White Paper

Power Reliability – The value of Power Control Systems and Paralleling Generators

ASCO Power Technologies®

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INTRODUCTION

The growing importance of power reliability has led a significant number of facilities to install multiple generators to meet their requirements for emergency/backup power. For facility executives who manage more than one generator, it's worthwhile to evaluate the option of using a power control system to parallel generators.

"Depending on your application, power interruptions can impact productivity, public perception, revenue streams, loss of work, and loss of product," says Steve Smith, Director of the Physical IT Network for Arvest Bank Operations. "Paralleling allows you to proactively operate and maintain systems while supporting to the overall business throughput and helping to lower utility expenses."

Paralleling generators can improve reliability, provide flexibility for the future, and reduce the cost of using generators. Power control systems can make it easier to add generators to meet demand and help reduce initial capital costs of the power system. The systems make it easier for facility staff to respond when action needs to be taken. Today's well-designed graphical user interfaces make the systems simpler for building operators, and the systems themselves are straightforward to operate.

Facility executives do not need a deep technical understanding of power control systems to understand the value of generator paralleling, suggests Steven Shapiro, Partner at EYP Mission Critical Facilities, Inc. "Think of the generators as rows of swings all moving at different speeds. If one kid falls off, paralleling allows that swing to be shut down, so the kid doesn't get hit in the head by the swing," Shapiro explains.

GROWING IMPORTANCE OF POWER RELIABILITY

Power reliability once concerned mostly mission critical operations, such as hospitals, financial institutions and data centers. Today power reliability is becoming increasingly important for educational campuses, government facilities, and commercial offices.

One reason for rising concern is the steady increase in natural disasters such as tornados and hurricanes. "Recent storms have disrupted electrical power for several days or more," notes Andrew Hay, Infrastructure Electrical Engineering Manager at RMF.

At the same time, society has become intolerant of losing access to anything it regularly uses — including electrical power. "People have become accustomed to being connected to information and to communicate on a continuous basis," notes Nicholas Yalich, Vice President of ESD Global. "It is an integral part of their lives."

"As an acquaintance said to me a few years ago regarding power availability, 'The lights are supposed to be on,'" Smith notes. "Things that used to be viewed as a convenience are now an expectation."

A third factor that has made reliable power essential for a growing number of organizations is their dependence on data for minute-to-minute operations. Electrical power must be available 24/7, despite Mother Nature's fury, accidents involving above ground power lines, or other utility outages.

"So many businesses today have a large reliance on data," Hay explains.

Paralleling control

One indication of the increasing importance of emergency power comes from an ASCO/Building Operating Management survey of facility executives. That survey found that, among respondents who reported having emergency/backup power, 66 percent had multiple diesel generators, while 23 percent reported having multiple natural gas generators. (See Figure 1)

Figure 1. Do any emergency/backup power systems in your facilities have multiple units of any of the following? R=276	
Diesel generators	66%
Microturbines	2%
Natural gas generators	23%
Rotary UPS	3%
UPS batteries	56%
Other	3%

When multiple generators are required, connecting those generators in parallel can offer important benefits. “In applications where a single genset can be matched to the load and economically connected, that is always the most cost-effective solution,” observes Yalich. “Larger capacity and more complex requirements frequently make paralleling the best solution.”

Running generators in parallel is a proven strategy that has been used for many years. “Paralleling of electrical systems has been in existence for as long as public electrical service itself,” says Smith. “Paralleling generation eliminates the blink associated with traditional open transition switchgear (as long as utility is available when you elect to transfer). It makes a wider range of operational options available when doing test runs and maintenance, and in critical power applications, it can help mitigate a certain level of risk by seamlessly assuming load from a utility source that may be vulnerable when in a UPS failure scenario.”

Today’s digital technology makes it easier than in the past to run generators in parallel. A power control system, when teamed with paralleling switchgear, features microprocessor-based technology to simplify total generator load control and engine management. Power control systems can be locally operated using graphical interfaces or monitored remotely from a control center over a local or wide area network or the Internet.

Generator paralleling switchgear responds to the power control system's assignment of specific, structured priorities for distributing loads. For instance, groups of transfer switches that provide power to life safety loads receive top priority. Individual switches within this group may be assigned sub-priorities, or "steps", within the life safety block. Critical equipment may be assigned the next highest priority and can be ranked within its block.

Technology advances continue to improve the systems. "Advances are made in monitoring, testing, and predictive failure processes literally every day," Smith says.

Paralleling benefits

One key benefit of running generators in parallel is increased redundancy, and therefore increased power reliability. "Paralleling improves redundancy, specifically when it is providing power to critical systems that could suffer catastrophic failure of one generator was supporting the power requirements," says Louis M. Galante, Jr., Associate Director of Central Maintenance Services at The University of Iowa. "If a two-generator parallel configuration is utilized and one generator failed, the second generator should be able to sustain power requirements."

Paralleling also improves generator reliability, says Sam Keel, Project Electrical Engineer at RMF: "We normally design N+2 in generator capacity. Because of the 24-hour operation of mission critical facilities, redundancy is necessary to ensure uninterrupted operations. One generator can be down for maintenance when another one fails, and the generator plant can still carry the data center's full load."

Facility staff can attest to the benefits of redundancy provided by operating generators in parallel. "Maintenance coordination efforts are virtually eliminated with installation of N+1 or greater capacity," says Alex Roberts, Supervisor — Plant Operations at Froedtert Health. "Even simple oil changes can be performed without risk of interruption to available generator power."

In a hospital, redundancy translates into a life safety advantage. "When a generator is tested or serviced, generators on the other side of paralleling can handle the life safety and critical loads if we should lose [utility] power," explains Cory Johnson, Facility Electrician at Mary Washington Hospital.

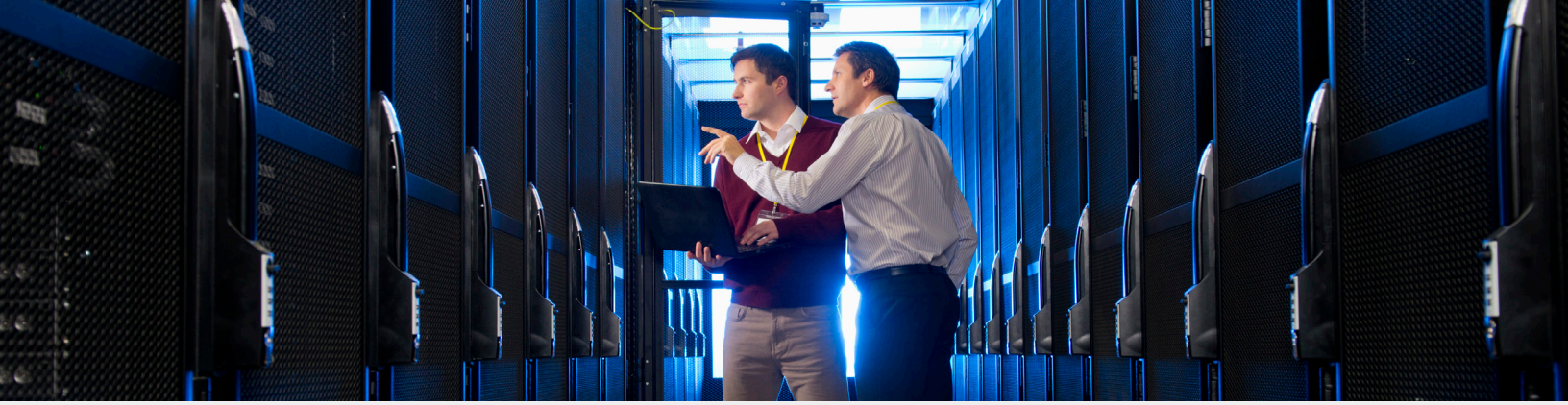
There are other operational advantages to generator paralleling.

"Data centers use generator paralleling so that they have no stranded capacity," Keel says. "When you have five generators with dedicated loads, four may be running at insufficient capacity while the fifth is overloaded. Paralleling prevents that stranded capacity." In doing so, paralleling can also reduce the cost of operating the generators, since they run more efficiently at higher loads.

Investment in switchgear for generator paralleling may open the door to significant financial benefits. "We use generator paralleling to reduce utility impacts via load sharing, load shaving, and peak shaving," explains Craig Cummings, Director of Facilities Engineering for Mary Washington Hospital. "Reducing our utility impacts can save as much as $60,000 monthly, so we can take advantage of those cost savings without any risk to our patients."

While paralleling is an established approach to improving power reliability, it is not always the best option for specific facilities. For instance, in data centers, generator paralleling is only half as prevalent as it was 10 years ago, says Shapiro. One reason is that hyperscale companies such as Amazon and Google have moved away from generator paralleling, instead focusing capital improvement monies on IT software application redundancy. "For these companies, IT application operational reliability is more important to their business than mechanical, electrical, and other building systems reliability," explains Shapiro.

For medium-sized electrical distribution systems, Hay believes generator paralleling is "not mainstream, but it is almost always evaluated."



Emergency Power Considerations

How and whether emergency power can be used for other purposes depends on many factors, including industry type, codes and standards, and life safety considerations. For example, mission critical facilities do not link emergency with backup/standby electrical power systems.

“Emergency power has code implications and is not put on generator circuits in data centers,” says Steven Shapiro, Partner in EYP Mission Critical Facilities, Inc. “Instead, emergency power is connected to battery backup systems. Mission critical facilities use standby power systems.”

Hospitals must meet stringent requirements for emergency power.

“We actually have two full generator systems to serve one process,” explains Craig Cummings, Director of Facilities Engineering for Mary Washington Hospital. “One is for life safety, the other for critical hospital equipment.”

In some higher education facilities, emergency power can be applied for central plant maintenance and for load shedding, where the lowest priority loads are removed according to generator capacity. Louis M. Galante, Jr., Associate Director of Central Maintenance Services at The University of Iowa, says doing so not only increases emergency systems maintenance, but also enhances their readiness when power outages do occur. “Many emergency systems sit idle and never see more than 30 percent load over a year’s time frame or even multiple years,” he says.

Galante says that, even though using emergency power systems more frequently adds maintenance and fuel costs, it helps ensure emergency systems are ready when needed.

Power control systems

In emergency/backup power systems, a power control system plays a key role. “The power control system drives the entire system,” notes David Belford, Facility Director at Weiser Memorial Hospital.

A power control system can provide facility executives with multiple benefits. One is that a power control system can make it easier to add generators to meet future demand. “Flexibility is improved as long as the power control system installed allows for growth and that growth is easily added,” Galante says.

As a result, a well-designed system can help reduce initial capital costs of the power system. “As long as the power control system is designed for scalability upfront, you can buy only the generators you actually need now and add others over the life of the facility,” says Shapiro.

Graphical interfaces make using and understanding power control systems simpler for building operators. “A centralized system features a single user interface for working with switchgear, generators, and renewable power sources such as solar and wind,” Hay explains.

From an operational point of view, a power control system simplifies response when action needs to be taken. “Being able to control at a moment’s notice your array of gensets from a central location does improve flexibility and reliability,” observes Gerald R. Tilson, Director of Student Auxiliary Services at Wayne State University. “The ability to transfer loads increases both reliability and more importantly safety for the end users.”

Facility executives will appreciate the simplicity of most power control system operations. “Today’s power control systems have touch screens or large visual displays where you can touch with a finger or mouse and drill down to the smallest element of the system,” says Shapiro.

Monitoring is an important element of power control systems, with remote monitoring capabilities available on current technology. In the ASCO/Building Operating Management survey, 91 percent of respondents reported that they have some monitoring capabilities for their emergency/backup power systems, but more than half of the respondents indicated that those capabilities can only be accessed on-site. Another 33 percent lack remote monitoring capabilities for some of their equipment. (See Figure 2.)

Figure 2. Does your emergency/backup power system have monitoring capabilities? R=327

Onsite or at equipment only	52%
Remote with telephony or wireless connectivity	6%
Combination of both	33%
None	9%

Communication capabilities are crucial

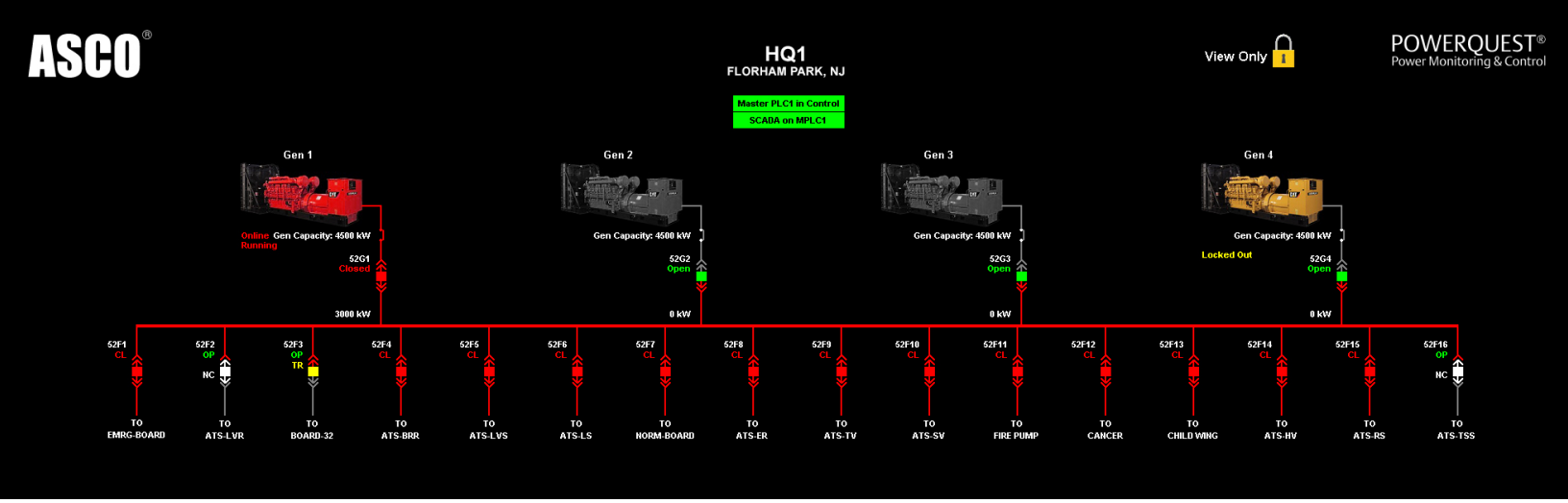
Power control systems need to have built-in flexibility and be able to interface with the facility’s electrical power monitoring system or building management system, according to Shapiro. “You need flexibility so that revised utility transitions have no impact on your operations.”

To accomplish this flexibility means programming the system to enable all possible features, locking out certain ones that are currently not applicable. If the situation changes, the locked-out features can be activated without disrupting operations.

Tying the power control systems into a power management system or a BMS interface provides many advantages. For example, power management systems can provide millisecond time stamps, enabling forensic investigation of operation and failures of a system, according to Shapiro.

To do that, the power control system must be able to communicate with other building systems. For the City of Orlando, Florida, the power control system must be BACnet-ready, according to Ian L. LaHiff, Energy Project Manager, Office of Business and Financial Services for the City of Orlando. “We need it to tie directly to our building management system,” he says.

Orlando needs to keep electrical power supplied to its fire and police stations, 911 operations, emergency operations center and other essential 24/7 infrastructure, even when the area is being clobbered by hurricanes, according to LaHiff. As a result, many of these facilities have their own dedicated generators.
“Our emergency operations center is where essential city staff deploy during a storm to keep the city operating,” explains LaHiff. “Because the operations center is critical during a disaster, it has multiple layers of redundancy and uses multiple generators to keep power supplied to the facility.”



Standard vs. custom

Systems can be customized to meet the needs of specific facilities. There also are standardized systems that have features most often required in popular specified and engineered systems.

"Standardized systems are suitable for basic applications, usually with a single utility source, and provide paralleling and transfer controls, genset optimization, and load shed controls," explains Yalich. "A customized system might involve multiple utility sources, multiple generator busses, and more complex load add and transfer controls. Customized systems can also have SCADA systems that perform automated switching functions of other downstream loads."

The ASCO/Building Operating Management survey shows that both standardized and custom solutions are common today in existing systems. (See Figure 3.) For new applications, fewer respondents would want to limit themselves to standardized offerings, the survey shows. (See Figure 4.)

Figure 3. For existing emergency/backup power applications involving multiple generators, which of the following controls solutions have you used? R=199	
Standardized packaged controls (off the shelf, quick-delivery type solutions)	27%
Customized control solutions (designed specifically for your facility)	22%
Both, depending on application	27%
Do not know	24%

Figure 4. For new emergency/backup power applications involving multiple generators, which of the following controls solutions are you most likely to use? R=231	
Standardized packaged controls (off the shelf, quick delivery type solution)	20%
Customized control solutions (designed specifically for your facility)	26%
Both, depending on application	29%
Do not know	25%

Coming to grips with complexity

When facility executives are deciding between standardized and custom power control systems, the factor most often rated "critical" is maintainability, at 48 percent. Cost, often one of the biggest considerations when new building systems are selected, was deemed critical by 28 percent, putting it fourth on the list, behind criticality of emergency/backup power application (42 percent) and staff capabilities (29 percent). (See Figure 5.) The high totals for maintainability and staff capabilities suggest that facility executives are concerned about the ability of their staff to handle customized solutions.

Figure 5. In deciding between standardized packaged controls and customized control solutions for emergency/backup power systems with multiple generators, how important are the following factors? R=245

	Critically Important
Maintainability	48%
Criticality of emergency/backup power application	42%
Staff capabilities	29%
Initial cost	28%
Flexibility	18%
Availability of advanced control functionality	15%
Scalability	14%
Control system complexity	12%

Customized power control systems may seem complex. But like most software today, the complexities are not visible to the end user. User-friendly graphical user interfaces on the systems make it easier for the facility staff to understand the power control system and to respond appropriately to situations that develop. "Once the facility's staff is trained on the equipment, operating it should be comfortable," explains Shapiro. "It's like riding a bike. As long as you ride it often, you don't have to relearn everything just to get on the bicycle. The same goes for power control systems. Training and practice are required." Training is key. "Facilities operations staff requires extensive training on the operation and maintenance of all the equipment," points out Yalich. "This includes knowing exactly how the system will respond during a utility outage; how to manually control the system, if and when required; and how to respond to warnings and alarms."

Yalich also notes that this knowledge "is always supported by the genset and switchgear vendors for regular maintenance and system updates."

Shapiro says one option to keep operators familiar with the power control system's design is to obtain a simulator from the manufacturer. The simulator replicates the controller and its logic and connected devices to allow for training at any time. Although the simulator comes at an additional cost, Shapiro thinks the investment "is well worth it." In addition to training and retraining, the simulator can be used for event sequence testing and evaluating test scenarios, such as utility failure and restoration, generator or circuit breaker failure, and synchronization failure.

Many facility executives recognize the key role of training, according to the ASCO/Building Operating Management survey. Asked whether their staff has the expertise to use advanced controls capabilities, 41 percent said yes, but only if additional training was provided. (See Figure 6.). That's not surprising, given that 62 percent of respondents described the staff responsible for the emergency/backup power system as generalists, not specialists. (See Figure 7.)

Figure 6. Does your staff have the expertise to use advanced controls capabilities? R=277	
Yes	15%
Yes, once additional training is provided	41%
No	29%
Not sure	15%

Figure 7. How would you describe the staff responsible for your emergency/backup power systems? R=280	
Specialists in emergency/backup power	16%
Generalists	62%
Both	22%

Overcoming obstacles

Facility executives interested in using power control systems to run generators in parallel face some familiar obstacles. As with most facility investments, cost is one hurdle. Physical space for the switchgear is another.

But cost is not an insurmountable objection, say facility executives. “Everything starts with cost and need,” explains Belford. “If we have the need due to life safety functionality, we may decide the cost is not too much because it would help save lives.”

It’s worthwhile to remember that a power control system can also help reduce costs. “Peak shaving or load abatement agreements can help lower the overall cost of ownership,” Smith says. What’s more, he says, “making load shed (load breaker control) or generator load management (shutting down excess generator capacity) available improves flexibility to operate while keeping expenses as low as possible.”

Resistance to change can be a significant obstacle to wider use of power control systems for generator paralleling. “As with anything that is a change to the way that things have been, there is often hesitance to accept changes, even when they are positive,” Roberts says.

Another question that must be addressed is whether the system will be supported long after it is initially installed. Galante says the need for reliable future service makes it "critical to find those manufacturers who have a long history in the power generation business."

Smith puts it this way: "No matter how robust or advanced a system is, if you cannot get it fixed when it fails, it's not much better than a brick."

The ASCO/Building Operating Management survey suggests that many facility executives currently rely on manufacturers for expertise with power control systems, with equipment manufacturers cited more often than other groups as the first source facility executives would think to contact for assistance with controls technology. (See Figure 8.)

Figure 8. If you were looking for assistance with controls technology, which of the following types of organization would you think of turning to first? R=274	
Equipment manufacturer	41%
Facility service provider	29%
Local system integrator	26%
Other*	4%

Expertise: Finding the right mix

In the ASCO/Building Operating Management survey, 33 percent of facility executives reported that in-house staff was responsible for the emergency/backup power systems; 46 percent report using a mix of in-house and outsourced staff. (See Figure 9.)

Figure 9. Is the staff responsible for your emergency/backup power systems in-house or is it outsourced? R=281	
In-house	33%
Outsourced	21%
Both	46%

How much expertise does a power reliability system demand? The answer depends, say experts.

"Typically, data center power control systems are maintained by the installer or manufacturer under a maintenance contract," points out Shapiro. "Provided facilities staff is trained as part of the power control system installation and start up, the power control system is easily operated. A typical operating engineer needs no programming whatsoever."

Running generators in parallel brings in other considerations. "In large scale paralleling, there are many automatic transfer switches and possibly load shedding schemes," says Hay. "Periodic testing needs to be done on the entire system to make sure sequences are still functional."

As the survey showed, many facilities rely on a mix of in-house and outside sources of expertise. “Individuals who are trained and experienced with electricity are best suited to operate paralleling systems,” notes Roberts. “That said, outsourced staff is typically needed to maintain paralleling gear. A particular skill set and specialized equipment are needed to properly maintain electrical systems and appurtenant paralleling components. For example, governor systems on generators must be properly maintained so that paralleled generators are able to maintain synchronous operation.”

Weiser Memorial Hospital has three inhouse personnel to perform preventive maintenance, repairs, and tests. But Belford concedes keeping everything at peak performance requires outside expertise. “When our diesel generators need testing or work, we want someone who has daily expertise in diesels and motors, as well as the expensive equipment designed to test them thoroughly.”

Conclusion

With a growing need for reliable power, facility executive interest in power control systems is likely to grow. The systems are proven, bring a range of benefits, and are within the capabilities of facility staff in many organizations provided that the staff receives good training. When considering power control systems, facility executives should look for “simplicity, operability, [and] availability of service technicians in a short timeframe,” Smith says. A properly engineered system should provide protection, maintainability without outages, and on-the-fly expandability, he says.

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