DOE OFFICE OF INDIAN ENERGY

2021 Tribal Energy Webinar Series
Planning for a Changing Climate

Demonstration of community scale low cost highly efficient PV and energy management system at the Chemehuevi Community Center

CHEMEHUEVI INDIAN TRIBE

UC RIVERSIDE UNIVERSITY OF CALIFORNIA

GRID ALTERNATIVES

Agenda

- **Overview and Industry Partners**
- **GRID Alternatives**
- **Project Site and Chemehuevi Perspective**
- **Project Methodology and Approach**
- **Chemehuevi Microgrid System**
- **Project Results**
- **Project Benefits**
- **Lessons Learned**
- **Microgrid System Modifications**
- **System Monitoring and Operation**

Chemehuevi Microgrid

The project objective was to manage energy use profiles and provide uninterruptable power at the Chemehuevi Indian Tribe's Chemehuevi Community Center (emergency response center for the community) located in Havasu Lake, CA. The Microgrid system is composed of 90 kW solar PV system, 25 kW/125 kWh flow battery energy storage system, data historian, advanced control system, and energy management strategies.

Problem Statement

- Remote communities with a single transmission line connection to the grid are extremely vulnerable to power outages and downtime maintenance.
- Microgrids are ideal for providing resiliency to critical facilities within remote communities.
- There is need for the successful demonstrations and pilot projects that demonstrate and document energy, economic, and societal benefits of community-based microgrids.
- To achieve greater grid resiliency new solutions and technologies will be required for microgrids to provide reliable and cost-effective electricity.

Project Goals

- Implement various energy management strategies, including: 1) Peak Reduction, 2) Load Shifting, 3) Demand Response, and 4) Load Control.
- Achieve lower electricity bills by reducing kW demand by more than 10 percent of the daily average energy demand during peak times.
- Demonstrate greater electricity reliability by intelligently managing energy use, large loads (HVAC), PV generation, and battery energy during daily energy load profiles.
- Improve resiliency by addressing prevention of power disruption, mitigating the impact of power disruptions, and maintaining critical loads.

Anticipated Project Benefits

- Projected benefits to the CCC (over 20 years)
- Lower energy costs (i.e. demand charge reduction)
- Improved data and energy management
- Increased grid stability, robustness, and reliability
- Decreased GHGs emissions
- Workforce development & best practices
- Support increased renewables and market-ready technologies
- Foster collaboration between private and public entities

Community-Powered Solutions

GRID ALTERNATIVES

GRID-Alternatives Job Training

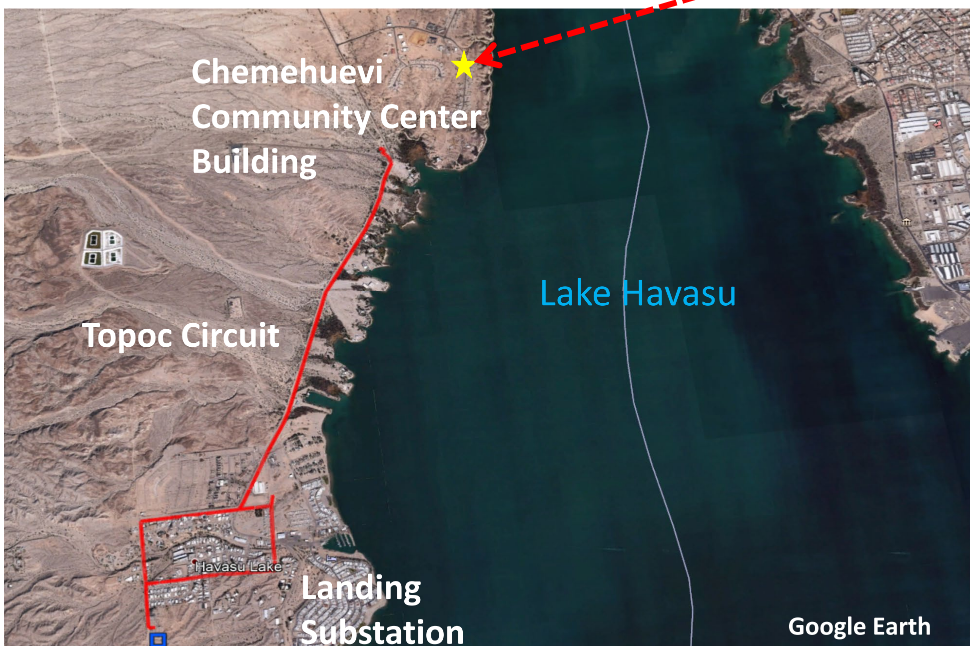
- Workforce Training
- In-class & on the job training taught by GRID
- Hands on installation, teamwork installing solar
- GRID Solar Futures Program - high schools and colleges
- Partnerships with Tribal and community colleges and vocational programs

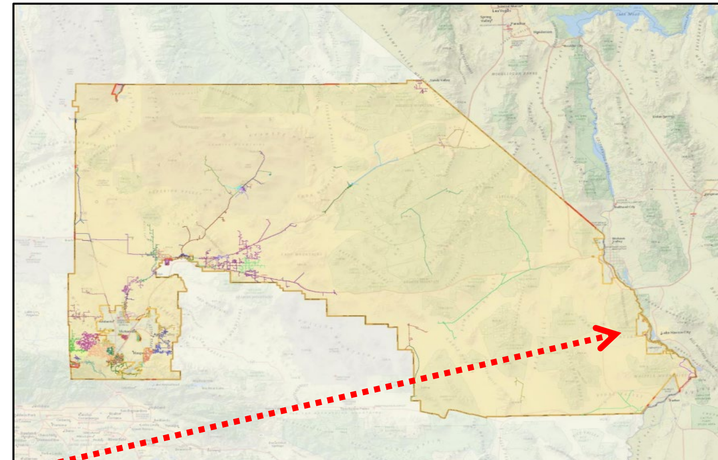
Carport in Process at Chemehuevi

Chemehuevi Carport Solar Array

Chemehuevi Community Center (CCC) Building Location

The Chemehuevi Community Center building is equipped with 175 kVA diesel back-up generator and serves as a refuge for the community residents during extended power outage events.



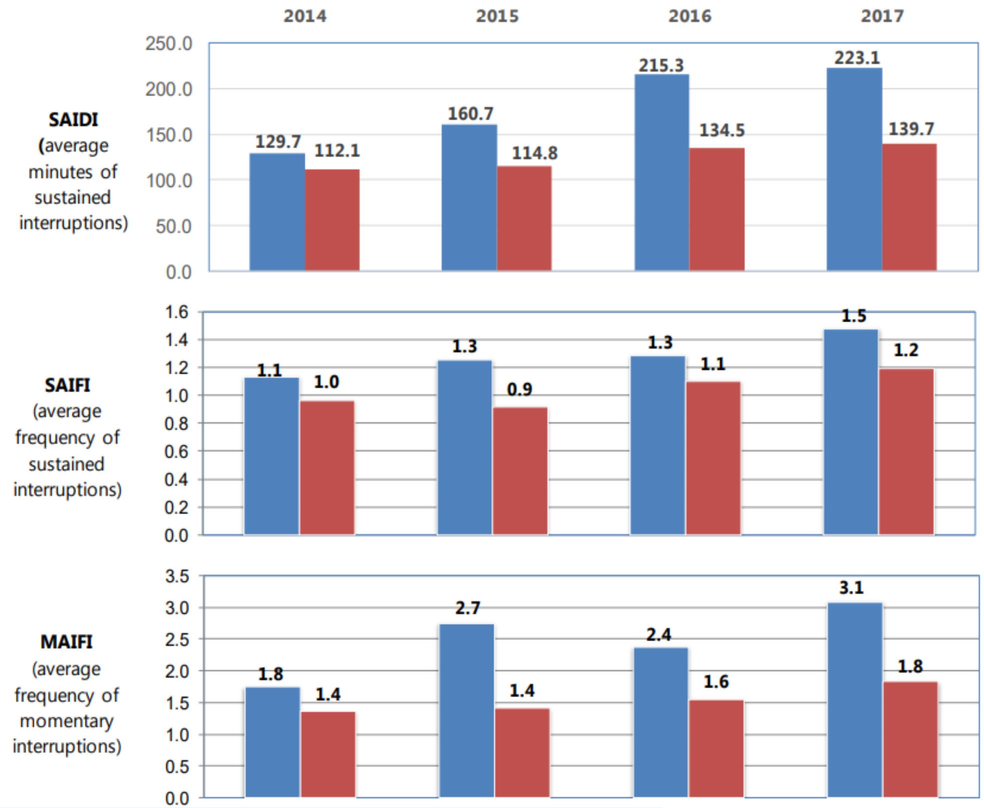


San Bernardino District 1 Unincorporated County Areas

The Chemehuevi Indian Reservation located on the California side of Lake Havasu in San Bernardino county. Electric power is provided from a single SCE substation and 16 kV Topoc circuit.

SCE Circuit Reliability Review January 2018

SCE's reliability report indicates that the circuit serving the Chemehuevi community experiences significantly larger number of power interruptions, at a significantly longer duration, and larger number of events compared to the average SCE system wide and San Bernardino District 1, with average SAIDI of 1,661 and SAIFI of 5.9.



Reliability History of Circuits Serving San Bernardino District 1 (No Exclusions)

"Exclusions**" are days which utilities are allowed to remove from their metrics because the outages on those days were caused by acts of nature.

**Data is as of 02/20/2018, data can be slightly different due to outage data validation process

Project Methodology and Approach

Baseline Analysis

- Baseline cost analysis of integrating technologies
- Baseline cost and energy analysis existing operations

Control Algorithms

- Intelligent management of resources
- Optimization for energy management strategies (i.e. kW peak reduction)

Data Collection

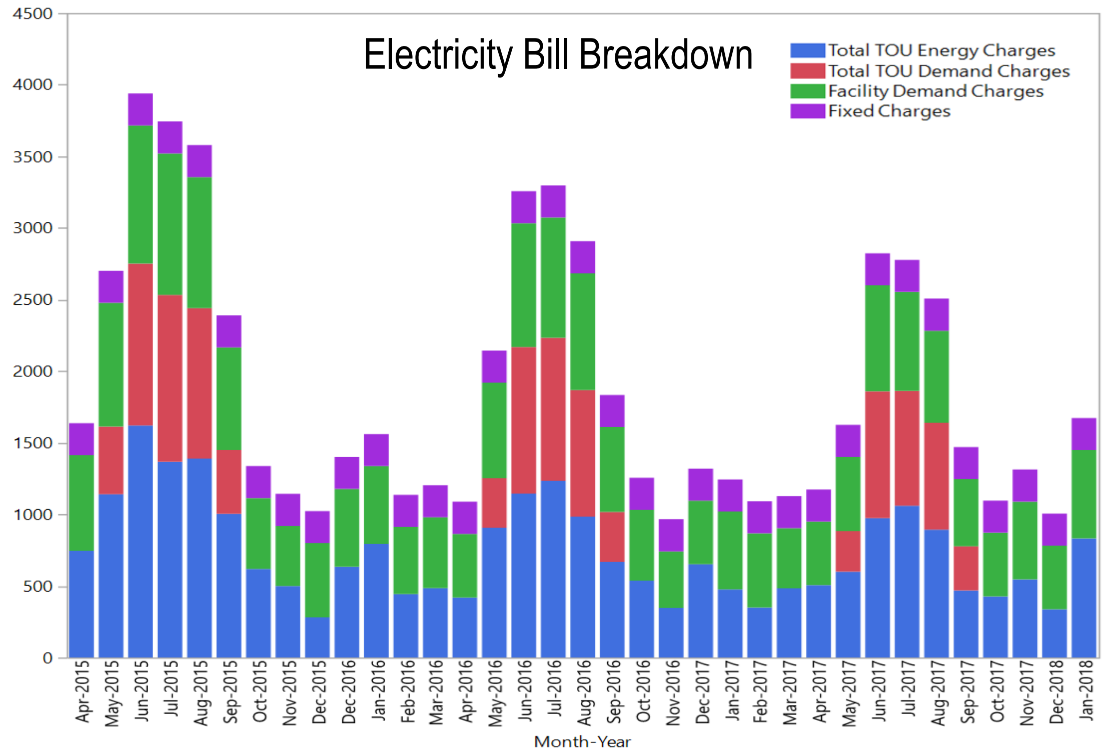
- Field demonstration of microgrid at a critical facility in a remote community

Data Analysis

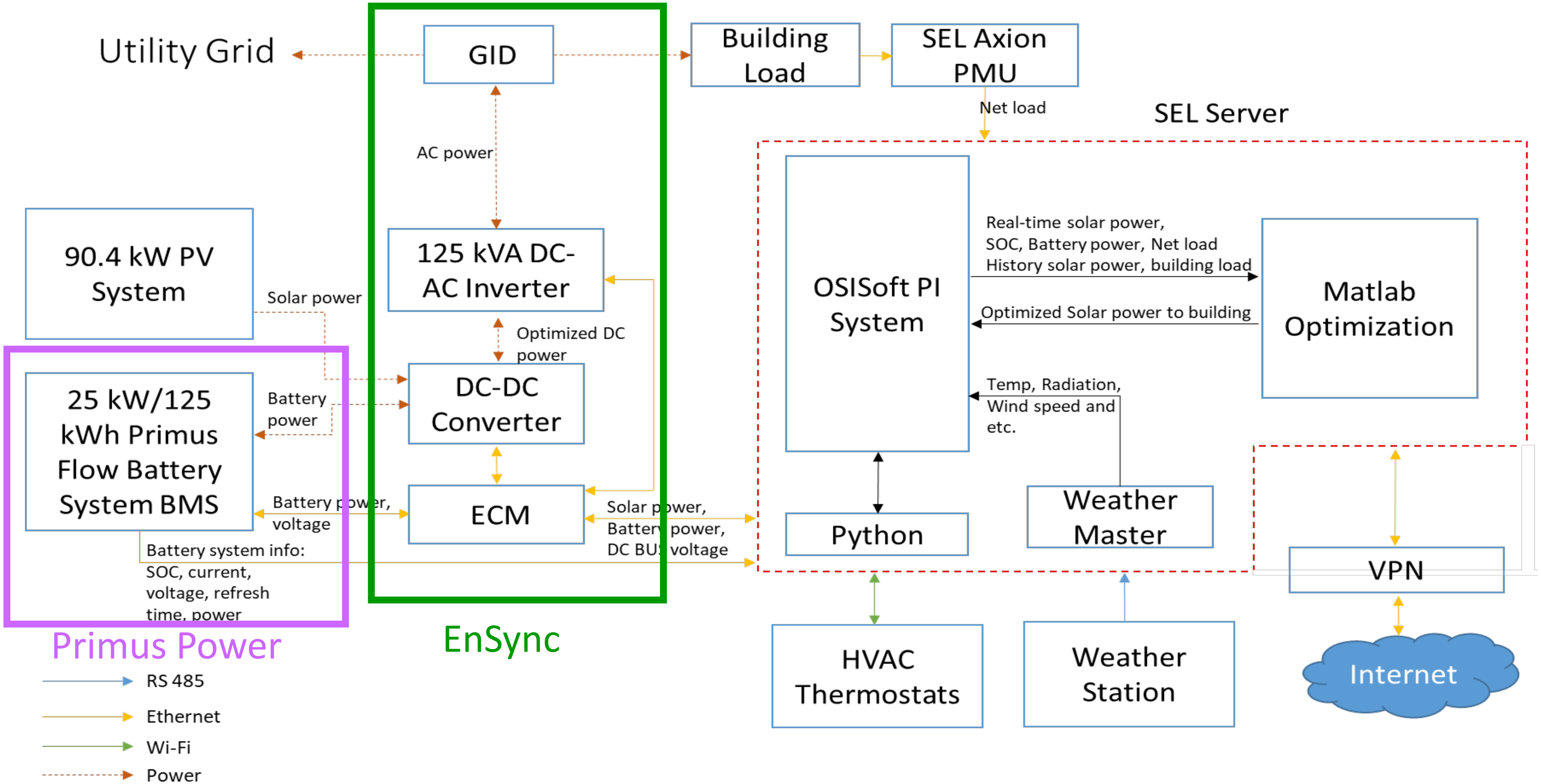
- Performance and economic analysis to determined actual benefits

CCC Building Rate Schedule and Bills

- The CCC building was under TOU General Service – Option B tariff.
- About half of the summer electricity bill charges consisted of facility and TOU demand charges.
- There was a reduction in the overall energy and demand use from 2015 to 2018 due to lower utilization of the building and long term malfunction of some HVAC units.
- Solar PV generation and battery storage showed great potential in reducing electricity bill with new TOU schedule.



Chemehuevi Microgrid Architecture



Solar PV System and Weather Station

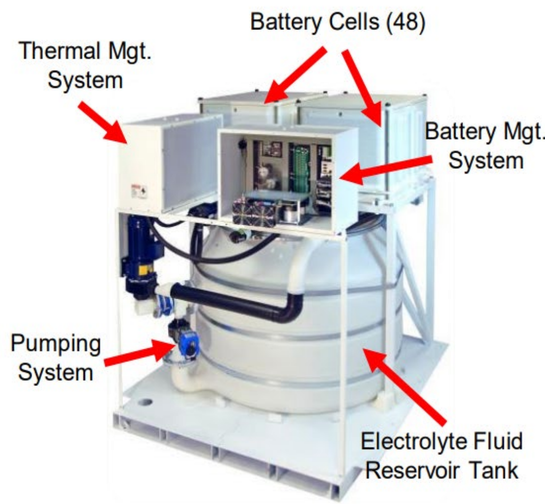
Capricorn FLX weather station monitors solar Irradiance, module temperature, air temperature, wind speed and direction, dew point, density altitude, and rainfall rate.

PV Array 1 - 28.56 kW
88 panels
SunPower P-series
SPR-P17-330-COM

PV Array 2 - 62.64 kW
144 panels
SunPower E-series
SPR-E20-435-COM

Battery Energy Storage System

The Primus Power Zn/Br flow battery (EnergyPod 2) is comprised of an electrolyte tank, a pumping system to circulate the electrolyte, two stacks of 48 titanium electrodes (battery cells), a thermal management system, and a battery management system.



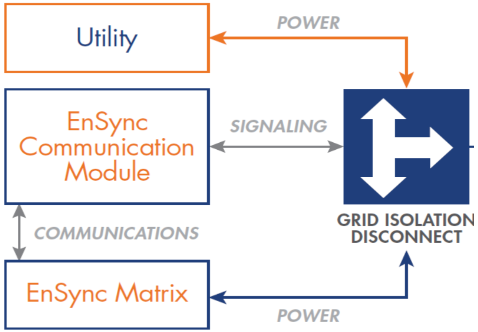
Internal View

Peak Power	25 kW
Energy Storage	125 kWh
Lifetime Cycles	30,000
Efficiency	70%

Key Performance Parameters

EnSync Energy Matrix System

DC-DC Conversion - 4 x 25 kW

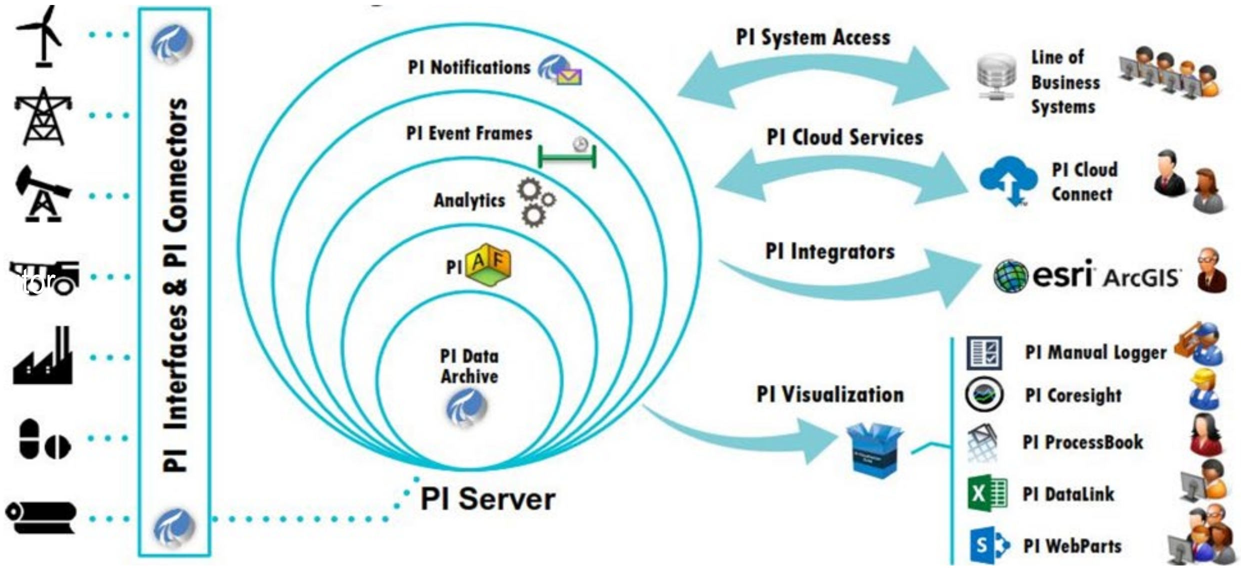


Grid Isolation Disconnect

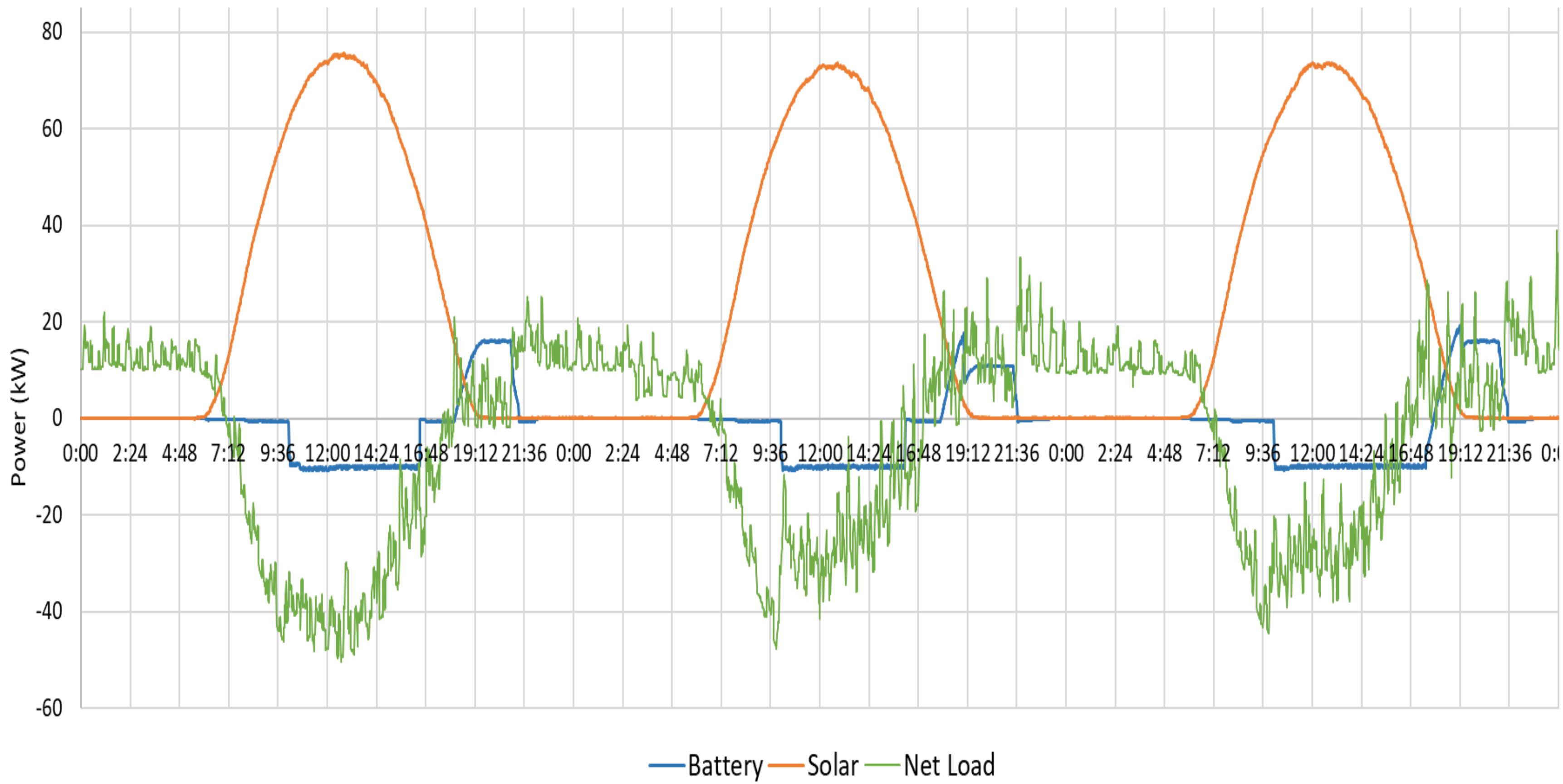
125 kVA AC-DC Inverter

Energy Management System

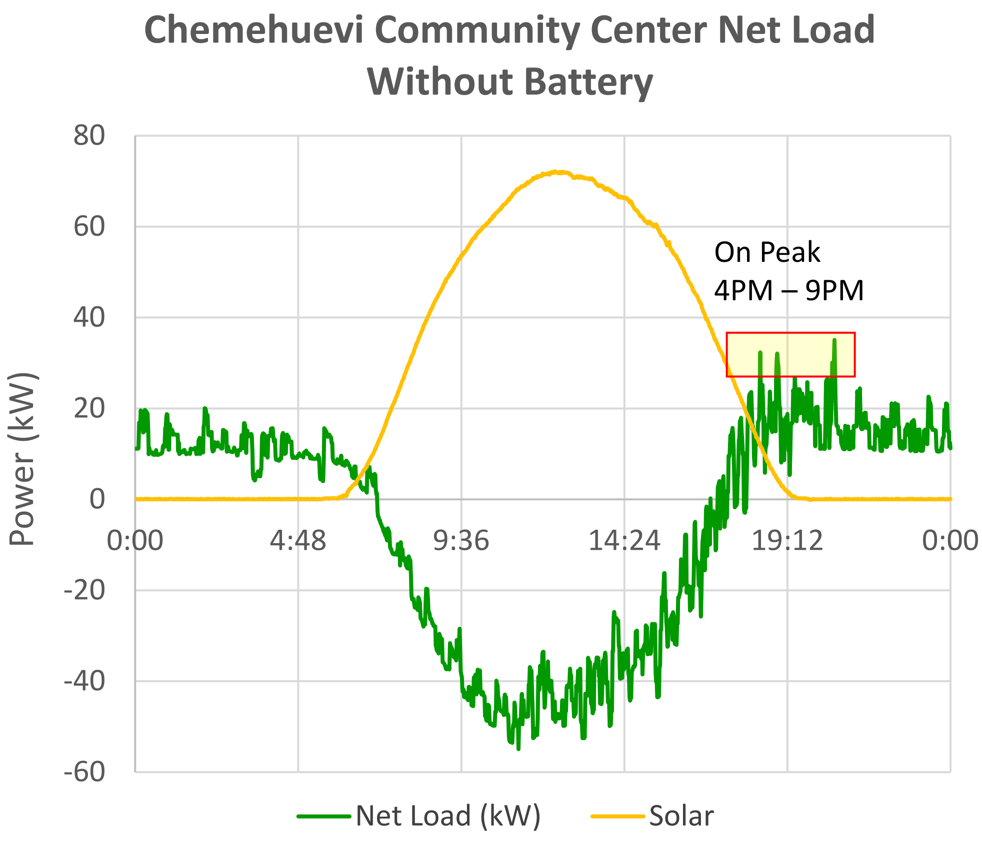
- The PI Server handles the storage, collection, integration, processing, computation, and delivery of data throughout the microgrid.
- PI Interfaces and Connectors collect data from data sources, such as PMU, BMS, ECM, weather station, and thermostats.
- PI Vision allows users to visualize data in the form of graphs, spreadsheets, or system diagrams.

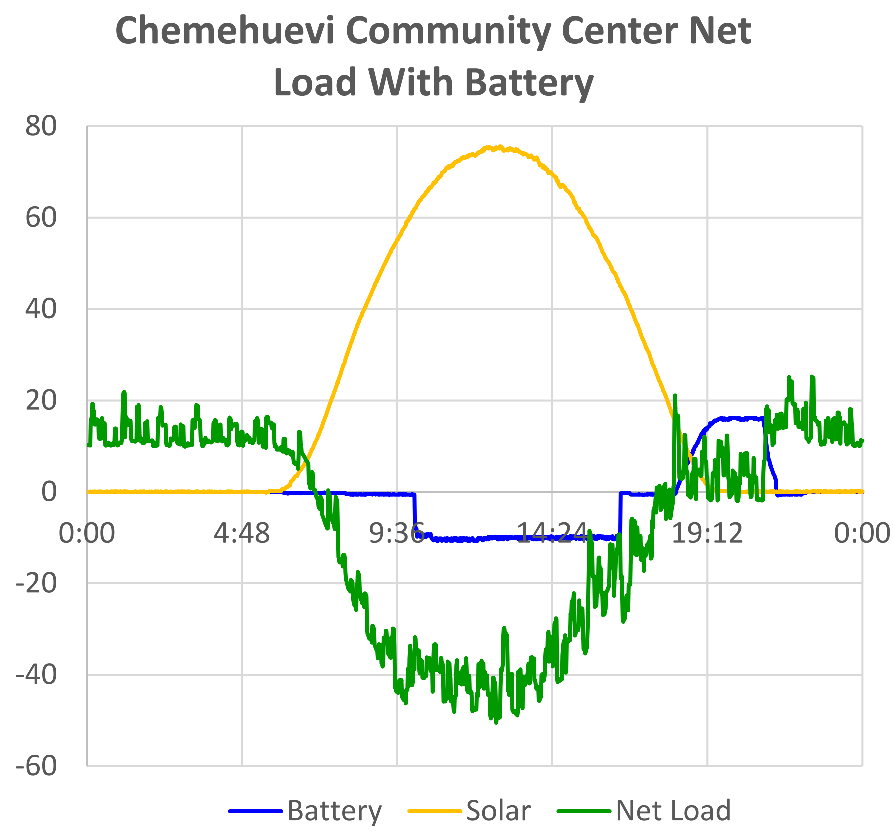


Daily Operation of Solar PV and Battery

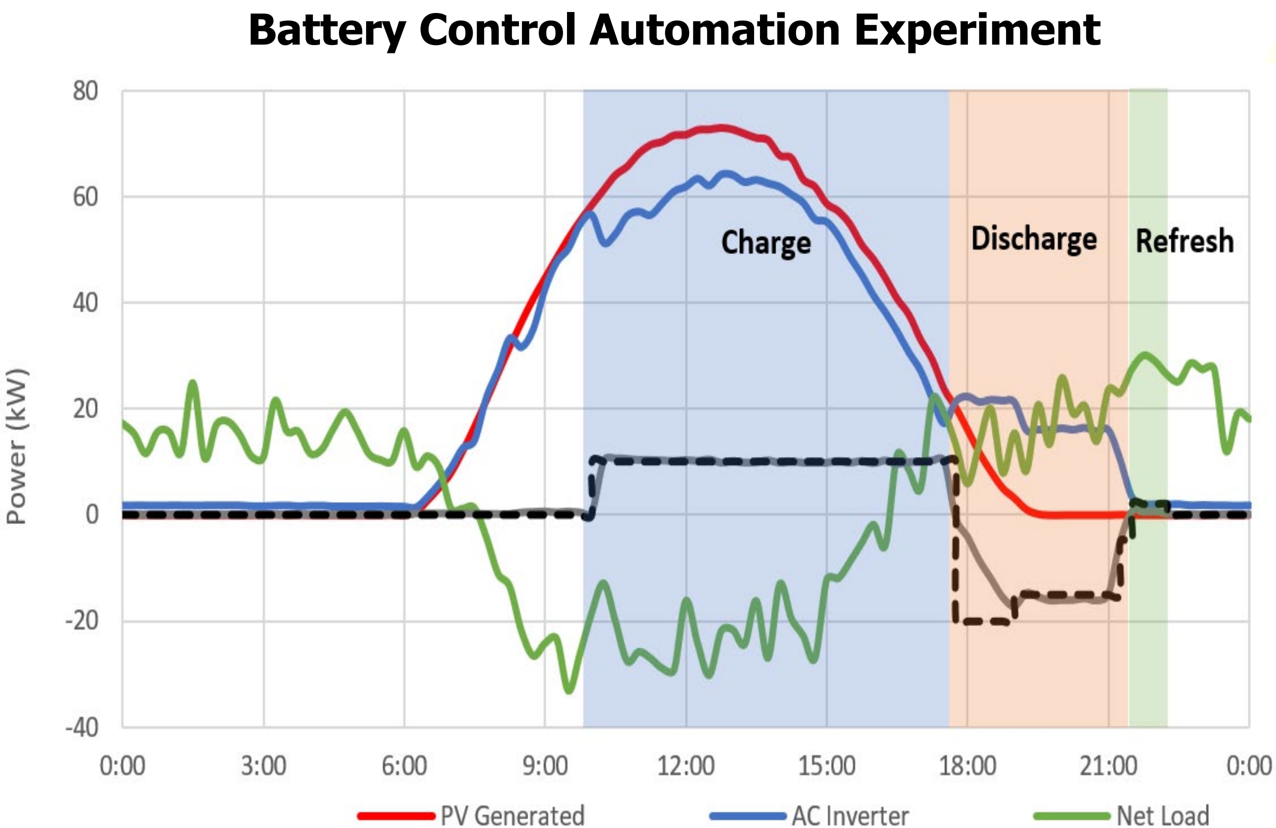


Primus Power Flow Battery Operation



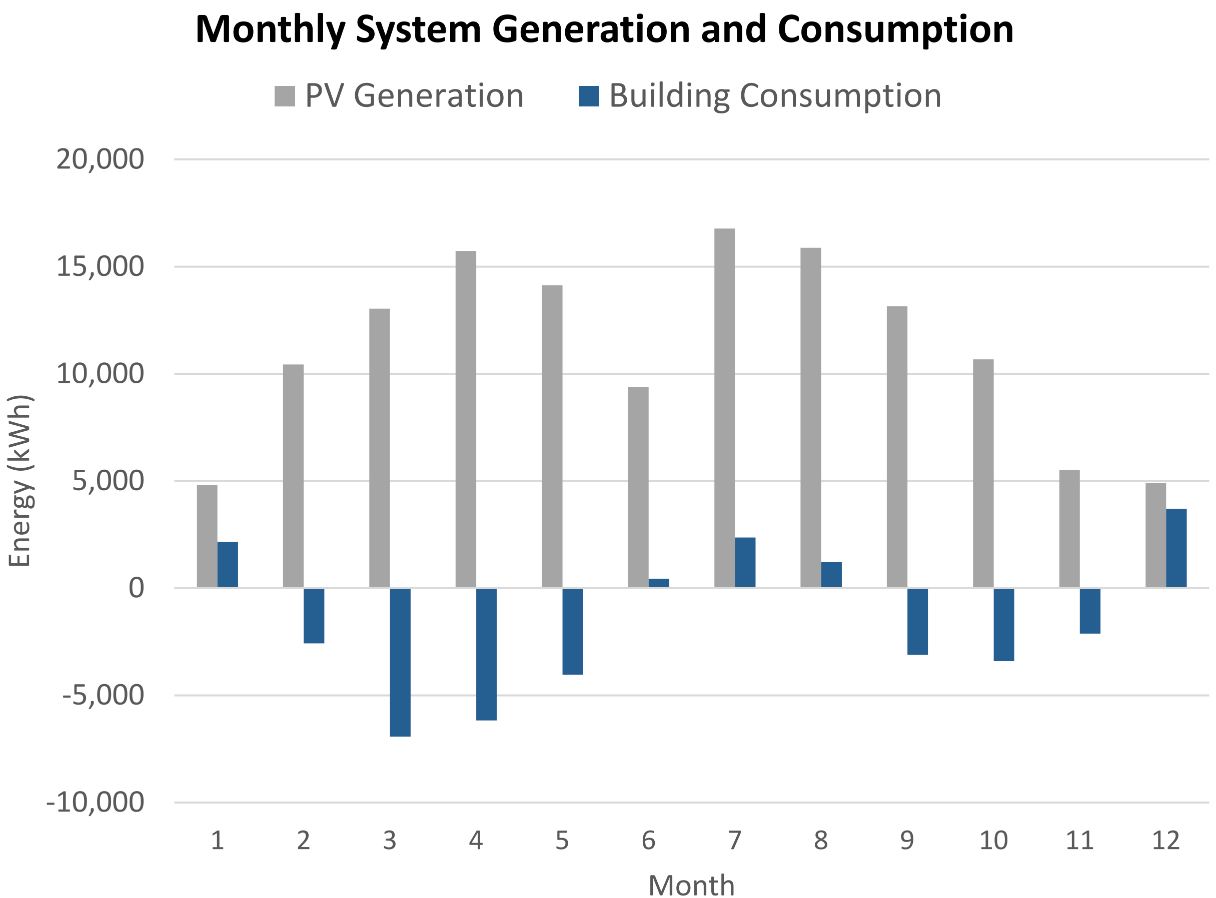


Primus Power Flow Battery Operation



Battery Power Command curve (black dotted line) represents the control command from the MATLAB to the energy storage system's BMS via TCP/IP Modbus communication. The actual battery response is shown by the gray solid line. Battery is charged at constant 10 kW rate from 9:30 AM until it reaches its maximum capacity of 30 to 40 kWh. Battery is discharged from 5:30 PM to 9 PM.

Project Results

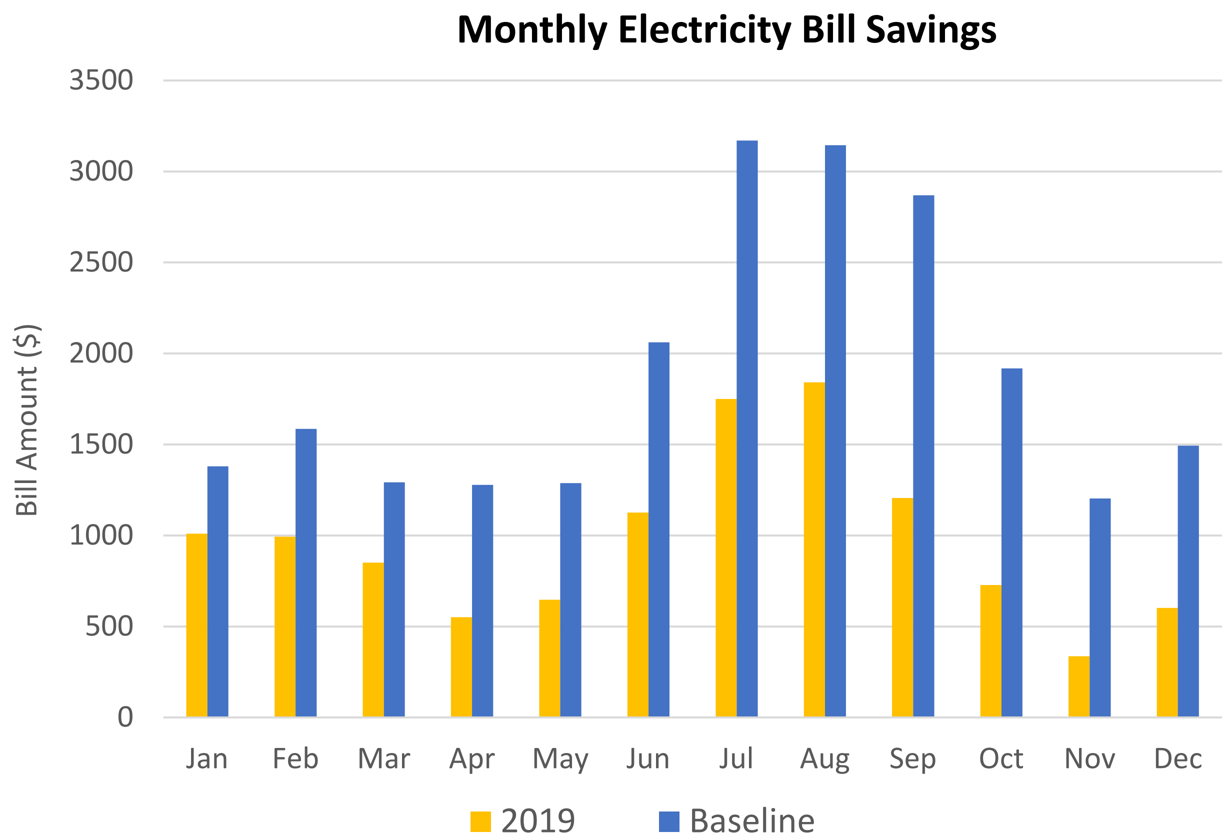


Over 12 months the system generated 143,368 kWh AC renewable energy, displacing 47,455 kg of CO_2e greenhouse gas (GHG) emissions from grid electricity.

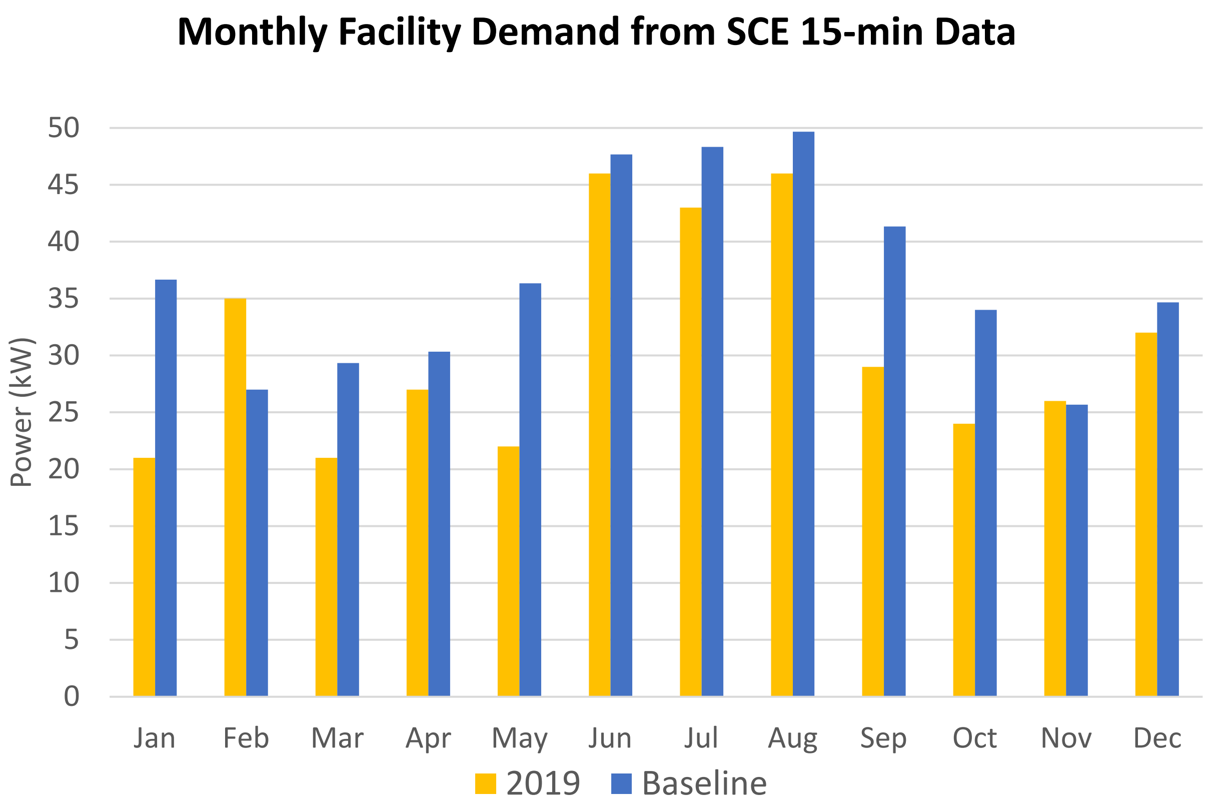
There are total of 27 days when the solar PV system was down, or the PI server system unsuccessfully collected the data.

Project Results

The total annual electricity cost was reduced $11,042, or nearly 50% reduction from the average annual electricity cost of the previous 3 years. An addition benefit of $491 was issued by SCE for participation in CPP demand response program



Project Results



Overall there is a total 69 kW peak reduction over one year with the introduction of the system. Which exceeds the original project goal of 10% demand peak reduction.

Project Benefits

Financial Savings:

- Electrical Energy Savings
- Electrical Demand Savings
- Demand Response Participation

Other Broader Benefits:

- Greenhouse Gas Emissions Reduction
- Technology De-risking
- Increased Grid Reliability
- Work Skills Development
- Increased Awareness of Energy and Demand Use

Lessons Learned

Construction:
- Close oversight and coordination (integration of pre-commercial technologies)
- On-site support (local training)

Permitting:
- Work with local jurisdictions (construction permits)
- Consider implications of environmental law (NEPA/CEQA)

Commissioning:
- Work closely with the utility company (field testing of equipment and deviating from standard procedures)
- Coordinate with third party (UL)

Lessons Learned

Site Requirements:

- Understanding local needs (blackout frequency)
- Detailed technical specifications (operating temperatures)
- Proper site preparation (location of equipment)

Engineering:

- Understanding of the design, appropriate topology, and operation
- Gathering necessary documents (soil study, location of utilities lines)

Equipment Procurement:

- Equipment compliance (CA Rule 21)
- Interconnection agreement requirements (Non-export relay)
- Keep up with interconnection standards (IEEE 1547)

Lessons Learned

Demonstration:

- Closely monitor the system (system fault)
- Training of local personnel (troubleshooting and maintenance)
- Identify local subcontractors (electrician)

Sustainability:

- Transfer of technology and ownership of system (documentation)
- Secure funding for maintaining project (equipment service agreement)
- Operation and maintenance of the system beyond the project end.

Lessons Learned

EMS integration with common microgrid components.

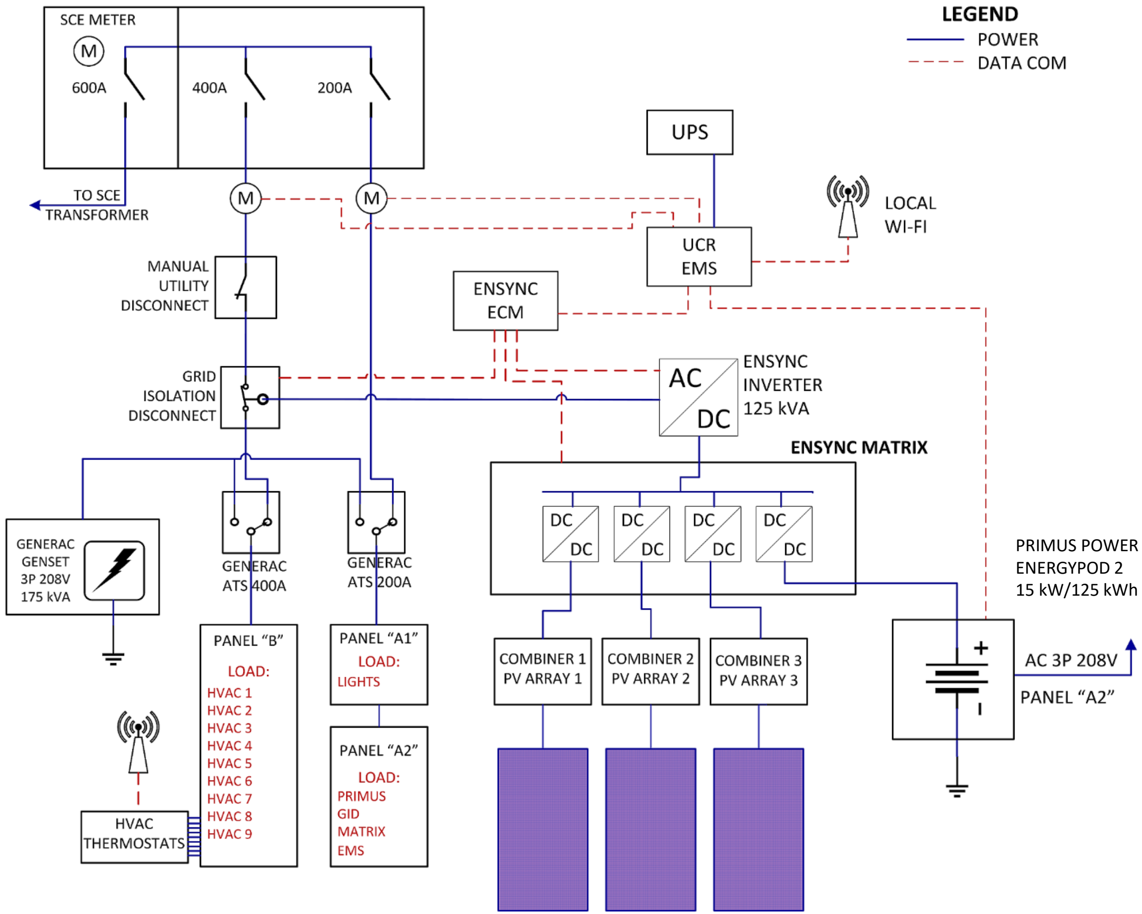
- EMS control of third party microgrid components (HVACs and other loads, solar PV inverter, energy storage inverter, BMS, islanding disconnect, electrical meters, etc.) is not trivial.
- Most devices have open APIs and support Modbus communication protocol. However, functionality over API is usually limited, while manuals and documentation are lacking.
- UCR team worked closely with software and applications engineers from Primus Power and EnSync to deploy new API features to the EnSync inverter and Primus Power battery's BMS.

Lessons Learned

Equipment compliance with safety standards, local AHJ regulations, utility interconnection rules, NEM agreement requirements.

- EnSync Inverter was not compliant with UL 1741 SA required by CA Rule 21 Phase 1 from September 2017. An exemption was granted by SCE, but it delayed the interconnection process several months.
- In order to meet NEM agreement requirement to ensure battery does not charge from and export to the grid, a software solution had to be implemented by the project team. SCE required independent NRTL witnessing and report. The process resulted in significant delay in interconnection.

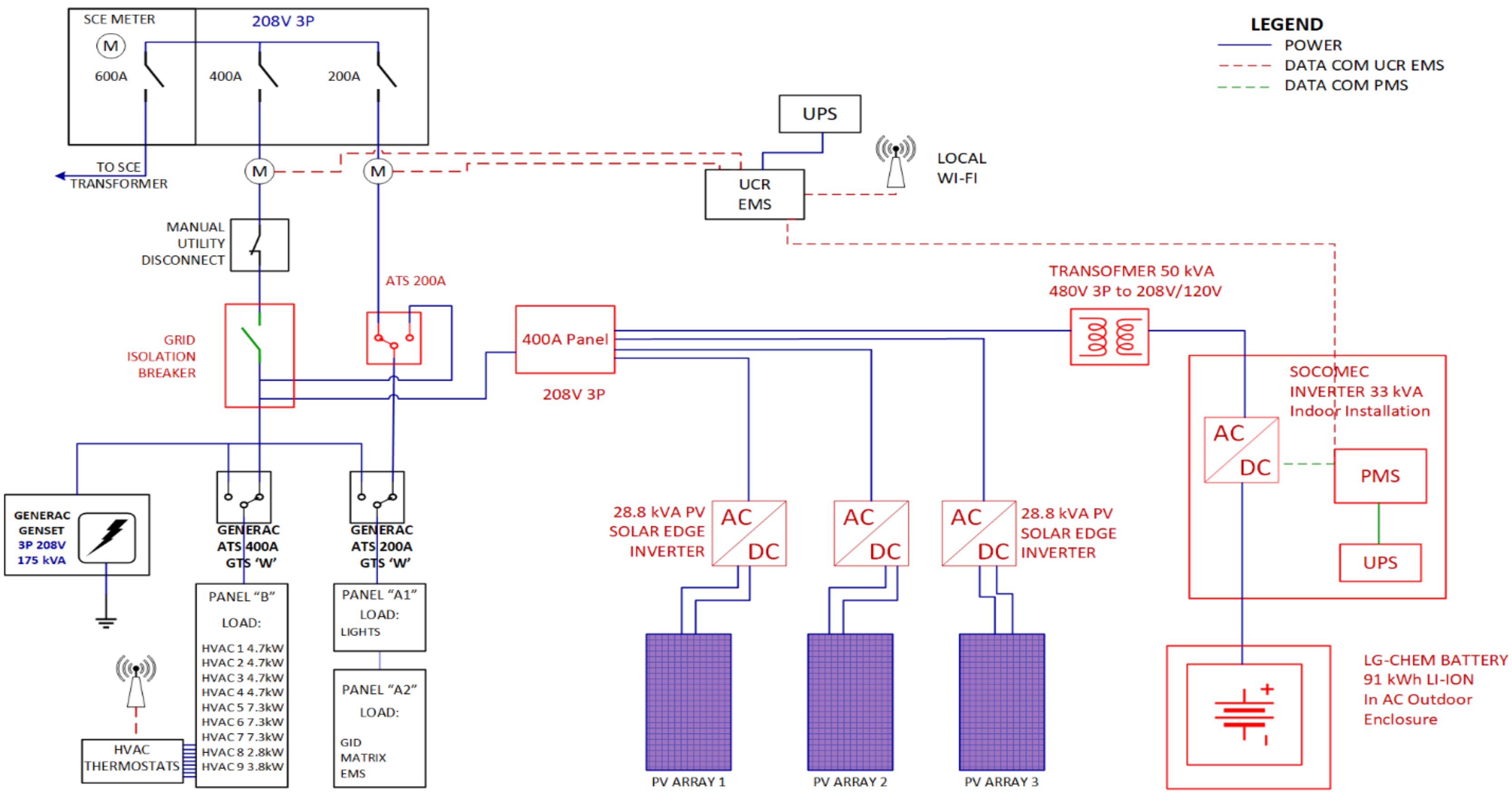
Initial Microgrid Single Line Diagram



Microgrid System Modifications

- Remove all components requiring EnSync parts or support.
- Remove Primus EnergyPod prior to end of project.
- Install three 30 kW solar (SolarEdge) string inverters.
- Install solar PV module optimizers (SolarEdge).
- Install energy storage system 30 kW/ 92 kWh capable of blackstart (Socomec).
- Install new grid islanding disconnect.
- Update EMS to manage microgrid islanded operation.

Upgraded Microgrid Single Line Diagram



Upgraded Microgrid

Solar Inverter

Battery Inverter and Controller

Battery Rack in Enclosure

Outdoor Battery Enclosure

Solar System Monitoring

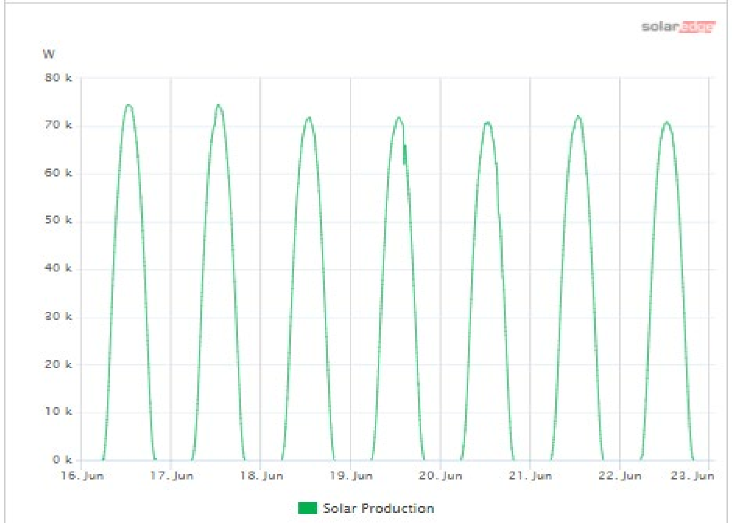
Current Power	Energy today	Energy this month	Lifetime energy
248 W	7 Wh	2.61 MWh	147.46 MWh

Power and Energy

Day | Week | Month | Billing Cycle | Year

06/16/2020 - 06/23/2020

System Production: **4.3 MWh**

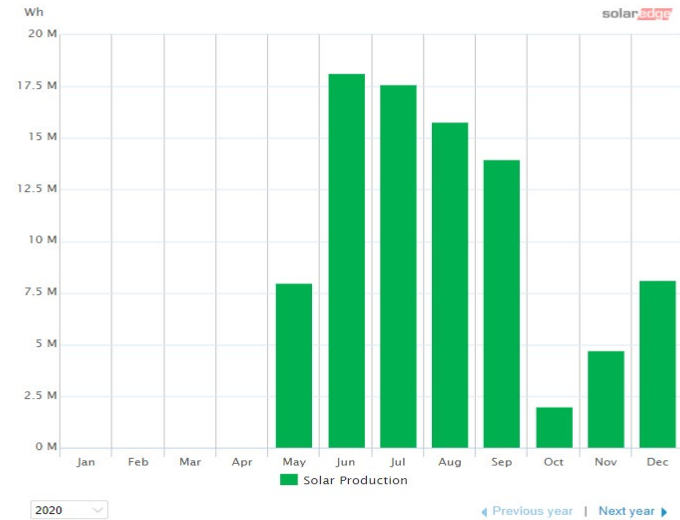


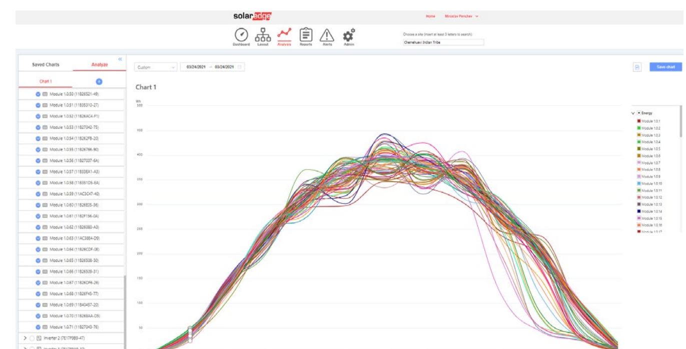
solaredge

Site Status	
ID	1627283
Name	Chemehuevi Indian Tribe
Address	North Valley-Mesa 4, Havasu Lake,California,Unite...
Installed	02/20/2020
Last Updated	04/06/2021 06:30
Peak Power	87 kWp

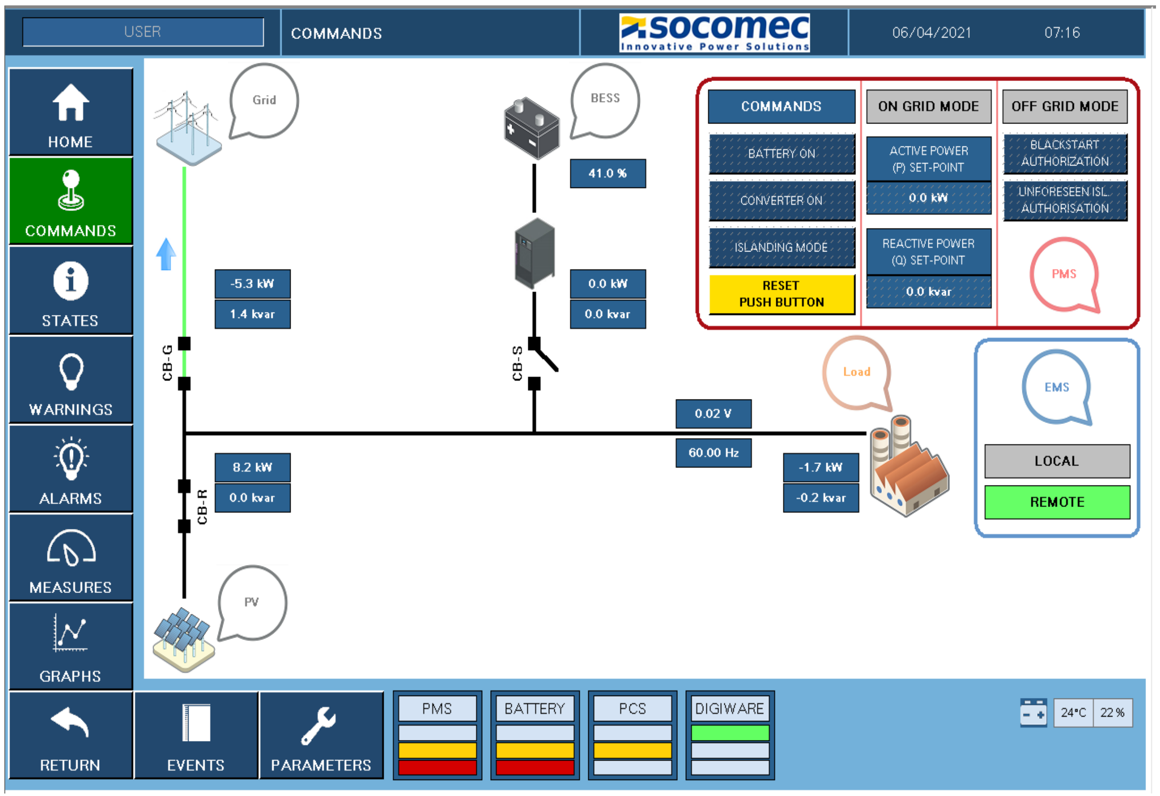
Partly Cloudy
72 °F
Feels like 72 °F
Wind W, 6 MPH
Humidity 22 %
Sunrise at 06:18
Sunset at 19:03

Tuesday	Wednesday	Thursday
90 - 55 °F Mostly Sunny	93 - 64 °F Sunny	95 - 63 °F Mostly Sunny



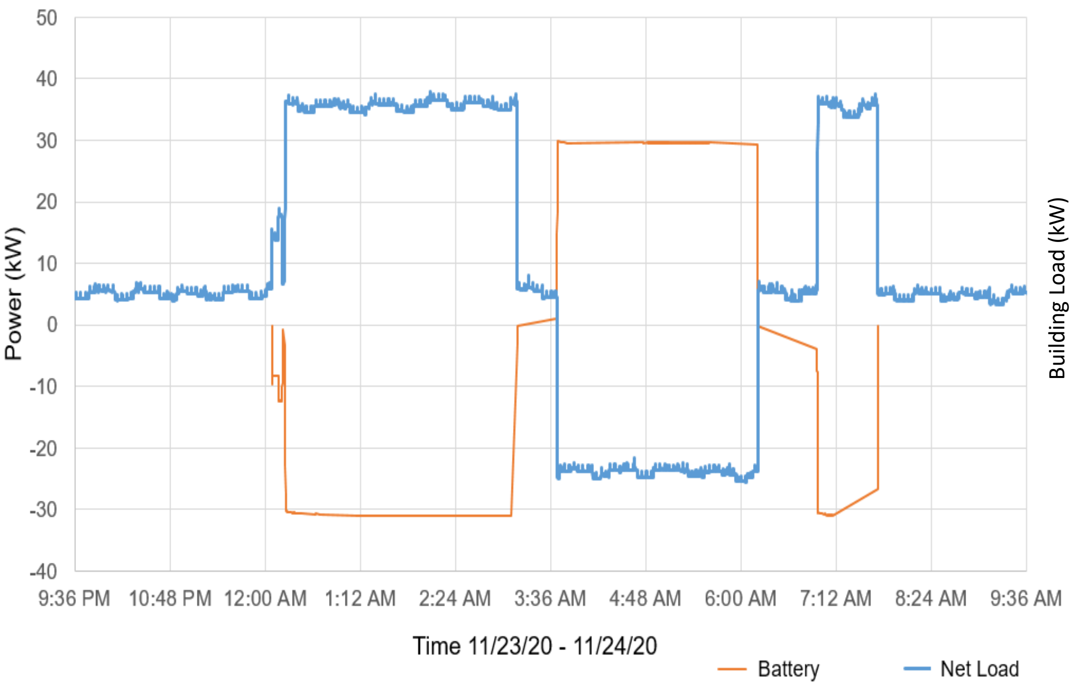


Battery Monitoring and Control Display

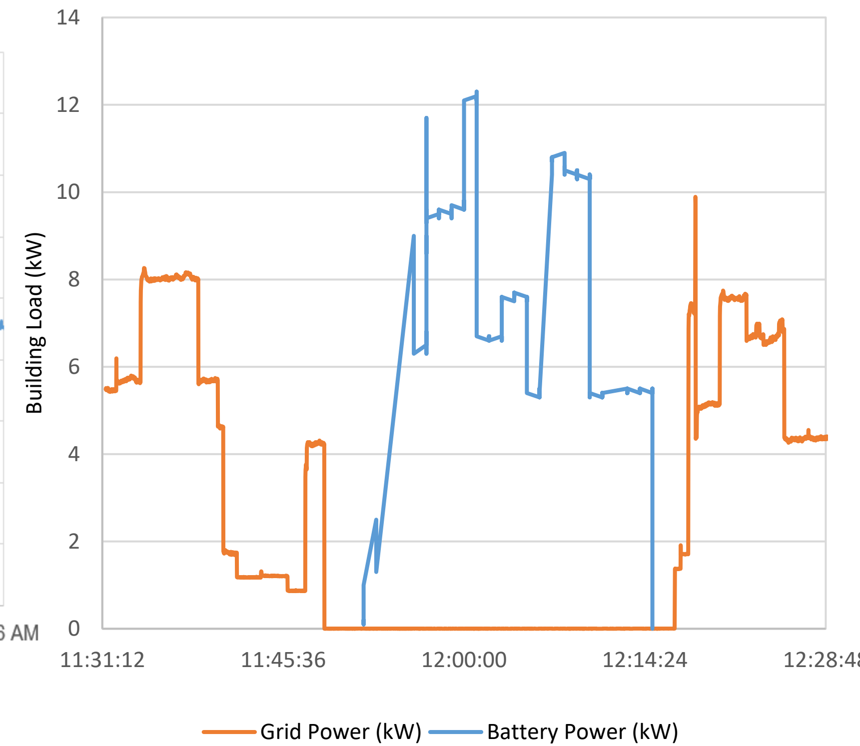


Battery Operation

Full Charge-Discharge Battery Test



Islanded Operation



Thank you

Project Team

Front row, from right to left: Lorrie Ellsworth (CIT), Alfredo Martinez-Morales (UCR), Miro Penchev (UCR)
Back row, from right to left: Glenn Lodge (CIT), Emmanuel Evans (CIT), Nick Challis (CIT)
Not present in this photo: Mike Todd (UCR), Henry Gomez (UCR), Sadrul Ula (UCR)

Project Team

Left to right: Dan Glasow (GRID), Lisa Castilone (GRID), Rizaldo Aldas (CEC), Tom Stepien (Primus Power), Glenn Lodge (CIT), Charles Wood (CIT), Alfredo Martinez-Morales (UCR), Eduyng Castano (SCE).

Questions?