The Future of String Inverters for Energy Storage







The Global Energy Market is Booming

Grid-scale storage installations are **projected to grow** 13-fold over the next six years, from a cumulative 7 gigawatts/12 gigawatt-hours in 2018 to 63 gigawatts/158 gigawatt-hours in 2024, according to Wood Mackenzie Power & Renewables. Inverters are a key piece of the intelligence that both standalone and hybrid storage systems offer, making them one of the most important considerations for energy storage projects.



Global Cumulative Energy Storage Capacity



With vast market opportunity comes competition and relentless pressure on price, particularly for utility-scale storage developers. WoodMac forecasts that turnkey system prices for front-of-the-meter storage are entering a new phase of declines where prices will drop 8 percent annually from 2017 to 2022, a rate that is slower compared to the price drops for energy storage before 2017, but still higher than the annual solar PV system price rate of decline in the coming years.

At the same time, inverters are being asked to deliver ever-higher levels of reliability and a wider range of grid services – particularly for distributed commercial and industrial installations, and, increasingly, microgrid applications.

A handful of inverter manufacturers caught between these potentially conflicting demands are shifting their focus from central inverters to string architectures that allow for more granular control and optimization over each unit in a battery system.



It is a natural transition that has already taken hold in the solar market. String inverters have a dominant share of the solar market, with three-phase string inverters being the most popular choice globally for utility-scale projects under 15 megawatts. For even larger projects, distributed central inverters, also known as centralized string inverters, are becoming more popular. For battery storage systems, string inverters offer even greater advantages than for standalone solar projects because storage requires management of complex charge-discharge cycles and grid services.



LS Energy Solutions' PowerBRiC (Bi-directional, Resilient, Intelligent, Converter) is a modular building-block string inverter that offers a case study in how the industry is innovating to meet the challenge of managing energy storage systems, which are often required to provide many functions. By combining modular flexibility with the intelligence and autonomy of string architecture, the PowerBRiC was engineered to minimize cost while maximizing value for a wide range of customers.

The Path to the PowerBRiC

LS Energy Solutions' path to the storage inverter market is different from inverter manufacturers approaching energy storage from the solar industry. Long before the energy storage market's coming of age, LS Energy Solutions – then Parker EGT – was building inverters for industrial motor control systems, which required high levels of reliability and safety, as well as application-specific customization for diverse end uses such as steel processing plants and automotive assembly lines.

Drawing inspiration from the automotive and data server industries, Parker EGT began developing a modular inverter to ensure maximum uptime while also meeting the needs of a wide range of applications. Dubbed "Project Bladerunner" in 2004, this initiative provided industrial customers with the easy maintenance and reliability of a car or data farm, where the system can continue operating through the failure of a single component – and where that component can be quickly replaced by a technician instead of requiring an engineer for repairs.



As Parker EGT turned toward utility-scale energy storage applications in 2008, the need for reliability was only heightened. Storage asset owners sign contracts with grid operators guaranteeing availability at specific hours for energy or for other grid services, which means that they are liable for unexpected downtime. Operational redundancy is highly valued, further driving Parker EGT's focus on modular, string inverter-based products.

In 2018 Parker EGT was acquired by LS Industrial Systems (LSIS), a multibillion-dollar industrial and utility energy infrastructure company spun off from the Korean electronics conglomerate LG, to form LS Energy Solutions. With the acquisition, LS Energy Solutions has seen several synergistic improvements with access to LSIS' additional R&D resources and extensive supply chain network, further supporting the vision of continued development of advanced functionality and lowering the cost of the PowerBRiC.

Modular Design Minimizes Costs

The PowerBRiC is a 125-kVA autonomous string inverter that can operate as a standalone string inverter or be packaged into a "central string" configuration. The Power BriC has a very wide DC operating range of 200 (with de-rating) to 1,500 VDC, and an AC operating range from 380 to 690 VAC, allowing for compatibility with nearly all DC storage technologies and generation technologies at virtually any scale and configuration.

This modular flexibility translates into cost savings through the ability to right-size inverters, as well as the configuration of battery installations for specific applications. For example, developers relying on central inverters must frequently purchase oversized inverters in order to achieve desired energy levels. Similarly, a storage owner looking to provide multiple grid services simultaneously might need to install extra units of a given storage technology.

By contrast, a PowerBRiC system can be right-sized in 125-kVA blocks to more precisely deliver the optimal power-to-energy ratio for a specific application. If the operator wants to provide both energy and power services to the grid, it can combine different types of storage technologies – for example, batteries and ultracapacitors – to meet these needs more cost-effectively than just adding more batteries. In both cases, the modular PowerBRiC architecture can trim excess costs and improve project economics.

The combination of PowerBRiC's modular design and LS Energy Solutions' supply chain access minimizes costs through the use of off-the-shelf components wherever possible. In particular, when compared to central inverters, there is a lower cost and shorter lead time for branch circuit protection components such as circuit breakers and fuses for the PowerBRiC building block. These types of components are also more widely available – a particular concern for installations overseas and in remote areas, including many microgrids.





A Focus on Maximizing Value

Despite the advantages of string architecture, central inverters may still win out for some utility-scale customers focused exclusively on cost. But according to Jim Hoelscher, president of LS Energy Solutions, "Our goal is not to be the cheapest; it is to produce the most value to the customer, to be the most reliable and robust partner that they can have."

The PowerBRiC serves this goal in two ways: greater reliability and more flexibility for value stacking.

Reliability and Safety

Maximizing reliability and availability of storage assets is paramount. Component failures aren't just costly in terms of lost revenue. The potentially lethal voltages and currents of these systems can put workers at risk if not carefully managed. LS Energy Solutions has focused on maximizing both reliability and safety in three key ways with the PowerBRiC:



Operational Redundancy

One of the core advantages of string inverters is the ability of the system to seamlessly continue running at a de-rated power level even if individual inverters go down. This feature has been key to the technology's success in the industrial market and is expected to drive increasing adoption for storage applications as well. The autonomous standalone inverter design also avoids the need for a separate master controller – another potential point of systemwide failure.



String-Level Diagnostics

Fault alerts and diagnostics happen at the string level, enabling remote system health monitoring and troubleshooting of any potential issues before they result in larger failures. To enhance this functionality and meet growing customer demand for performance data and intelligence, LS Energy Solutions is developing an online communications portal with an intuitive dashboard akin to a vehicle's 'check engine' light that also presents detailed diagnostics.



Ease of Maintenance

Downtime is also minimized because string inverters can be replaced when they fail, much like servers in a data farm. If an installation has spare units onsite, a technician can replace it in minutes by simply unplugging the malfunctioning module, connecting a new one, and hitting the reset switch. LS Energy Solutions is particularly known for its adaptation of touch-safe power connectors from the automotive industry to make swapping out PowerBRiCs a safe and easy process.

As the storage industry continues to scale, LS Energy Solutions expects safety regulations to become increasingly stringent, especially as some high-profile safety incidents have rocked the burgeoning energy storage market in the past two years.



LS Energy Solutions

Value Stacking

Storage assets of all sizes are being used for an increasingly diverse range of services, which places a premium on PowerBRiC's string-level intelligence. Being able to manage and coordinate different operational modes across different PowerBRiC units in the same project offers maximum flexibility for value stacking, which increases potential revenue streams and improves project economics.

Likewise, there is significant diversity in the values being stacked by different types of customers, with increased complexity in demands for microgrid customers in particular.



Utility-Scale

Utility-scale storage installations are primarily focused on frequency regulation and other auxiliary grid services, in addition to energy applications like peak shifting. Optimal configurations for these installations may include a mix of different storage technologies such as ultracapacitors alongside energy batteries, and the PowerBRiC's flexibility in being compatible with a wide range of components is a significant advantage when a project involves multiple types of energy storage technologies.



Commercial and Industrial

Commercial and industrial installations can have a more complex value stack, which is facilitated by being located close to the load. The primary application for these users has been demand response and peak shaving to reduce electricity costs. However, there may be opportunities to sell energy and grid services as well depending on the wholesale markets, while also providing potential on-site needs for improved power quality and VAR support. The PowerBRiC's intelligence and granular controls allow operators to tell the energy storage system what to do and when.



Microgrids

The emerging microgrid market has the most complex needs of any energy storage application. As with C&I installations, microgrids may need to coordinate multiple generation and storage resources while providing both energy and power services with a high level of reliability. However, microgrids also need features to enable operation independently of the grid, including islanding and backup power, black-start, and seamless transfer from grid-following to grid-forming via virtual inertia, which mimics the rotational inertia of the spinning generators the grid relies on for frequency stability.





A String Inverter Future for a Global Storage Market

The need for more reliable, intelligent and flexible storage inverter solutions will only grow as energy storage technology costs continue to decline, applications proliferate and policymakers in jurisdictions around the world continue to encourage clean, distributed power generation. LS Energy Solutions sees autonomous string-inverter architecture as the most versatile and scalable approach to meeting those needs.

Having a single building block to certify for multiple configurations reduces regulatory barriers. Additionally, the ability to leverage global supply chains for replacement components like circuit breakers and fuses makes maintenance much easier, particularly in remote regions. Lastly, the ability to work with a virtually unlimited range of technologies and applications gives PowerBRiC the flexibility to meet the needs of a globally differentiated customer base, and particularly the emerging microgrid segment.

Although it is still early days for the growing energy storage market and its many applications, it is virtually certain that innovative approaches to inverter design will be necessary to provide the intelligent power needed to support a decarbonizing world.









For more information on how the PowerBRiC can benefit your energy storage system, contact **LS Energy Solutions**. LS Energy Solutions is an affiliate of LSIS, Korea's major power solution provider and the largest ESS solution provider in North America. Since launching the ESS business in 2007, LS Energy Solutions / Former Parker EGT has offered total solution with key technologies in global-level ESS system, PCS design, manufacturing, implementation and service. It has quickly entered the world markets, recording a cumulative deployed supply of more than 450 MW.

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