YOKOGAWA

A Yokogawa Company

PXiSE Energy Solutions

Case Study

Guam

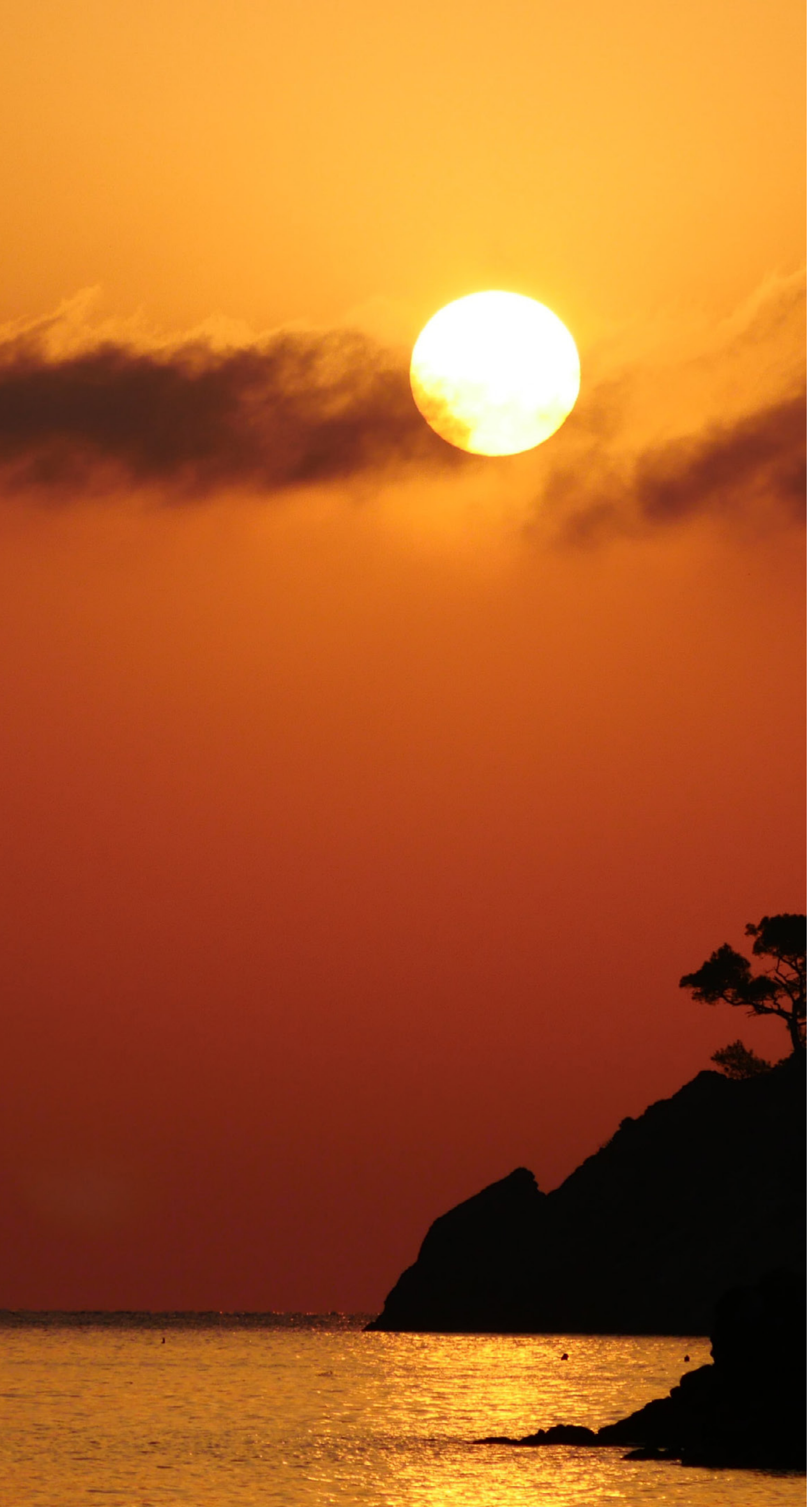
Mitigating power and frequency fluctuations with real-time control

Overview

With a population of just over 168,000, Guam is an island that spans a bit more than 200 square miles in the Western Pacific. Guam Power Authority (GPA), a public corporation, provides electricity throughout the island through Guam's electric grid, including about 1,800 miles of transmission and distribution lines with a load of about 200 MW.

Because Guam has no fossil fuel energy sources of its own, it must import petroleum to meet all of its energy needs, which is part of why rapid transition to renewable sources like solar is so critical. In addition to petroleum-based power plants, Guam has a 25 MW photovoltaic farm. Guamanian customers may also contribute homegrown solar and renewables, and are paid by GPA for their excess, which is then distributed across the grid. Guam's legislature has set a goal for 100% of the island's electricity to be renewable by 2045.

The military accounts for about one-fifth of Guam's power consumption, and this could increase in the near future with US government plans to relocate military personnel from Okinawa to Guam in 2024. Thus, upgrading infrastructure to enable accelerated growth of renewables is crucial to support Guam's growing power demands.



The Challenge

Due to the challenges inherent in being a Western Pacific island, Guam Power Authority was looking for real-time control to manage their grid assets. In 2015 a 25 MW solar farm came online, reducing reliance on fossil fuels, but creating instability issues for the grid due to weather variations. Although the island has a relatively stable tropical marine climate, with temperatures throughout the year ranging from 70-90 degrees Fahrenheit, it can experience extreme typhoons during the rainy season, from November through May. In fact, in 1997, Guam recorded one of the highest wind speeds on earth (230 mph) during Super Typhoon Paka. Storms, clouds, and other weather conditions mean that Guam’s PV farm’s output ranges from 5-25 MW, a significant fluctuation frequently resulting in severe grid disturbances.

Additionally, grid frequency also needed to be addressed. When power on the grid flares or drops, grid frequency responds in opposition. The lifespan of equipment like motors is significantly impacted when frequency deviates from 60Hz. High usage causes a downward spike in frequency, and if it goes below 59.3 Hz, outages begin to occur. The lower the frequency, the more outages the island experiences. Some equipment (like motors) might not function properly outside of that nominal frequency range. Additionally, mechanisms like clocks that are not connected to GPS, such as in appliances, use grid frequency to stay in sync. An increase in frequency will make clocks fast, and a downspike in frequency will make clocks slow. If the daily average frequency is 60.1 Hz, the island’s clocks will be three minutes fast each day. In order to compensate, the system would need to manually lower the frequency in equal amounts to a spike, leading to potential outages.

In order to mitigate both power and frequency fluctuations, GPA commissioned LG CNS to install two energy storage systems, procured from LG Chem; one battery to mitigate solar fluctuation, and the other to provide active frequency support. The missing piece was a system controller to coordinate the charging and discharging of the energy storage system to meet the GPA requirements.

GPA and LG CNS had specific requirements for this controller, including:

- A very tight 250 kW/minute ramp rate (the rate at which a power plant can increase or decrease output), to be checked every second, with a greater than 97% success rate
- Fast deployment: the intended deployment time was under six months
- Two separate, compatible controllers: One controller to manage the PV farm, and one for frequency regulation, with the potential for future connection
- Response time of 200 milliseconds or less

The Solution

Thanks to a history of cooperation, including a demo project on South Korea's Jeju Island, LG CNS was familiar with PXiSE, and soon brought the company on board to supply the control system for this challenging setup. PXiSE deployed two of its controllers—One at Agana for frequency control and one at the PV farm in Talofofo.

These two controllers offer several unique features:

- **Tight ramp rate control:** with a success rate greater than 97% at keeping the ramp rate at or below 250 kW/minute
- Both PXiSE controllers **use the same code** to ease future connection of additional devices
- **Real-time asset control:** renewables ramping, smoothing, real and reactive power control, and energy shifting by leveraging the battery system
- **Virtual Power Plant (VPP) control:** PXiSE's Renewable Power Plant Controller aggregates solar farm and batteries as a single virtual power plant
- **Scalable, reliable, and safe:** As assets grow, the system can expand horizontally and vertically. PXiSE can deploy additional controllers and aggregate them via a higher-level controller
- **Rapid deployment:** Although the Guam deployment was delayed due to COVID and typhoon season, PXiSE can typically deploy its controllers in four months or less

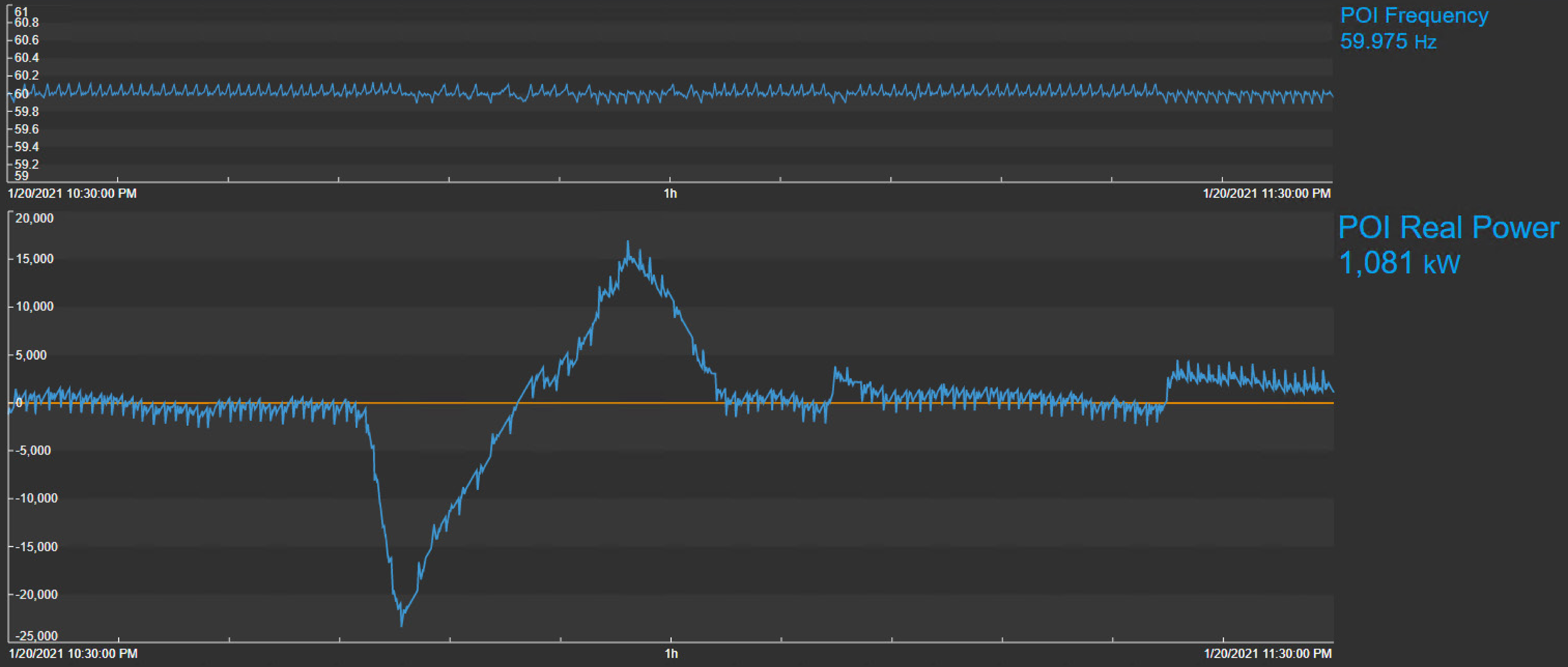
PXiSE's controllers are straightforward, with a custom graphical interface for customer ease of use. Because of this, PGA staff required just one 4-hour training on navigation and day-to-day operations in order to use the system.

The Results

In testing, PXiSE's controllers met all of GPA's and LG's required metrics. Notable results include:

- Met the required ramp rate 98% of the time. Without the controller, the system had previously exceeded their upper limit 40% of the time, which can lead to outages.
- 50-60 millisecond response time (far exceeding the 200 millisecond requirement)
- Automatic controls proved to be 10 times better than manual control when it came to managing frequency fluctuations
- A 99.3% reduction in time drift—time drift decreased from up to 15 minutes per day to only 13 seconds per day

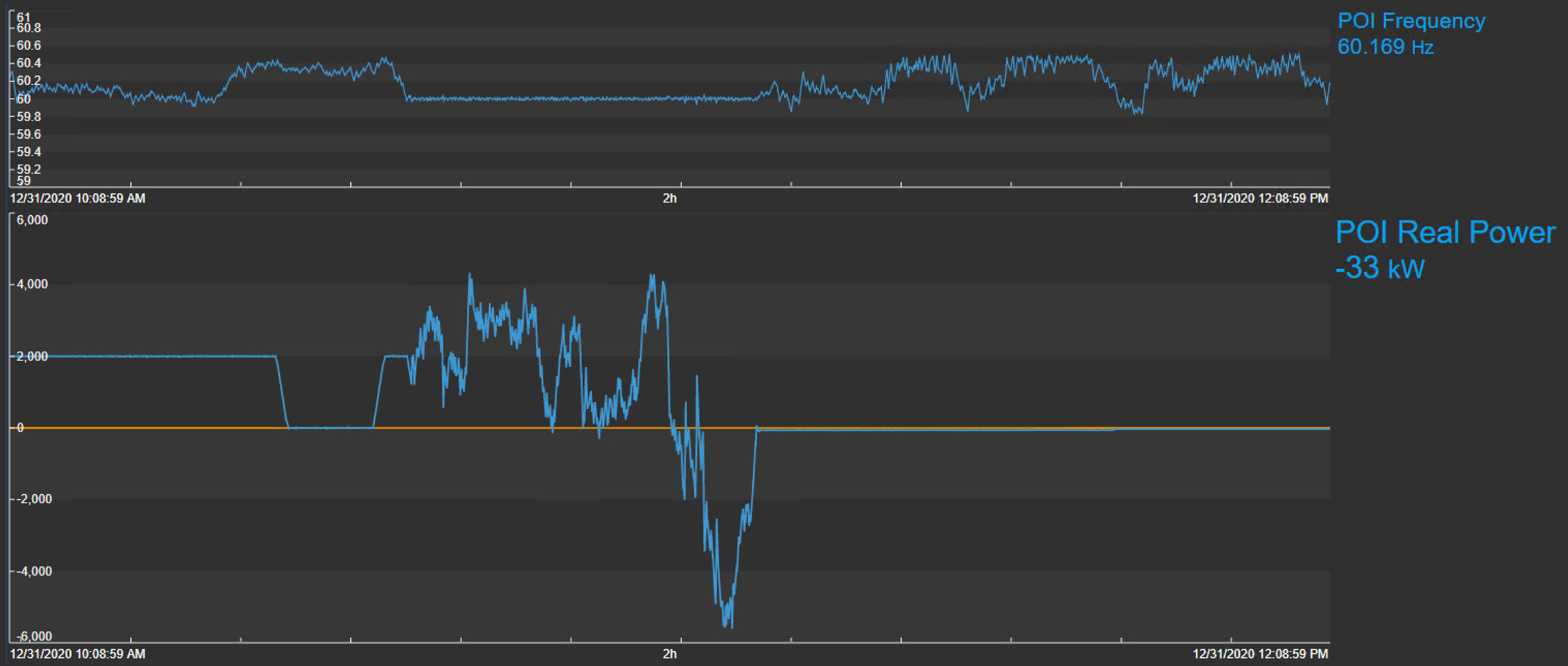
FREQUENCY WATCH
WITH +/-0.1HZ DEADBAND
This figure shows frequency variation using the PXiSE controller (the upper line) vs. power usage variation at the same time (lower line). The PXiSE controller kept the frequency within the safe range of 59.9-60.1 Hz, despite dips and flares in power usage and output.



The Results

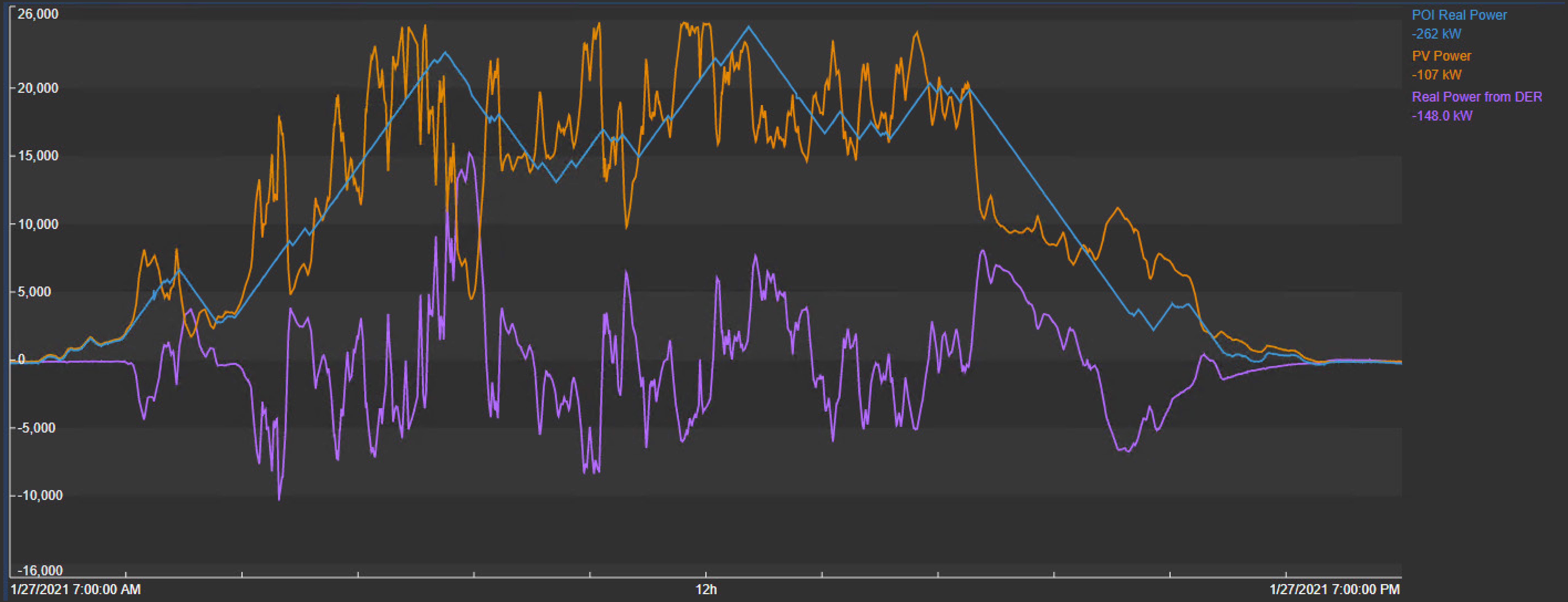
ACTIVE FREQUENCY CONTROL

This figure shows the frequency variation (upper line), with and without use of the PXiSE controller, vs. power usage (lower line). Frequency variation was significant without use of the controller, even with little deviation in power usage. In contrast, the PXiSE controller maintained the safe frequency range of 59.9-60.1 Hz, even with considerable power fluctuations.



The Results

SOLAR RAMP CONTROL



Project at a Glance

01 **Location**

Agana

Infrastructure

24 MW/6 MWh Battery Energy Storage System

02 **Location**

Talofofo

Infrastructure

16 MW/16 MWh Battery Energy Storage System

Project Partners

A Yokogawa Company PXiSE Energy Solutions

LG Chem

Sources eia.gov - Click Here postguam.com - Click Here

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