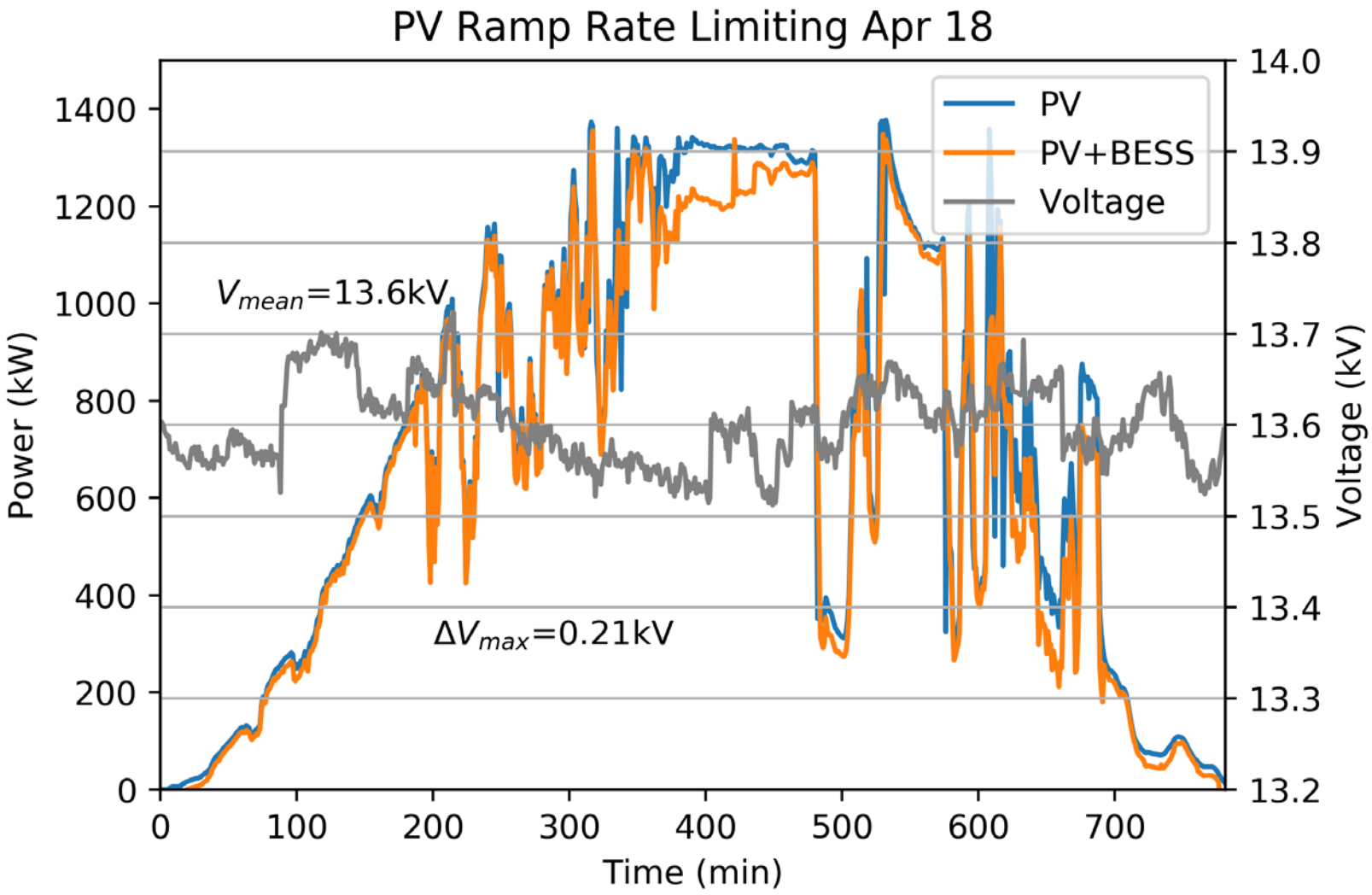
PV & PRIMARY VOLTAGE
NO RAMP RATE LIMITING



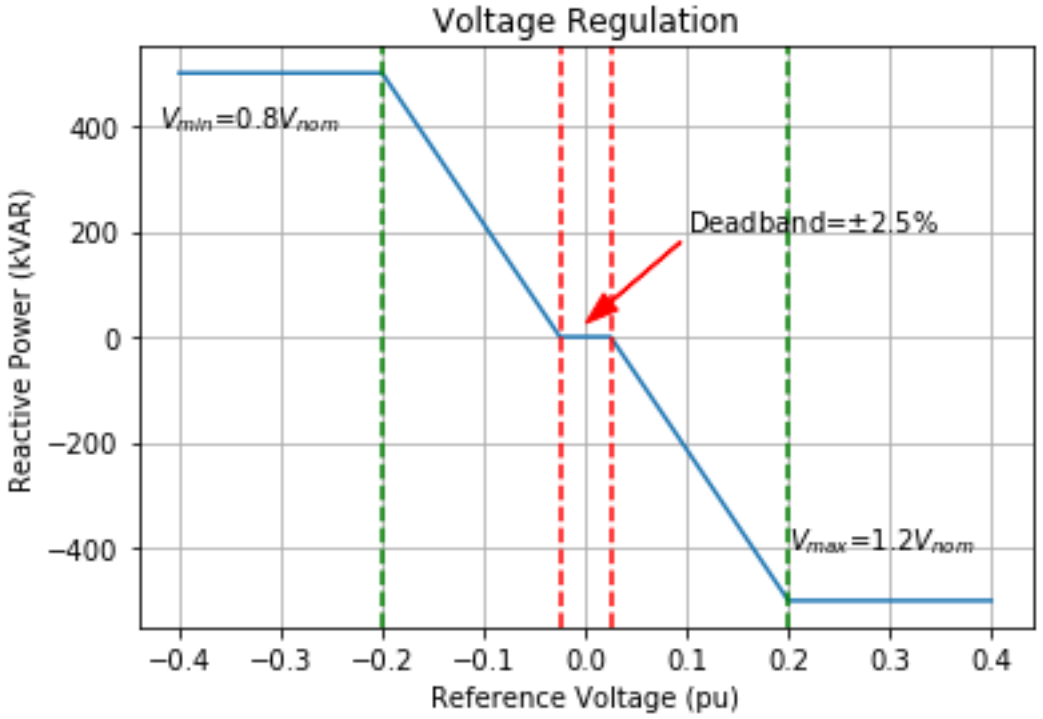
PV & PRIMARY VOLTAGE WITH RAMP RATE LIMITING



PV RAMP RATE LIMITING



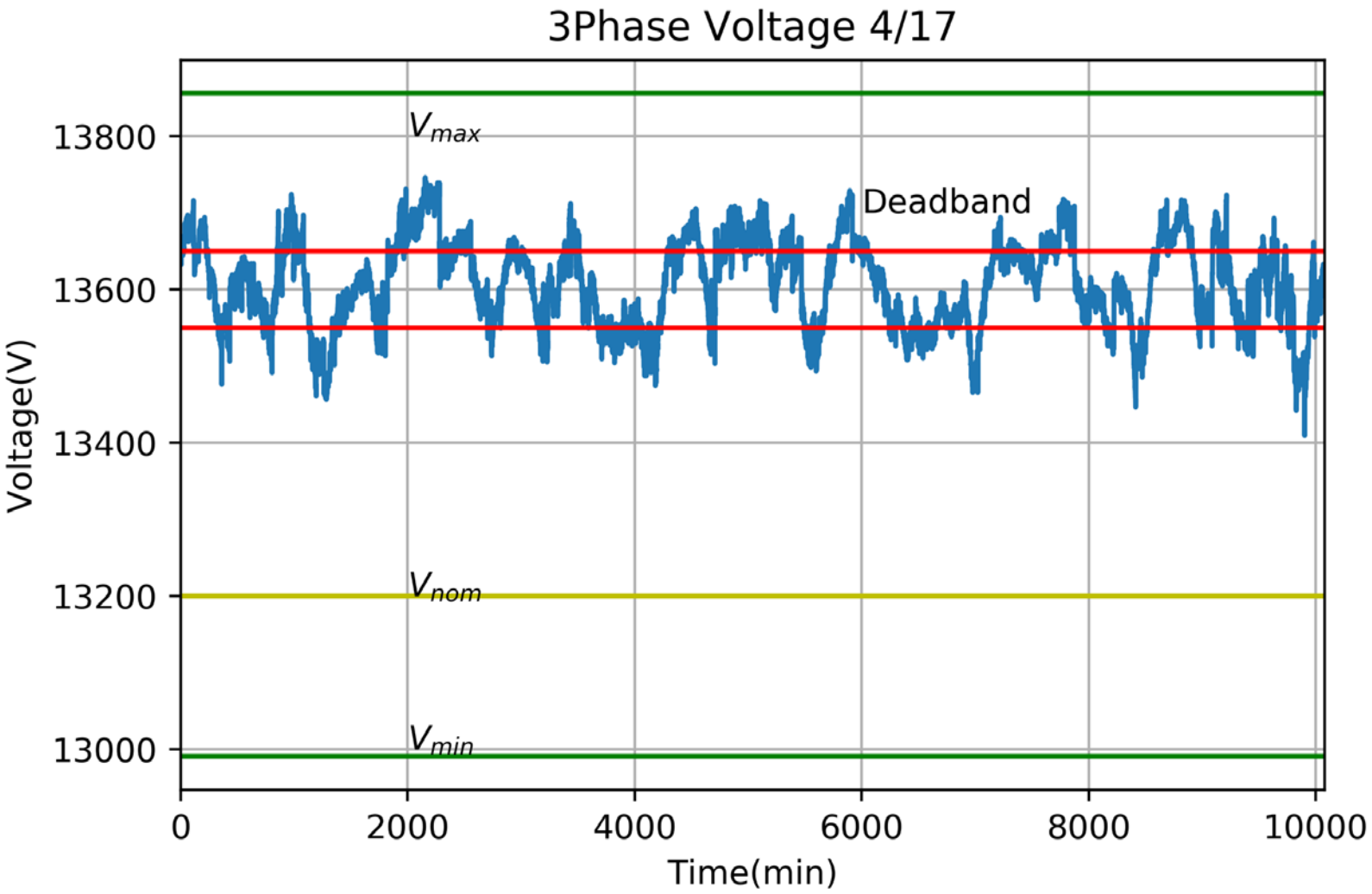
VOLT-VAR CURVE



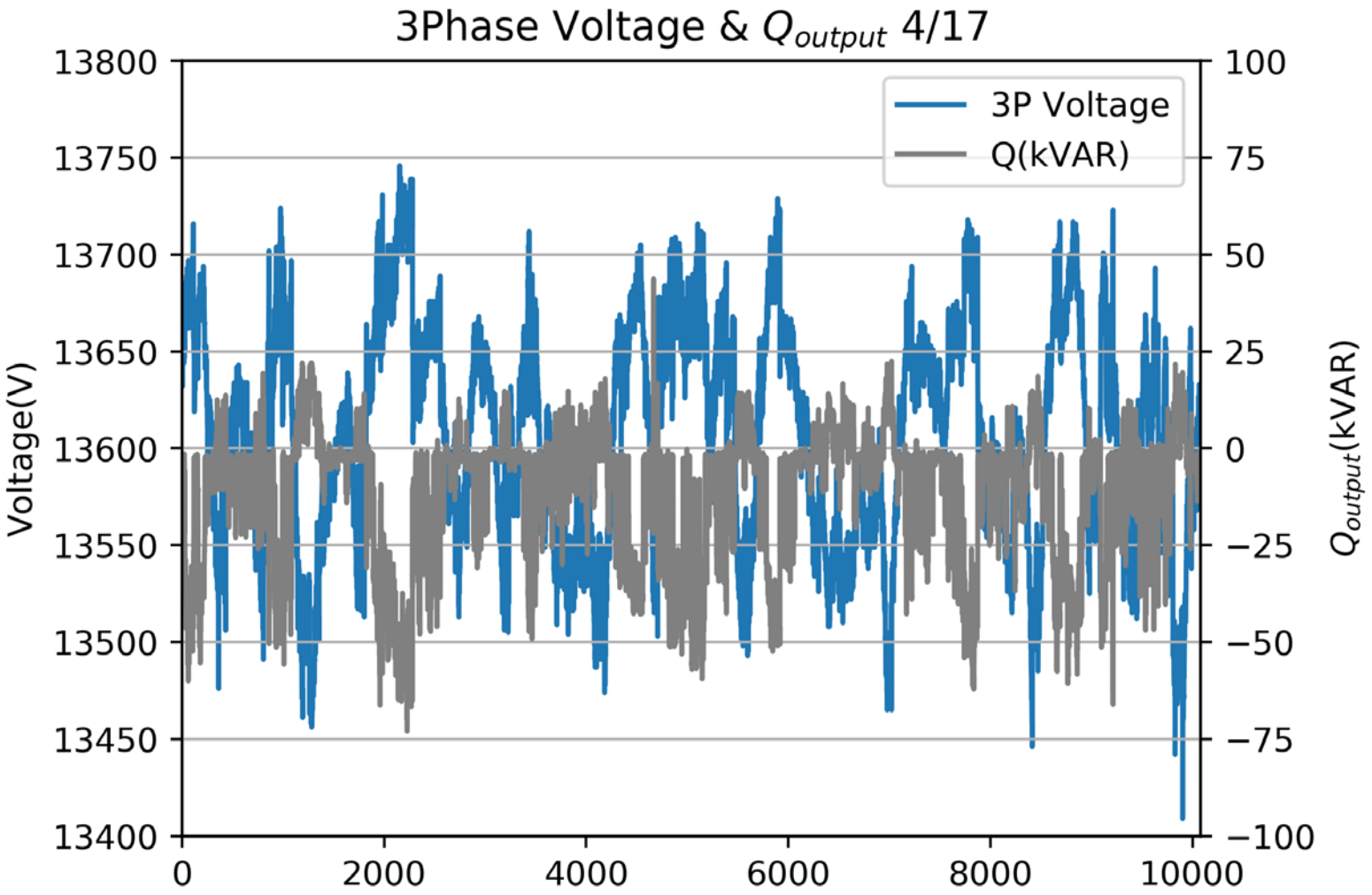
Example Volt-VAR

- Nominal voltage = 13.2kV, i.e. voltage at the transformer primary
- Deadband = ±2.5% of nominal voltage
- V_{min} = 0.8 $V_{nominal}$
- V_{max} = 1.2 $V_{nominal}$

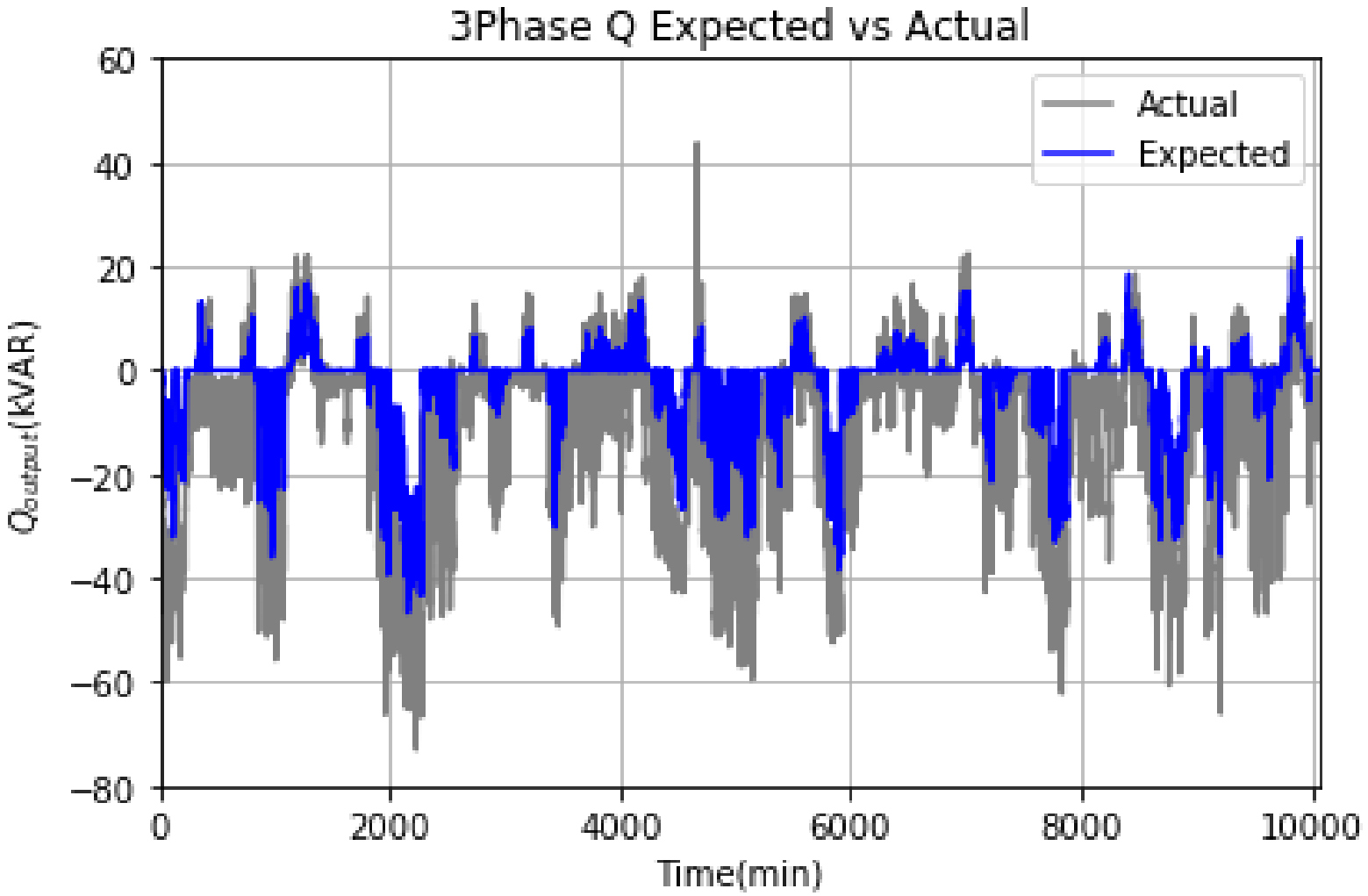
OVERVOLTAGE ON PRIMARY 4/17-4/24



VOLT-VAR BY BESS 4/17-4/24

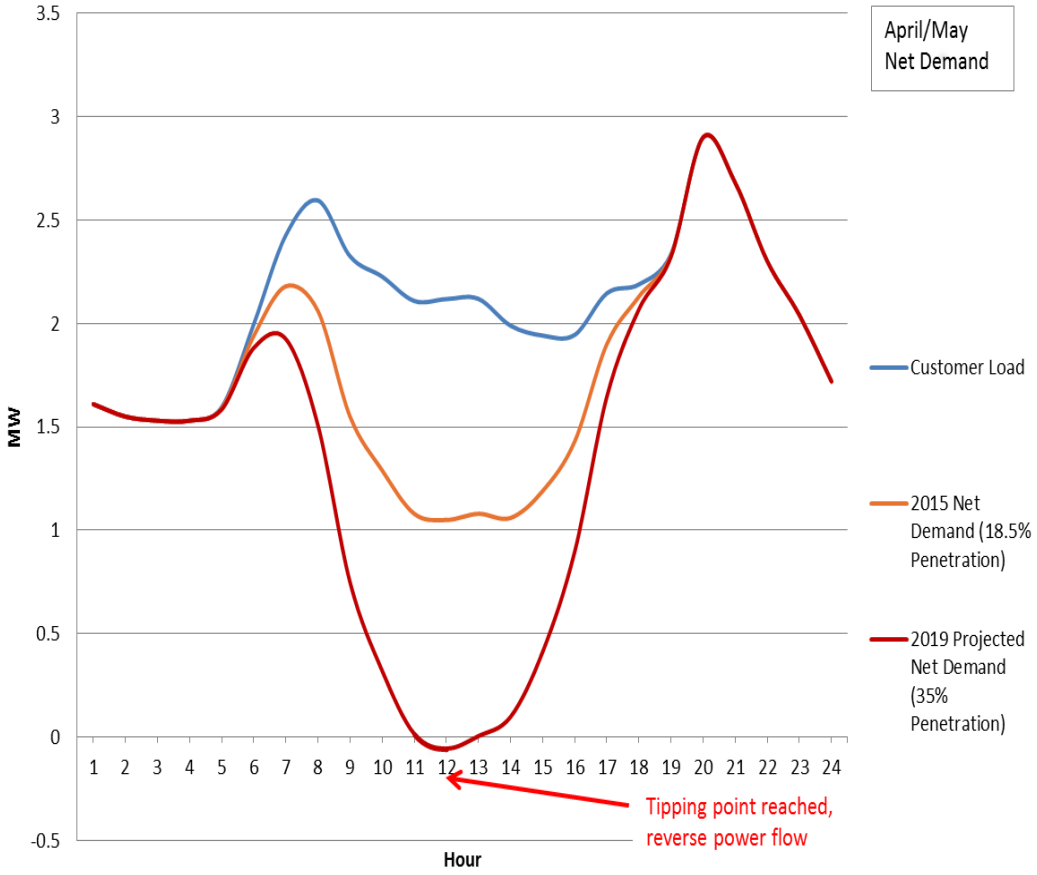


EXPECTED VS ACTUAL OUTPUT



STAPLETON PROJECT

STAPLETON NEIGHBORHOOD



- Stapleton feeder has ~18.5% PV penetration (2017)
- Utility-Sited Systems:
  - Six Li-Ion battery energy storage systems
  - Sited along the feeder at two different phases
- Behind-the-Meter Systems:
  - Six Li-Ion battery energy storage systems
  - Sited in a customer's home

STAPLETON UTILITY SITED OVERVIEW

Northern Reliability Modular Units:

- 2 x 18 kW/69 kWh
- 2 x 36 kW/138 kWh
- 2 x 54 kW/207 kWh

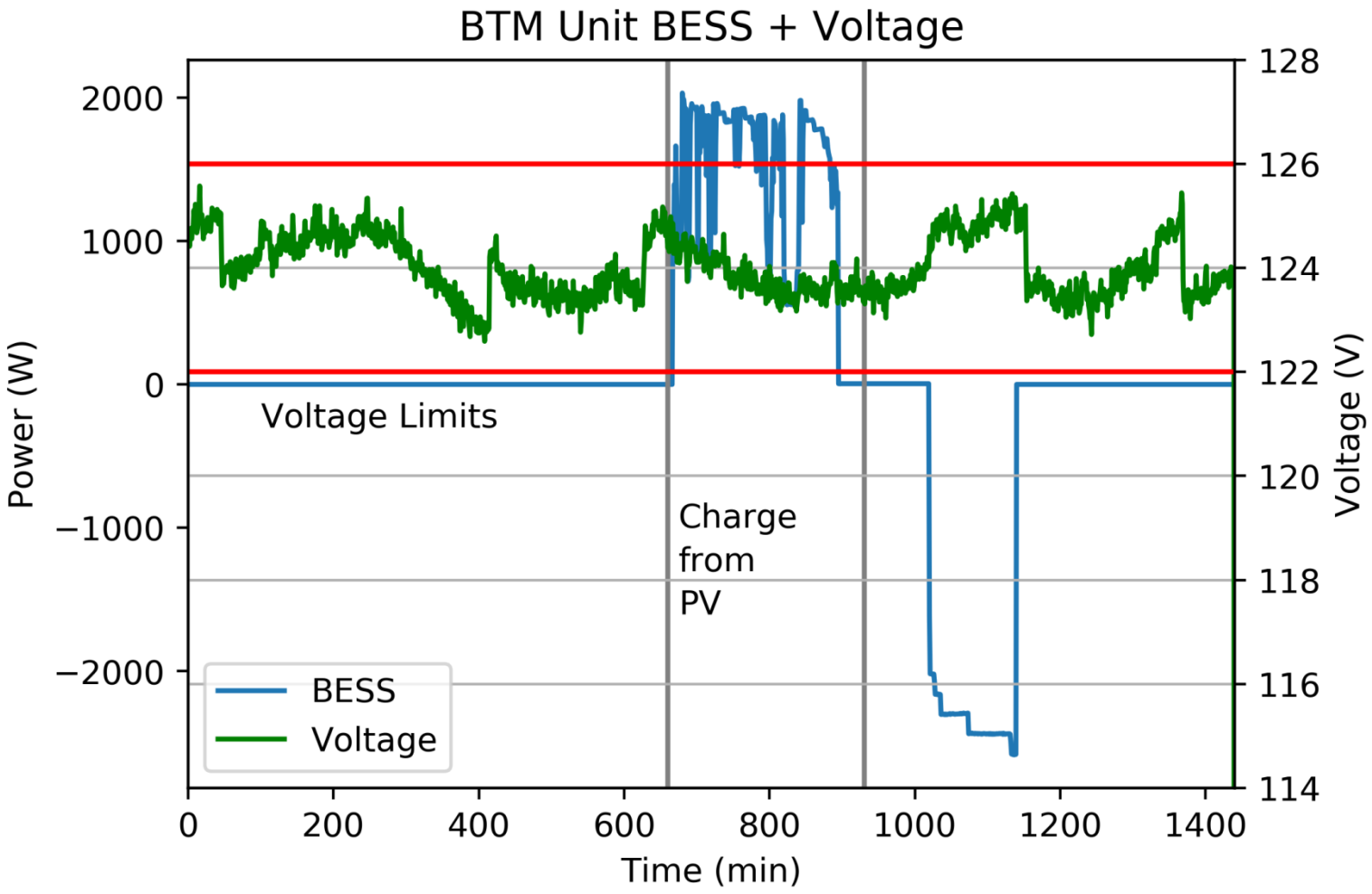
Objectives/Use Cases:

- Peak Demand Reduction
- Voltage Regulation
- Solar Time Shifting
- Energy Arbitrage

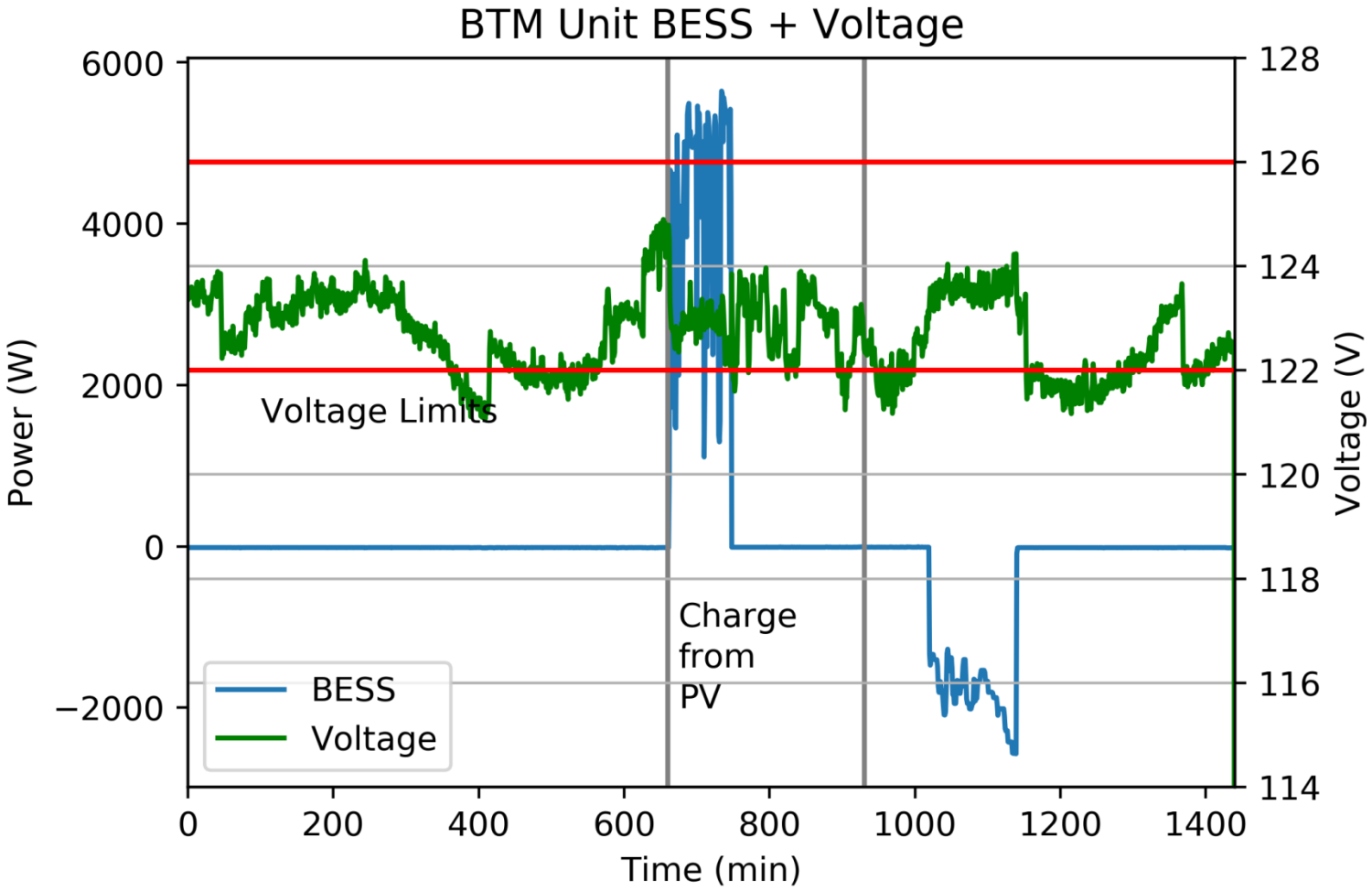
STAPLETON BEHIND-THE-METER OVERVIEW

- **Sunverge SIS units**
  - 6 x 6 kW/15.5 kWh
- **Objectives/Use Cases:**
  - Providing Residential Backup Power
  - Peak Demand Reduction
  - Solar Time Shifting
  - Volt-Watt Operation (?)

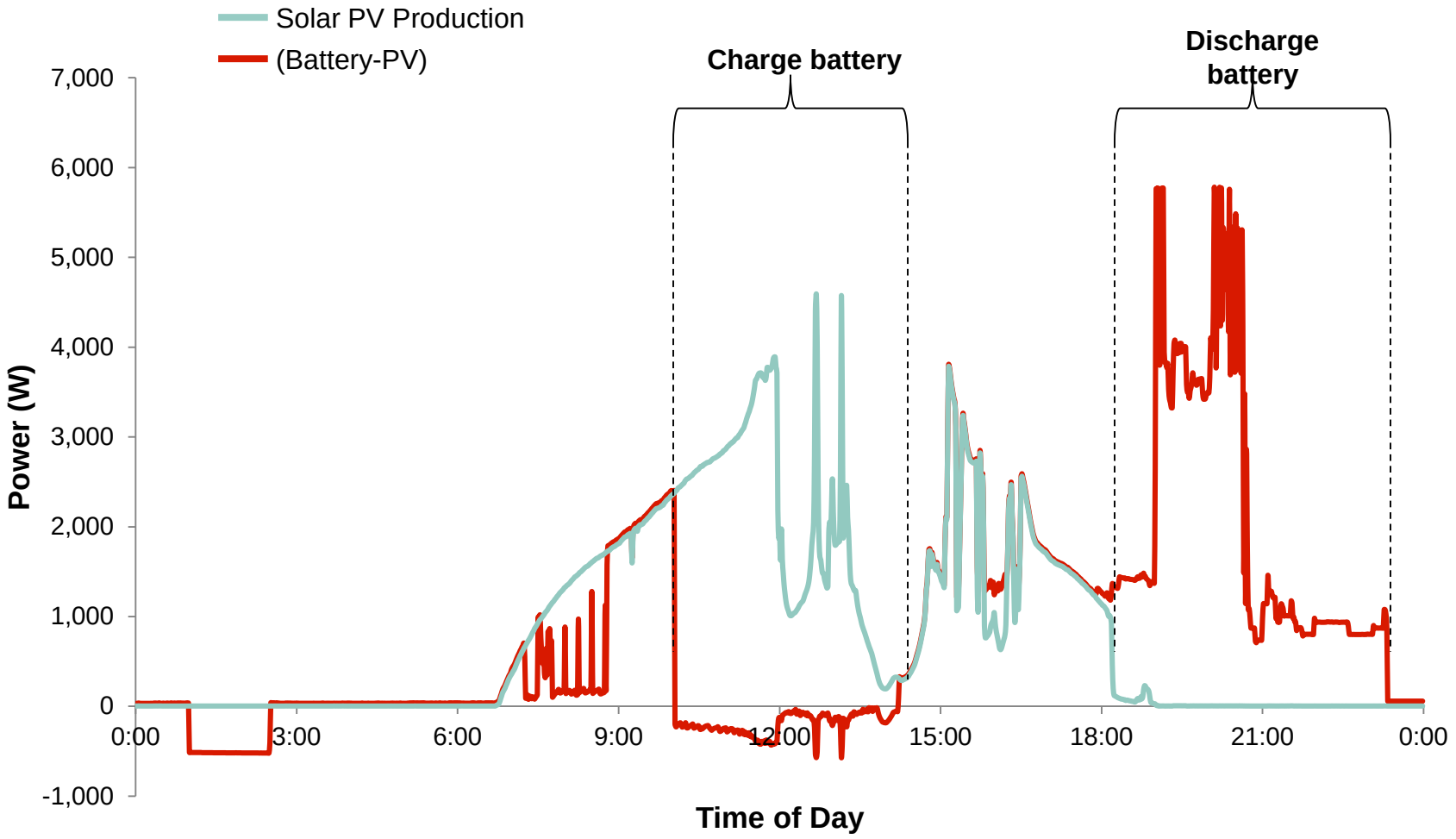
CHARGING FROM PV AT HIGH VOLTAGE



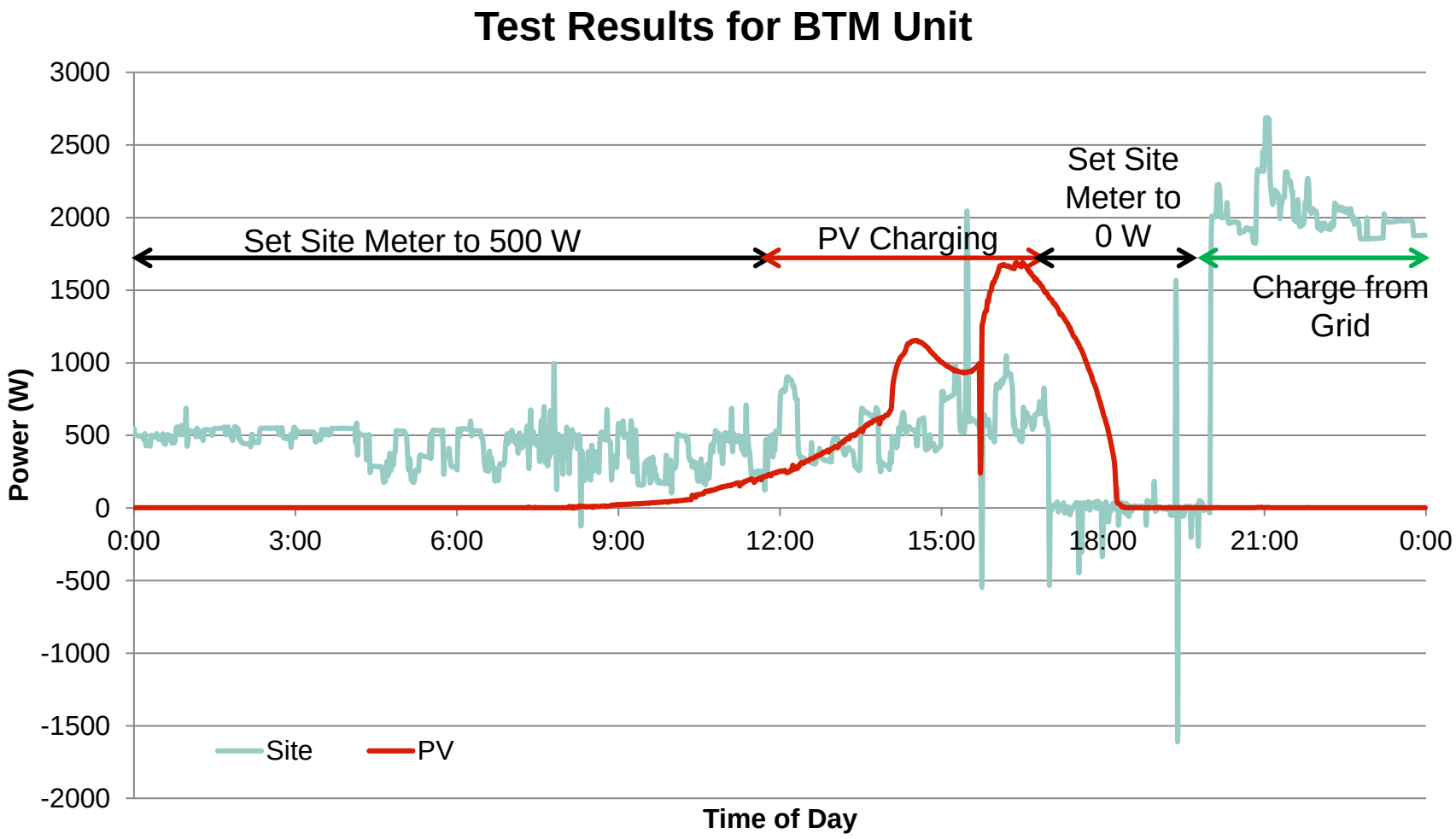
CHARGING FROM PV AT HIGH VOLTAGE



SAMPLE TEST
SOLAR TIME SHIFTING



TEST SAMPLE RESULTS



Thank you

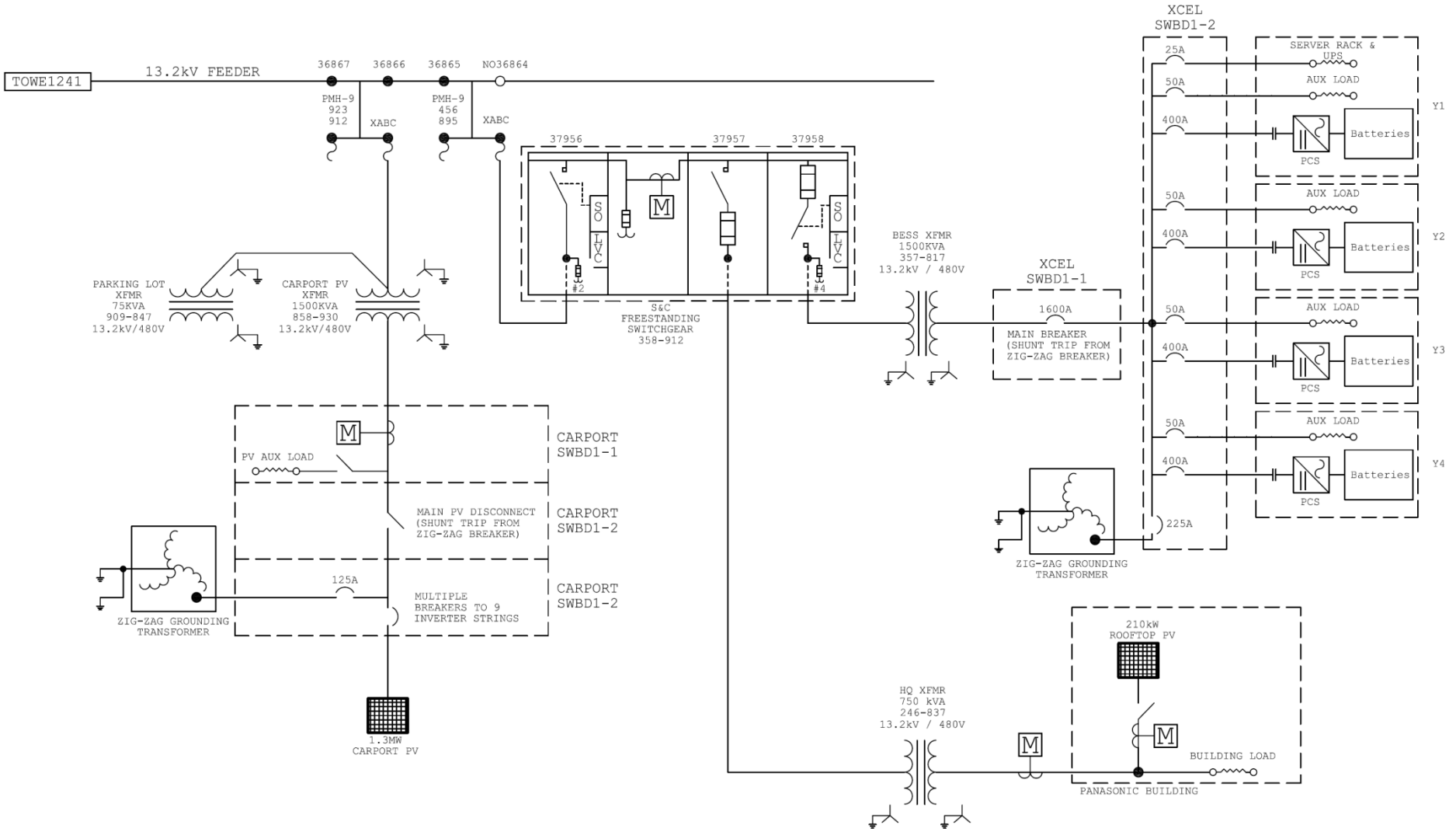
UPDATES & SUMMARY

- Environmental controls
  - Panasonic: Multiple cold-temperature alarms. Solution: Use the inverters to output reactive power (~50 kVAR) to ensure heating stays on.
  - Sunverge: Cold temperatures kicks the units into self-preservation mode, disrupting schedule. Solution: Sunverge has updated the control logic to allow heaters to come on at specific times.
- Lack of standardization across vendor platforms
  - Control algorithm for the modes of operation
  - Communication protocol (all support DNP3 but Xcel is connecting to all the systems in different ways)
- Lessons Learnt:
  - Make sure data is captured consistently (scaling factors, polling time, latency etc)
  - Make sure vendor understands specific operation/mode/use case

Communications / Control

- Treated site as a substation
- Fiber to site with multiple security zones
- 2 RTU’s
  - One for SCADA
  - One for DNP3 to Modbus
- Battery control is through vendor UI
- Islanding control utilizes SCADA
- Stapleton will be controlled through SCADA (no vendor UI)

Panasonic One-Line



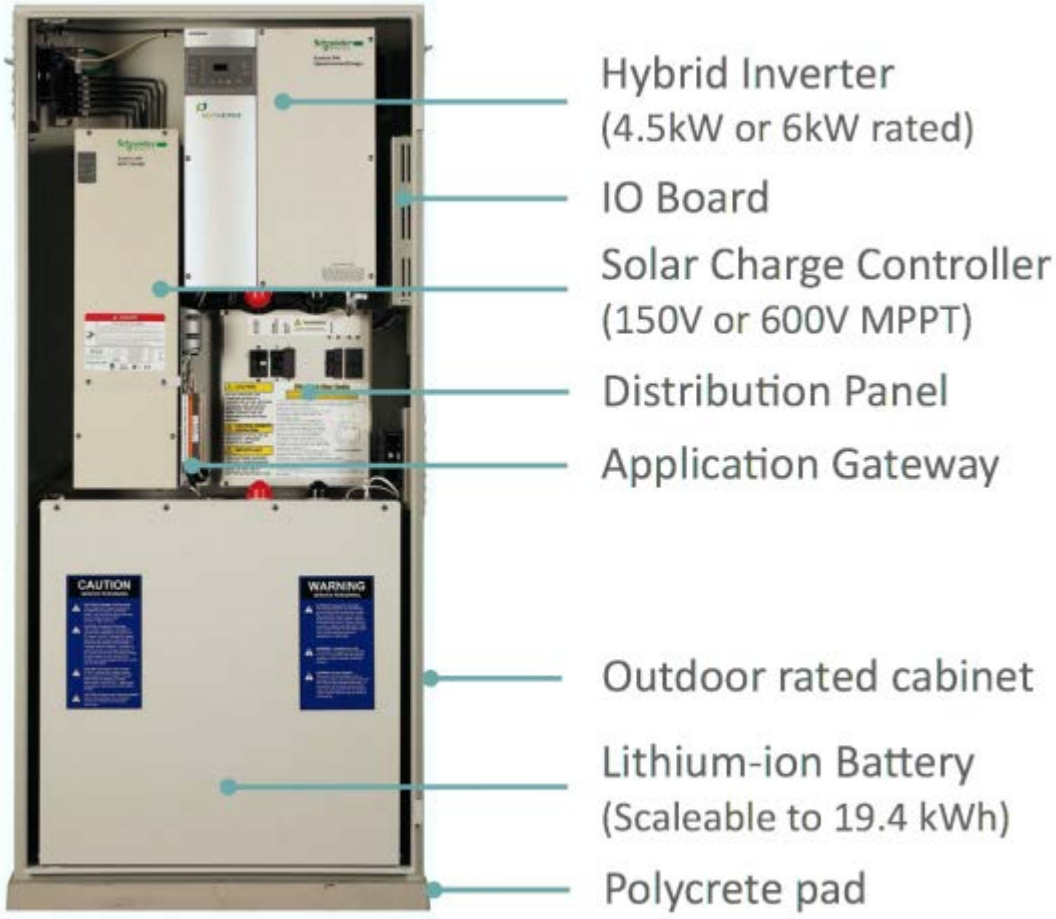
YOUNICOS ENERGY STORAGE PARAMETERS

Description	Value
Rated Apparent Power	1,000 kVA
Rated Real Power	1,000 kW
Rated Energy	2,100 kWh
Available Energy	1,690 kWh
Round-Trip Efficiency	85.5 %
Voltage Range	432-528 V
Rated Continuous AC Current	1,200 A
Operating Temp. Range	-10°C - 45°C
Physical Dimension	42’ x 10’

NRI ENERGY STORAGE PARAMETERS

Description	18 kW System	36 kW System	54 kW System
Rated Apparent Power	18 kVA	36 kVA	54 kVA
Rated Real Power	18 kW	36 kW	54 kW
Rated Energy	69 kWh	138 kWh	207 kWh
Round-Trip Efficiency	N/A		
Voltage Range	172 – 264 V		
Rated Continuous AC Current	94 A	187 A	281 A
Operating Temp. Range	-30°C -50°C		
Physical Dimension	56” x 52.75” x 53”	112” x 52.75” x 53”	159” x 52.75” 53”

SUNVERGE SIS UNIT

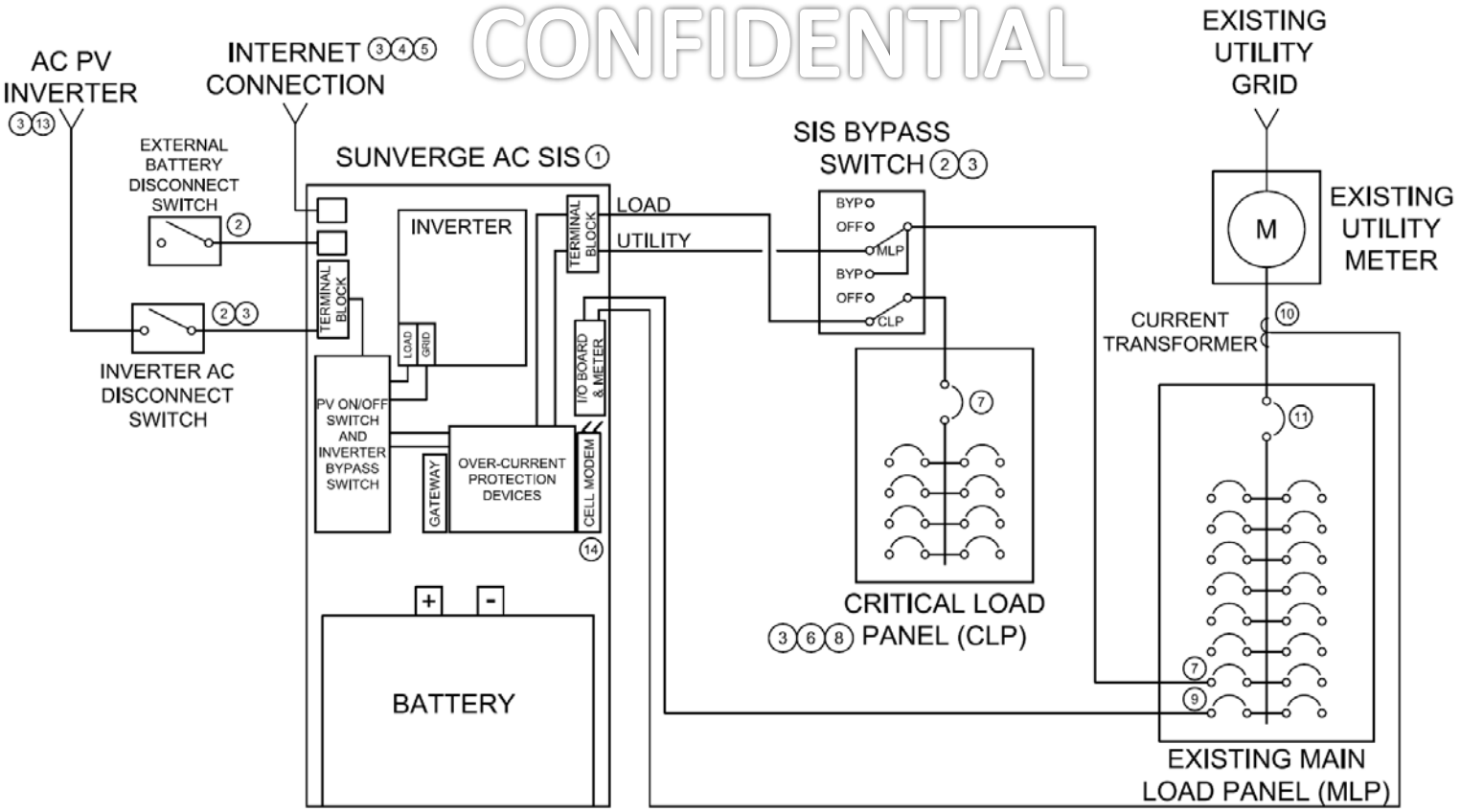


SUNVERGE ENERGY STORAGE PARAMETERS

Description	Value
Rated Apparent Power	6 kVA
Rated Real Power	6 kW
Rated Energy	15.5 kWh
Available Energy	11.64 kWh
Round-Trip Efficiency	92.5 %
Voltage Range	233 – 247 V
Rated Continuous AC Current	25 A
Operating Temp. Range	-20°C - 50°C
Physical Dimension	76” x 34” x 14 “

SUNVERGE ONE LINE

SUNVERGE "BACK COUPLED" AC SIS SINGLE LINE DIAGRAM



(1) SUNVERGE AC SOLAR INTEGRATION SYSTEM (SIS).
(2) NOT ALWAYS REQUIRED. CONSULT LOCAL CODE AND AHJ.
(3) NOT INCLUDED WITH SIS UNIT.
(4) MUST BE POWERED BY CLP.
(5) HARDWIRED CONNECTION TO INTERNET.
(6) NEW PANEL (OPTIONAL).
(7) 50A CIRCUIT BREAKER.
(8) TOTAL LOAD CANNOT EXCEED RATING OF SIS INVERTER.
(9) 15A CIRCUIT BREAKER FOR VOLTAGE REFERENCE.
(10) SPLIT-CORE AC CURRENT SENSOR.
(11) MUST NOT EXCEED 200A.
(12) NO = NORMALLY OPEN; NC = NORMALLY CLOSED.
(13) MAX CAPACITY 6KW.
(14) OPTIONAL 3/4G MODEM FOR INTERNET CONNECTION.