Flexible multiport power conversion systems deliver resilient hybrid microgrids

Microgrids | Islands are particularly vulnerable to the impacts of natural disasters such as hurricanes. John Merritt looks at some of the emerging solutions to building more resilient energy systems through the deployment of microgrids that combine multiple energy generation and storage technologies

The unprecedented natural disasters that took place in 2017 are bringing greater attention to the importance of resilient energy systems. Disasters cost the United States a record-breaking US$306 billion in damages last year alone, according to recent figures from the National Oceanic and Atmospheric Administration. While these disasters did not discriminate by geography, and many parts of the country and the world were impacted, island nations such as Puerto Rico were hit especially hard and are still in need of power for basic and critical services many months later.

Hybrid microgrids connecting renewable energy and distributed energy resources such as diesel generators are a cost-effective and adaptable option for providing power in these extreme-weather prone, remote areas. While conventional equipment is cumbersome, complex and inefficient with high upfront costs, advanced multiport power conversion systems provide unprecedented flexibility and adaptability, overcoming barriers to meet unique island energy needs. Most importantly, when critical facilities – such as schools, hospitals and municipal buildings – are offline and in need of power quickly, hybrid microgrids with seamless multiport power conversion can effectively deliver or return power to communities following a storm or another type of power disruption.

Challenges with traditional integration

System integrators and project developers have historically faced the challenge of power conversion technologies that fall short when it comes to stability, efficiency and flexibility. Bulky and inefficient components have been the mainstay of power conversion for decades. A conventional converter can weigh upwards of 700 pounds, with limited compatibility for outdoor installation – the significant size and weight of that type of equipment makes installation costs very high and laborious.

Credit: Ideal Power.

Recently commissioned Ideal Power project with JLM Energy at Carilion Roanoke Memorial Hospital

Cost is a significant barrier for islands in particular, as they already experience disparately high energy costs. The cost of electricity on the Caribbean islands averages about 50 cents per kilowatt-hour (kWh) – about three to five times that of the mainland US. If a project developer isn't aware that cost-effective solutions are available and can be adapted for island needs, this is the most significant hindrance to implementing microgrid projects.

Cumbersome and complex equipment can also be a major hurdle. Traditional solar-plus-storage microgrids require two separate power converters, making the management and integration of the hardware and software much more difficult. Connecting multiple resources can involve devices that are large in size and difficult to place, which is especially challenging for island communities with space limitations. Systems that require multiple power conversion boxes required complex and real-time embedded controls, complicating ongoing management. Additionally, it can be difficult to identify integrators and project managers with the technical abilities to develop, deploy, commission and manage such control systems.

For any system that includes storage, power converters without proper operational control systems can cause significant wear and tear on batteries. Putting stress on a battery is not only inefficient, but it also shortens the lifespan of a system. Storage efficiency is essential because solar

From 'squishy batteries' to pre-packaged systems - how the times are changing

ELM FieldSight has partnered with Ideal Power on a number of microgrid and related projects, designing and supplying the control system that makes the system tick, balancing the different distributed energy sources plugged into it. Vice president of operations Jason Petermeier shared his thoughts

We got introduced to Ideal Power about two-and-a-half years ago. The first project that we got involved with was in northern California where there is a customer at the very end of the grid. His utility power frequently came on and off. He was looking to supplement that with some backup, with regards to solar and batteries. He commissioned us and Ideal to design and install a system that would utilise utility power – and any solar he was able to produce we could apply to the load or put back to the utility power. The battery bank topped off from the solar. Any time the grid went away we would switch it to power from the batteries, we would monitor the batteries until they got below a certain charge level and you also had a startup generator onsite.

From high-end residential installations today, solar-plus-storage will gradually reach the mass market

Until fairly recently, it was common for microgrids to perhaps use lead acid and/or diesel, but lithium-ion has obviously changed the game. We've done three different types of battery with Ideal: Aqueon saltwater batteries, some advanced lead acid and also lithium and from my perspective the lithium-ion has really changed the game. Because it puts a lot more power in a smaller footprint and at a cheaper price for the customers so it really makes a return on investment much more achievable because prices have come down considerably over the last three to five years as that technology has evolved.

What we have found is that lithium-ion batteries have been a lot more stable and easy to monitor so when we charge and discharge them they're much more predictable. From a controls perspective that has been much easier for us. Some of the other battery systems that we've worked with, that we call 'squishy' batteries, we see their voltages drop and increase much more rapidly whatever discharges are applied to it. With the lithium-ions we don't tend to see that.

The more predictable everything can be in a system, the much easier it is to control. So the control algorithms behind all of this become much more simplified.

We see a wide range of project opportunities in the market today and in the future. Our projects with Ideal Power have ranged from: a vineyard, a movie theatre and high-end residential, as well as industrial companies that just look for a battery backup and solar option to supplement their utility power.

There are a lot of different paths microgrids are taking – there's the community aspect, where a community comes together wanting to supplement their utility power. Or there are remote communities – in Africa, Central America – that have no power, that are running off diesel generators and now looking to bring a microgrid-type system to their community.

You've also got high-end businesses looking to reduce their costs as well as improve their energy backup capabilities, for power outages.

The niche marketplace that our company and I think Ideal has found a niche in as well is the high-end residential and small industrial business.

While costs have come down significantly, they are still not quite affordable to the average person. What we've found, however, is that costs have come down enough for high-end residential houses (perhaps 10-15,000 square foot in size) where the owners aren't necessarily looking for return on investment but are more interested in energy independence and creating a green footprint.

So that's been our primary focus in the last 12 months, targeting that industry – with the goal that as the technology matures and costs come down, we can apply what we've learned from high-end projects. In the next 12-36 months it will only continue to get more affordable and we'll have learned so much by that time that it will be a lot more pre-packaged systems that actually could be deployed for more average homes at that time.

We see the growth of standardisation and 'pre-packaged systems' as an important driver for cost reduction. Over the last two years, everything that's been done has been kind of an engineering project. Everybody kind of hand-picked their components, had to design their architecture from scratch and then installed it. Then it takes two to three months to get everything working and talking together.

We've learned enough in the last few years that people have started to pre-package complete systems with inverters, batteries, switchgear and then you tie that in with the generator and you drop-ship pretty much a complete system to a site where you're then just making external connections rather than wiring the entire system onsite. We see that industry growing and going in that direction and as that enables other cost reductions, installation costs will come down while installation and commissioning times will also come down.

energy is an intermittent resource and on its own cannot be relied upon as a resilient power supply.

Finding the right technology

Emerging power conversion technologies allow for direct current (DC), alternating current (AC) and hybrid microgrid solar-plus-storage systems, with options to integrate solar photovoltaics (PV), diesel, energy storage and other distributed energy resources into a single hybrid microgrid project. Each system has benefits for various project types, but hybrid multiport power conversion systems are the clear solution for providing off-grid backup power. While hybrid microgrids come in different shapes and sizes, they have a few defining features. A hybrid microgrid includes solar-plus-energy storage, coupled with diesel generator sets that are strategically controlled and can operate in both "islanded" and/or grid connected mode when a grid connection is available.

Multiport power conversion allows multiple power inputs to be integrated through a single power processing stage to remove redundancies that exist with conventional single-port converters. Compact hybrid multiport converters save space, weight and dramatically simplify wiring interconnection and installation. The most effective multiport solutions also include embedded key control functions, which further simplify management.

US Virgin Islands: putting concepts into practice

Ideal Power and its integration partners deployed a hybrid microgrid system in Saint Croix in the US Virgin Islands in June 2017. On this site, six Stabiliti 30C3 multiport power conversion systems operate in parallel to integrate solar, storage and diesel into a hybrid 180kW microgrid powering a local entertainment facility. Similar to many commercial sites in the Caribbean, the facility was never connected to the central power grid and prior to the solar-plus-storage microgrid implementation, the site relied entirely on diesel generators for its power needs 24/7. Diesel generators are common in island nations with unpredictable and costly grid-supplied power, but these generators can be paired with solar-plus-storage to create a more affordable, and green microgrid solution.

The facility experiences peak load – its greatest energy use – during the late after-

noon and early evening when customer traffic and air conditioning demands are highest. Solar on its own could not be relied upon to deliver enough power during peak hours and moving the site from a 24/7 diesel-powered microgrid to a 24/7 solar-plus-storage microgrid was cost prohibitive for the site owners. Ideal Power's project team determined that integrating solar-plus-storage alongside diesel would slash operating costs and pollution by reducing annual diesel fuel consumption by 30%. The right multiport power conversion system made this possible by connecting diesel, solar and storage in a compact and modular solution. Lastly, the six-converter configuration provides a robust level of redundancy. If a single converter faults and trips offline, the remaining five systems will support the building in a seamless manner – resulting in lights that never flicker.

Unfortunately, shortly after the Saint Croix project was deployed, the project site was impacted by Hurricane Maria. The storm's high winds ripped off most of the rooftop solar panels, but the batteries, control equipment, generators and converters remained intact. The team will restore and rebuild the rooftop solar array using new mounting hardware designed to better withstand high winds. In the interim, the power converters will continue to offset fuel use by paralleling the batteries with generators. Eventually, the goal is for the facility to run on batteries alone from late night until early morning. This capability will require intelligent load management equipment, such as HVAC and lighting controls, to ensure building loads are minimised during unoccupied periods. When considering opportunities for future project sites that rely on diesel generators, even greater fuel savings of 60% or more could be achieved by increasing battery capacity.

The existing system will reduce emissions and energy costs while post-hurricane repairs take place. The Saint Croix site has the potential to achieve greater efficiencies once solar panels are replaced and integrated back into the system. Through effective technologies that meet unique island community challenges and needs, the Saint Croix project site has proven that multiport power conversion capabilities that support a hybrid microgrid are an effective solution for day-to-day operations and also in the face of a devastating storm.

Key factors for resilience

The flexibility and adaptability of multiport conversion technology supports effective hybrid microgrid sites, which in turn offer island nations, isolated communities and any area vulnerable to natural disasters with resilient, cost-effective and green power generation. As a changing climate means years like 2017 become more of the norm rather than the exception, hybrid microgrids will play a growing role in the future of energy use for island nations, rural areas and beyond. ■

Author

John Merritt helps deliver next-generation power conversion technologies to remote and island communities as Ideal Power's director of applications engineering. He has more than 30 years of technical marketing experience spanning product marketing, product development, engineering and project management in both high-tech and clean-tech companies.