By Alexandra Walsh

FIGHTING UNPREDICTABLE POWER WITH MICROGRIDS

Integrated energy systems are tailored to the individual needs of cold storage facilities.

From South Africa to Central California, energy-intensive cold storage new builds, expansions and renovations face challenges from long utility interconnection delays. Even after they are connected to the grid, cold storage facilities are vulnerable to blackouts. Increasingly frequent extreme weather events, political policies, rising energy costs or crumbling infrastructure are just some of the unpredictable power challenges that can result in food spoilage and create a public health threat.

Origo Cold Storage's off-grid microgrid system generates enough solar photovoltaic cells to provide for all of the facility's energy needs. (Photo courtesy of Scale Microgrids.)

What Are Microgrids

Microgrids are emerging as versatile, on-site, cost-effective systems tailored to meet the needs of individual cold storage facility end users. These integrated energy systems can address the challenge of long interconnection queues, which are a significant barrier in agricultural regions like California's Central Valley in the United States.

Long wait times for utility service interconnection or upgrades can lead to operation delays. Many utilities are struggling with long queues for the interconnection of new facilities or site capacity expansions for existing facilities. Microgrids can be developed and begin powering facilities in under 12 months.

Microgrids enhance resilience by integrating multiple layers of energy assets, typically including on-site solar and battery storage, dispatchable generation for backup and advanced controls to ensure critical operations always stay online. Off-grid microgrids may include additional measures to allow for incorporation of emergency generators as a failsafe.

A microgrid typically incorporates on-site solar power generation that provides significant cost savings compared to utility tariffs. In addition to saving on electricity costs today, microgrids lock in energy costs by minimizing or eliminating exposure to future utility rate increases.

Grid-connected microgrids offer additional opportunities for cost savings. The use of battery storage and optimized microgrid controls allow for load shifting to hours of the day when electricity is cheapest as well as peak energy management to avoid excess demand charges. Beyond these savings, grid-connected microgrids can potentially generate revenues through participation in utility demand response programs and virtual power plants.

In addition to saving on energy costs, the low-cost on-site solar generation included in most microgrid configurations can deliver emissions benefits that are increasingly valued by cold storage facilities and their customers. Microgrids can often deliver reductions in greenhouse gas emissions of 30% or more compared to relying exclusively on the utility grid. By utilizing zero-emission solar energy to meet a significant portion of energy demand, microgrids directly reduce a facility's carbon footprint.

Microgrids provide a flexible platform for additional energy upgrades down the road, allowing businesses to future-proof their plans in case utility delays persist over the long term.

Origo Cold Storage in Central California provides a case study of microgrid applications in a cold storage facility.

Microgrid Case Study

Origo Cold Storage is using a microgrid.

Amond World is the operating partner for Origo Cold Storage, a commercial property developer building a state-of-the-art, 500,000 square-foot refrigerated cold storage facility in the Madera Airport Industrial Park in California's Central Valley.

Faced with grid interconnection delays increasing unreliability and cost concerns, Origo decided to power its facility with an off-grid microgrid designed and built by Scale Microgrids.

The Problem: Central California Is Nuts

Central California is a national and global agricultural powerhouse, with revenues from agriculture reaching $51 billion in 2021. The state is renowned for its nut production and particularly almonds, with 7,600 farms producing more than 2.9 billion pounds of almonds annually to supply approximately 80% of global demand.

This highly productive sector of California's economy also faces a major challenge. Nut crops have a short harvesting window, typically between August and October. Yet this seasonal supply must fulfill year-round global demand. It puts pressure on farmers and processors to quickly sell their crops, often at reduced post-harvest prices, which contributes to annual revenue volatility.

Cold storage facilities are a solution, however, limited cold storage capacity is difficult to secure for many small and medium-sized farms in particular. Today, 1.3 billion pounds of California almonds are stored outdoors despite vulnerability to spoilage, insects, fungus and mold.

The need for more cold storage capacity for the Central Valley's farmers is clear, but utility interconnection for facilities in rural areas is a persistent and growing problem. The refrigeration requirements of these facilities lead to long wait times and high costs to connect to the utility grid. For example, PG&E, the region's electric utility, would be unable to get power to Origo Cold Storage for two to three years.

Bypassing Interconnection

Instead of waiting in PG&E's queue, Origo "skipped the line" with an off-grid microgrid system to supply its entire energy needs. Origo's need for energy independence required an off-grid microgrid featuring 2,400 kW of solar, 2,400 kW and 4,800 kWh of battery storage, and two 1,200 kW low-emission dispatchable generators.

The first phase of the microgrid was designed and built in less than 18 months, allowing the cold storage facility to start its operations months sooner than originally anticipated – a major boon to the area's farmers.

In addition to saving time, the off-grid microgrid gave Origo Cold Storage the flexibility to be located at the "first mile," close to where crops are grown and harvested. This enables local farmers to store their crops as quickly as possible after harvest, which helps retain their quality and water content. This is crucial for a crop that can lose 10 to 15% of its water weight in the first 30 days without proper storage. Since nuts are sold by weight, this is directly tied to revenue losses for nut producers.

Origo Cold Storage is a contrast to most cold storage facilities today, which are located close to urban areas where it's easier to connect to the grid. The trade-off is that these more urban facilities are located far from rural agricultural regions.

Saving Energy and Money

Microgrids offer substantial energy savings for cold storage facilities, where refrigeration-related operations can account for more than 75% of total energy costs. Cold storage facilities require nearly 25 kilowatt-hours (kWh) of electricity per square foot and face rapidly rising electricity prices, with increases of almost 45% in recent years in some regions.

Origo's microgrid provides electricity cost savings that range from 10% to 30% compared

GCCA Working for Government Action on Load Shedding in South Africa

After severe blackouts in South Africa in 2023 exposed a critical vulnerability in the country's cold chain infrastructure, the GCCA commissioned a report on the effects of frequent power outages during load shedding (planned power outages to prevent system-wide failure).

The report shows that the resilience of the cold chain is threatened by energy challenges such as load shedding and an overreliance on ageing coal-fired power plants, particularly in Botswana, Madagascar, Mauritius, Morocco, Namibia, Senegal, South Africa, Zambia and Zimbabwe. Frequent power outages during load-shedding strain refrigeration equipment, leading to increased maintenance and breakdowns in cold chain operations.

For the Southern African cold chain to survive such shocks, the report contends the cold chain sector must urgently implement robust resilience mechanisms. Whether through backup power solutions, improved storage facilities or adaptive operational practices, fortifying South Africa's cold chain against load shedding is not just essential but urgent for food security and public health. The report suggests these issues necessitate significant investment in alternative energy sources to ensure a more sustainable and reliable power supply.

GCCA Africa Director Paul Matthew says, "An effective cold chain is the foundation of a safe, affordable and resilient food supply chain for Africa, maximizing the availability and shelf-life of food and substantially reducing post-harvest loss and waste. Our industry is also vital to economic growth and trade across the continent. Reliable access to energy is a core requirement for keeping food refrigerated in storage and in transportation, and our new report shows the impacts on the cold chain over the past two years of the worsening energy crisis and increase in load-shedding.

"GCCA is actively engaged with government and power companies to discuss its policy recommendations."

The line of white rectangular boxes to the left of the generators is a 4.8 MWh battery energy storage system. (Photo courtesy of Scale Microgrids.)

to a grid-connected cold storage facility, with savings increasing at higher loads.

These energy savings are achieved by leveraging low-cost on-site solar generation with advanced controls, which optimizes the charging and discharging of the site's battery system to minimize runtime for the more expensive dispatchable generators.

The facility also drives cost savings with predictive energy management systems that can analyze and anticipate fluctuations in the region's weather, adjusting the facility's energy use accordingly. For example, the software can temporarily idle the system without compromising temperature control because of the building envelope's ability to insulate and retain coolness.

Layers of Resilience

Grid reliability challenges can be particularly acute in rural and agricultural regions like California's Central Valley, where distribution infrastructure is often older and less robust than in urban areas. This is particularly problematic for cold storage facilities' high energy demand requirements and need to maintain 100% uptime for refrigeration and humidity control systems.

All of Origo's electricity is supplied by its off-grid microgrid, allowing it to be completely independent from the grid and resilient to disruptions. The cold storage facility's microgrid incorporates three levels of redundancy.

1. **Rooftop solar array and battery storage.** 2,400 kilowatts (kW) of solar arrays take advantage of Central California's abundant sunlight, while 2,400 kW/4,800 kilowatt-hour (kWh) of battery storage allows this energy to be stored for later use. With an expected load of 200-250 kW, the solar and battery will be able to power the facility for 12 to 18 hours a day, allowing it to be powered primarily by renewable energy the majority of the year. Even in winter, the facility can run largely on the combination of solar and batteries. The low outdoor temperature combined with the thermodynamically efficient insulation in the building's envelope allows for reduced energy requirements to maintain optimal temperature and humidity in the winter.
2. **Low-emission dispatchable generators.** Four 1,200 kW low-emission dispatchable generators are installed for use when solar

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The two 4.8 MW low-emission generators. (Photo courtesy of Scale Microgrids.)

and storage are insufficient to meet the facility's needs. The San Joaquin Valley Air Pollution Control District has granted permits for these generators, ensuring that their emissions are under required limits. The generators provide enough electricity to power the entire facility when needed. In normal circumstances, the generators alternate every few hours to allow for maintenance. If there is a sudden spike in the electricity demand, they're designed to be able to run simultaneously.

3. **Exterior plug for temporary generators.** In the unlikely case that all of these on-site systems fail, the facility is equipped to allow an external generator to be brought from off-site to be plugged into the switchgear, enabling the facility to maintain an uninterrupted power supply.

Sustainable Solar

The ability to power most of the facility's needs from solar energy delivers significant emission reductions, and the highly efficient dispatchable generators ensure that emissions are minimized. As a result, Origo's CO2 emissions are about 40% lower than a typical grid-connected cold storage facility.

Future Growth

Origo Cold Storage's microgrid system is designed to produce more power than the facility needs, giving it flexibility for future facility expansions or the adoption of new technologies. For example, the infrastructure could be optimized to charge electric trucks while they load, unload and wait at the facility.

Because the microgrid systems are modular, they can be rapidly expanded to match a facility's growing operational requirements. And, if Central California's distribution grid capacity is expanded in the future, Origo's microgrid can be interconnected with the utility grid to further optimize energy costs and resilience.

Predictable Outcomes

Avoiding the delays of grid interconnection ensured a faster, more predictable start to Origo Cold Storage's operations.

The facility's proximity to agricultural areas offers additional advantages for farmers, including enhanced crop quality and reduced losses during transportation.

Its microgrid, equipped with solar panels, battery storage and low-emission generators, delivers a robust and sustainable energy solution with three levels of redundancy to guarantee continuous power supply.

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