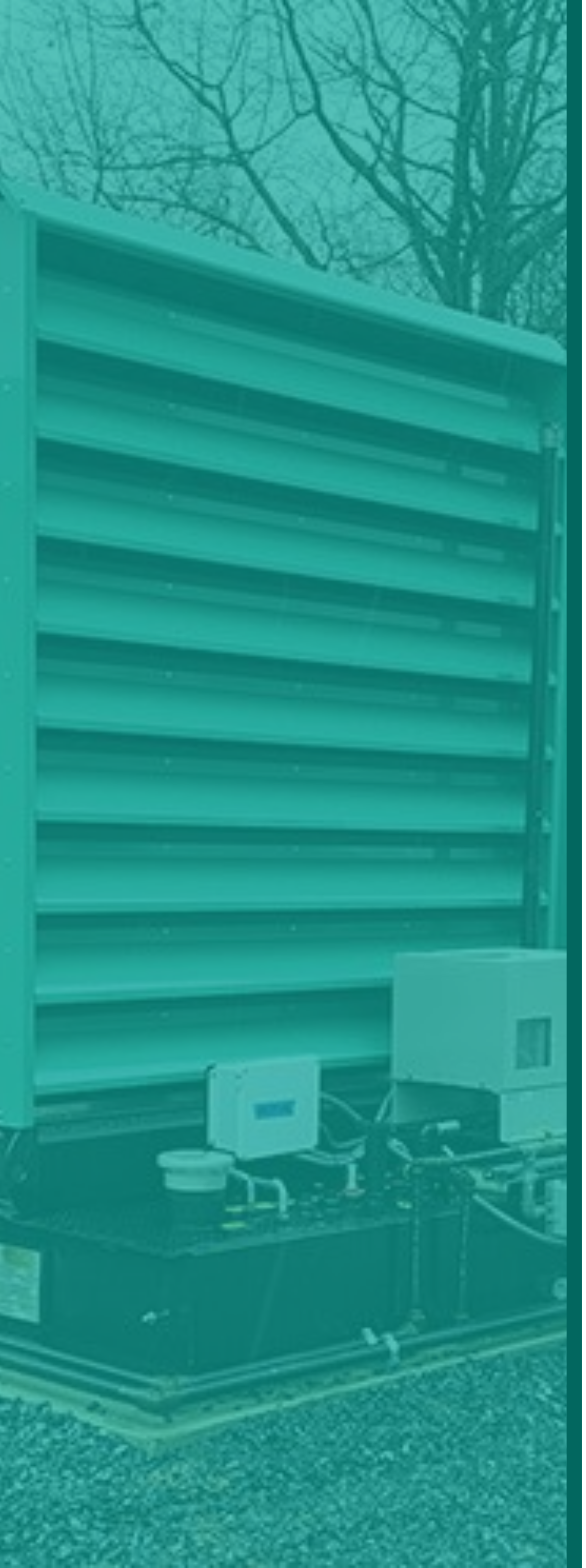
Electrical & Power

WINTER EDITION

CONSULTING - SPECIFYING engineer eBOOK | Cummins | Schneider Electric



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How vulnerable is your electrical system?

A discussion about vulnerabilities to electrical systems includes risks to facilities and recommendations for improved safety

The previous editions of NFPA codes allowed for electrical systems in commercial buildings to have vulnerabilities that modern versions of code have recognized. The 2020 edition of NFPA 70: National Electrical Code further enhances the protections of previous code cycle evolutions, including arc flash labels, selective coordination requirements, fire resistive construction and environmental conditions.

Facilities should be tracking the condition of the various electrical systems components during condition assessments. These assessments should factor in the importance of each component, which is determined through a risk assessment. If staff, occupants, patients or visitors could be injured or killed with the failure of that system, then the importance placed on reliability is high. Electrical systems and conditions that might need corrective action are:

- Generator testing methods that do not simulate an outage.
- Paralleling gear located within the generator room.
- Lack of selective coordination or lack of a coordination study.
- Unknown or incorrectly labeled arc flash conditions.

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- Lack of fire ratings on critical cables.

- Circuit breakers that predate the 1970s.

Generator testing methods

Generators are usually tested using a switch on the face of an automatic transfer switch, as noted in NFPA 110: Standard for Emergency and Standby Power Systems Chapter 8.4.3. This switch provides voltage on the start conductors that tells the generators to start.

The 2017 edition of the NEC added a requirement for monitoring of start conductor integrity in 700.10(D)(3). Once the emergency source is accepted by the transfer switch, the transfer is made after programmed delays. While this electrical system test procedure verifies the integrity of the start conductors and verifies transfer switch operation, the actual performance and delays that occur with an actual utility outage are not verified. It may be several years between outages with projects occurring during that timeframe.

NFPA 110 8.4.3 also allows for ATS testing by opening the circuit breaker that feeds the normal side of the ATS, With this method, the ATS will see a loss of the normal source and send a start signal to the standby emergency power supply. Unfortunately, it is inconvenient to generate a utility outage for ATS that serve computers or patient care areas. It may even be hazardous to simulate a utility outage for critical processes or equipment without proper shutdown procedures. As a result, the emergency or life safety branch is usually the least disruptive ATS to test with.

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When using this branch for testing, the facility will be alerted to alarms that will occur and staff should ensure the stairwells and elevators are clear so occupants aren't left in the dark during the generator start transition. This process will reveal the actual behavior of the system in an outage. Delays identified in NFPA 110 8.4.5 can then be evaluated to ensure a proper start and transfer within the duration required in NFPA 110 Chapter 4.

For a Type 10 applications, this is within 10 seconds. Transfer delays can be programmed into the ATS logic and those delays cannot be properly evaluated using the test switch. Other delays in the ATS programming may inhibit transfer and it is important to develop a testing procedure that evaluates any and all programming logic.

Mimicking an outage for the generator room is another important step to confirm that the programming is correct. NFPA 110 Chapter 8.3.5 identifies the list of inspections that are required, which includes verifying system operation.

An example of electrical system system operation is programming in the paralleling gear that may inhibit the generator breaker closure if the battery charger sees a loss of normal power. Such a condition will only present itself during a utility outage within the generator room. The facility can perform weekly testing using the test switches and can also have a procedure for monthly or bimonthly outage testing using the methods described above.

Additionally, whenever projects or procedures change or effect ATS programming or wiring, outage testing should be performed. It's suggested that an actual utility outage should be performed every 5 to 10 years, especially if the facility hasn't had an outage. While it is certainly inconvenient to perform this testing for facilities that are occupied constantly, such as a hospital, it would be better to perform the outage in controlled conditions.

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Electrical system locations

The locations of electrical equipment are typically unconditioned, which reduces longevity and increases risk. Environmental factors include the temperature range, humidity range and the dirt and dust accumulation within the space. Electrical rooms without heating, ventilation and air conditioning or with direct venting to the outdoors tend to suffer the largest fluctuations in temperature and humidity while also having high dirt accumulation. Equipment life spans in these locations are expected to be shortened with higher risks of failure.

While it is not common to consider conduit as a pathway for air transfer, the lack of seals in most electrical raceway systems allows for air transfer between rooms. When distribution equipment is located in rooms that are subject to high temperature and humidity, condensation can occur in distribution equipment where raceways serve air conditioned spaces.

These conditions are worsened in generator rooms due to the need for exterior cooling and combustion air and the lack of seals associated with intake and discharge operated louvers. Installations in climates with extreme cold should include supplemental heating, with the understanding that once the generators are running, the heating system will be ineffective.

Paralleling gear located in these rooms will suffer the highest risk of failure due to environmental conditions. Paralleling gear is also one of the most critical components in an electrical room. While NFPA 110 7.2.1.2 allows for emergency power supply system gear to be located in the EPS room, it may not be a good decision for long-term reliability. Facilities with this arrangement should have a policy for cleaning and investigation of electrical distribution equipment on schedule based on the environment.

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Another area of consideration is the chance of flooding by either natural or man-made causes. The 2020 edition of the NEC addressed this in 700.12(A) and (B), which mimicked previous versions of NFPA 110 Chapter 7 or NFPA 99: Health Care Facilities Code section 6.7.1.2.6. Locating critical electrical equipment in a basement was a common practice that leaves the equipment at risk of flooding from sprinkler systems, pipe breakage or other natural disasters. When equipment replacements are needed or desired, care should be taken to provide a new, compliant location when necessary and avoiding the trap of repeating prior approaches for convenience.

Age of the electrical system

Based on observations of electrical distribution systems across the country and participation is failure analysis studies, the reliability of electrical system components comes into question as components reach 40 years old. Even with the best environments, the materials used several decades ago present a series of challenges.

Circuit breakers can physically fail internally or the handles can break off. Broken handles occur when the plastics become brittle or the circuit breakers become difficult to close. Circuit breakers can fail in the on position, creating a fire or safety hazard. Circuit breakers can also fail in the off position, resulting in an extended outage that can present a risk to occupants. As equipment ages to the point where replacement parts become difficult to find, the risk of an extended outage increases.

Selective coordination and updates

The short circuit current study should also include selective coordination and circuit breaker setting recommendations. This is a required step to verify the proper settings to minimize the risk of a cascading outage. When a facility has already had a study, it should be updated each time system changes are made.

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To keep up with changes, the facility needs to have access to the software and files used to create the original study. If the facility lacks the staff or access, then a relationship with a local firm is recommended to assist with maintaining the program or the facility can require that engineering teams performing system changes should include program updates in their scope. Circuit breaker settings should be compared to recommendations from previous studies and adjusted when required.

Selective coordination of emergency power systems is required by NEC 700.32 for emergency branch systems, 701.32 for legally required branch systems, 517.31(G) for health care essential electrical systems, 708.54 for critical operation systems and 645.27 for information technology systems. The 2020 edition of the NEC includes new informational graphics that more clearly define what is required to be selectively coordinated on both the emergency side and the normal side of the associated ATS (see Figure 3). Simply put, the entire normal branch is not required to be coordinated. The overcurrent protective device on the load side of the ATS shall coordinate with both normal and emergency side OPCDs.

When making system changes, designers should pay close attention to the effects that those changes may have on existing systems. For example, if a project is putting a large addition on an existing building, the engineer needs to determine if the existing service can support the addition. In many cases, a large addition may require an increase in the building service. It is common to create the new service in the addition and back-feed the existing facility to minimize downtime and replace aging service entrance equipment.

Designers need to carefully evaluate the impact that this change will have on system ratings, short circuit current, arc flash values and selective coordination. If the available

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fault current increase from a larger service entrance transformer results in many existing panel ratings being exceeded, a corrective action should be part of the plans.

If a facility with aging equipment doesn't have an accurate or recent study, this effort should become a priority. These studies require an electrician open up every panel to verify ratings and actual wire sizes.

Wire lengths and overall system wiring configuration is another important step to verify for report accuracy. The available short circuit current can change over time as buildings electrical systems are revised and transformer equipment is replaced. If a transformer is replaced with a more energy-efficient model, the new transformer may have a lower internal impedance, which increases the available short circuit current. As a result, the panels and equipment served by the replacement transformer may have become inadequately rated, further increasing the risk of a catastrophic failure or extended outage. Both the circuit breaker ratings and the panel ratings should be evaluated as part of a short circuit current study.

Arc flash labels in electrical system

As electrical systems are modified, so are the available arc flash values. While new projects need to evaluate the risk that the design will have on the equipment added in the project, any impacts to the existing equipment should be evaluated. If the facility has arc flash labels already, any project affecting the values should include updates to the software and labels.

If a facility lacks an accurate study, it will be difficult for engineers to verify that their design is not causing a hazardous condition. It's also possible that previous studies may have made incorrect assumptions, resulting in labels that identify incorrect hazards.

Engineers should identify this concern early in the project and discuss possible solutions with the facility. NEC 110.16(B) requires that service equipment be labeled with available fault current and clearing time of the overcurrent protective devices. The 2018 edition of NFPA 70E: Standard for Electrical Safety in the Workplace section 130.5 requires an arc flash risk assessment to identify the hazards present.

To determine the appropriate level of personal protective equipment that a worker must wear, an understanding of the available arc fault energy is necessary. It is commonly understood that actively working on live electrical cabling or gear requires appropriate PPE. What may be overlooked is that removing dead-front assemblies, opening the doors on transfer switches or removing panels for inspection or documentation also presents a hazard to personnel. Knowing the hazards present is the first step to taking appropriate action.

Arc energy reduction is a newer requirement in the NEC in Article 240.87 that limits the available arc fault energy downstream of circuit breakers with a frame size 1,200 amperes or larger. Even if the circuit breaker uses a lower amperage trip plug or setting, this requirement is based on what the OPCD can be set to. In the 2017 Edition of the NEC, Section 240.67 was added to echo this requirement for fuses as well.

One of the options allowed by NEC 240.87(B) is to add a switch to the face of the distribution equipment that adjusts the instantaneous time-current curve portion of the circuit breaker's electronic trip unit. By making the system more sensitive the clearing time is reduced, thus reducing arc fault energy. Other options include zone-selective interlocking or differential relaying, which may be difficult to add to an existing electrical system.

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Electrical system fire ratings

Various sections of code require fire ratings on cables that provide critical infrastructure. Fire ratings are also required where cables pass through evacuation zones for survivability with the intent being that a fire in adjacent buildings or areas should not compromise the building or area of interest. Because fire rating requirements have evolved over the decades, existing facilities may not have compliance with the latest codes. While there is no enforcement for retroactive applicability, the facility should evaluate where existing cable systems are venerable as part of their risk assessment process.

Generator start conductors are required to be two-hour fire rated or protected in such a way to achieve a two-hour fire rating and the start conductors should be routed separate from transfer switch control cables. Acceptable methods for achieving a two-hour rated system are defined in NEC 700.10(D)(1). If a facility lacks these two requirements, replacement of start conductors would be a valuable investment.

Emergency or essential electrical power conductors are required to be fire rated for occupancies listed in NEC 700.10(D) and NEC 517. The list includes assembly occupancies with an occupant load greater than 1,000 people, high-rise buildings (defined as an occupied floor that is 75 feet above a level of exit discharge per 2018 International Building Code Section 403), health care occupancies where occupants are not capable of self-preservation and educational occupancies with an occupant load greater than 300.

These conductors are usually longer, larger and routed though congested areas of the building resulting in expensive replacement or upgrade costs. Because of the cost and difficulty, it is not uncommon for facilities to avoid upgrades and rely on the lack of retroactive code enforcement. Some authorities having jurisdiction may look at oth-

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er electrical system upgrades, such as replacement of generators or transfer switches as being a catalyst for bringing the entire system into modern applicable code compliance. System reliability should always be part of the discussions for both upgrade projects and acceptable risk.

Fire pump conductors are required to be fire rated per NEC Articles 695 and 700. Additionally, the location of the fire pump controller and transfer switch are required to be in a dedicated location separated by a two-hour fire barrier per 2018 IBC Section 913.

NFPA 20: Standard for the Installation of Stationary Pumps for Fire Protection includes requirements for a wide variety of pump types and configurations. The controller wires are also required to be part of a listed electrical circuit protective system per NEC 965.5(H). Feeders for the normal side are required to be sized for locked rotor current and should originate ahead of the main disconnect per NEC 695.4(B). Generator control wiring for fire pump service is also required to be fire rated per NEC 695.14.

If a facility lacks any of these arrangements, an upgrade should be considered. Evaluations of the fire pump and associated systems should be coordinated with applicable state and local fire marshals to determine appropriate steps and a plan of corrective action, if any.

Fire alarms and other low-voltage system conductors are another cabling system that has survivability requirements in NEC 760. This section lists appropriate cable types that are acceptable for each cable usage or rating. In addition, cabling that passes through rated walls requires equivalently rated fire stopping systems.

Two circuit types are defined in NEC 760: nonpower limited fire alarm and power limited fire alarm. Notable requirements include a red-handled OCPD for branch circuits

serving fire alarm equipment and the delineation between wiring methods defined in NEC 760.130. An evaluation of the current configuration of cabling is a prudent study for any facility older than 20 years. NEC 725.25 discusses removal of abandoned cable unless cables are appropriately labeled.

Fire alarm conductors are required to have survivability under NFPA 72: National Fire Alarm and Signaling Code Chapter 24, with Chapter 12 providing survivability definitions. For health care occupancies where self-preservation of occupants is not possible, the facility may have a partial evacuation or occupant relocation procedure.

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For example, when evacuating patients in the intensive care unit is not desired, the facility will have a procedure for relocating those patients to another area. The fire ratings required in NFPA 101: Life Safety Code and IBC are intended to provide sufficient time to relocate occupants. Cable survivability is required for these occupancies.
As with other requirements for fire ratings, the intent of code is to allow for critical systems to continue for enough time as required to evacuate the facility and to operate despite a fire occurring in another part of the building. For example, a fire in the south wing of a building shouldn't prevent the operation of the fire alarm system in the west wing.

While existing building systems may have been code-compliant when they were installed, the reason for code evolutions and updates is primarily to increase the safety of the systems to occupants and workers. As we look back at some of the previously tolerated practices, we can associate an unfortunate number of deaths that could have been prevented with modern code requirements. As a facility performs a risk assessment and determines the corrective actions required, an emphasis on safety and preservation of life should drive the order for which corrections are made.

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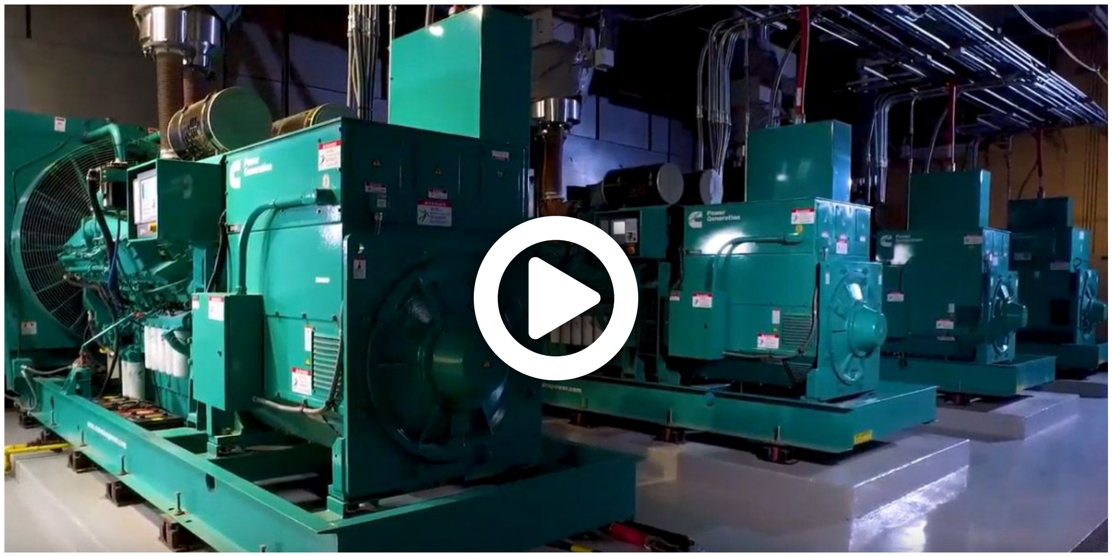

Cummins Power Generation Interruptible Facility

The Cummins Power Generation plant in Fridley, Minnesota has relied on this integrated power design for decades.

Wastewater Treatment Plant Reduces Emissions with Cummins Gas Solution

WHERE:
Syracuse, Utah (USA)

SUPPLY:
2 x C1100N6C, QSK60G gas generator sets

PURPOSE:
Upgrade old generators and provide cogeneration solution, meeting the customer's detailed specification.

CUMMINS PROVIDES COGENERATION SOLUTION AND SOLVES EXCESS GAS FLARE AT SEWAGE FACILITY

North Davis Sewer District (NDSD) collects and treats wastewater from around 80 square miles in North Utah, serving approximately 200,000 people. The district owns and operates around 100 miles of sewer collection lines which deliver wastewater to the Syracuse, Utah, treatment facility, located near the shoreline of the Great Salt Lake. The facility has the daily capacity to treat around 34 million gallons of wastewater, therefore it requires a reliable power solution.

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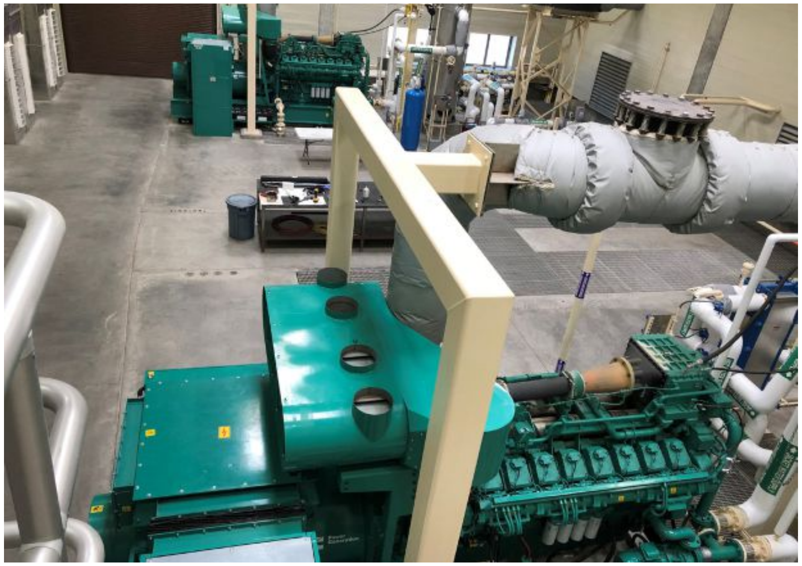
The two previous generators had been running for a combined average of 157,000 hours, producing high emissions readings of 19g/hp-hr NO_x and issues with flaring excess digester gas. The crucial requirements of this upgrade were to tackle the emissions and excess gas flare problems.

Upon the completion of the biding process, Cummins Power Generation was selected to complete the project's installation due to the unit's ability to meet all desired requirements; a max rpm of 1200, no excess gas flaring issues, and a turndown ratio option. In addition, the generators utilize lean-burn gas technology which provide low exhaust emissions. This meant the pre-existing high NOx emissions would be replaced with just 0.5gr/hp-hr. Cummins' ability to provide local support throughout the installation, as well as NDSD's proximity to a branch for future spare parts, cemented the selection process.



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The QSK60G gas generator range offers a fully integrated power generation system which utilizes state-of-the-art technology to result in the optimum performance and efficient use of fuel needed for the facility's cogeneration needs. The treatment facility, as a by-product of its digestion process, produces approximately 300,000 cubic feet of methane gas per day. This excess gas is utilized to power the generators which, on average, supplies 50-60% of the plant's electrical needs. The excess heat is also harnessed to support the plant's daily activities, providing heat to the primary digesters as well as supplying the hydronic heaters used for all on-site buildings. The cogeneration solution creates considerable financial savings for NDSD as the digesters must be kept at a constant temperature of 95-100°F in order to maintain the biological digestion process.

"NDSD chose the two Cummins generator sets due to their ability to run at 1200 RPM and have

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the largest turndown ratio, while maintaining emissions. By converting from the older naturally aspirated gas engines, the District lowered its NOx emissions from 19grams/BHP to 0.5grams/BHP, allowing the facility to drop below the threshold to be considered a Title 5 Plant by Utah's Air Quality Requirements. Utah has struggled to meet Air Quality Requirements and the District feels it's doing its part with the conversion to these Cummins generators.”

- Myron Bachman
NDSD Plant Superintendent

Modular electric rooms are the new normal

Modular electric rooms (MERs) are built out with electrical infrastructure that can be rapidly deployed at a data center facility and are becoming more common.

Since the market was reenergized in the mid-2000s, data center owners and clients have been looking to achieve lower first cost and higher quality deployments. First emerging in and around major cities with telecommunications infrastructure, the data center market has since expanded as fiber optic infrastructure has grown and as owners can now utilize more cost-effective land utility power solutions.

The shift to remote locations — whether to serve local client demand or achieve lower first cost and operational costs — has created unique construction obstacles, including the lack of highly-skilled electrical installers available at remote locations. Although remote work may have been a catalyst for modular electrical rooms, many clients are looking to implement these products in major U.S. cities and even overseas.

What's in a modular electrical room?

Modular electric rooms (MERs) are prefabricated modular assemblies built out with electrical infrastructure that can be rapidly deployed at a data center facility. MERs support a wide range of equipment with varying contents dependent on the client and their electrical topography.

With shipping constraints and the ability to maintain proper electrical clearances as the major limitation of MERs, MERs are typically approximately 40–60′ long, 14′ wide, 12′

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high and support a 1–2 MW electrical lineup in a weatherproof enclosure and contain varying combinations of switchgear, UPS equipment, transformers, and/or battery cabinets. Additionally, there are a wide range of cooling techniques from traditional chilled water, direct expansion equipment, or proprietary systems that may push the envelope of the electrical equipment's environmental requirements.

Even with some limitations, MERs present many prefabrication benefits.

Increased productivity in a safer work environment

Fabrication in a shop environment is much faster and safer than field work. When compared to stick-built, the absence of other trades enhances both productivity and safety. Typically, all that is needed onsite is a concrete pad for the new power modules and a pathway to get to the data center. All other work is performed in a controlled shop environment that has been optimized for workflow and safety.

High-quality work that eliminates waste

Repeatable work allows for skilled trade workers to master the MER they're working on in an assembly line-type workflow. This workflow enables them to cut repeatable lengths of conduit and reduce material-handling headaches like excess packaging and boxes. Less variables in the work environment produce a higher quality product, and offsite fabrication also requires less on-site project management and oversight.

Increased speed to market and simplified deployment

One of the most attractive aspects of MERs is the ability to overlap onsite work with offsite MER construction, resulting in a faster finished product and reduced total duration for construction, quality control, point-to-point testing, commissioning, and inte-

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gration. With a front-end focus on design and procurement, it allows for a simplified deployment of data centers.

Offsite pre-functional testing and commissioning

Once the proof of concept is validated in a factory witness test setting, the manufacturer will be able to produce and reproduce the same product via quality control checkouts, allowing owners to accomplish the majority of electrical, electrical power management system (EPMS), and mechanical/building Management commissioning offsite. The offsite testing supports the 'plug and play' mentality and a consistent product drives a more predictable and faster fully integrated systems test or final commissioning checkout.

However, some electrical equipment ratings assume space conditions that have been based on years of interior conditioned installations. Therefore, commissioning parameters may need to be reviewed prior to equipment selection to verify that performance can be met under different environmental conditions.

Scalability

Most owners seek to scale their data centers as the market demand increases or decreases. These pre-engineered systems provide more flexibility to adapt to market needs. If one market sees an increase in demand, while another sees a decrease, owners can deploy and shift resources (MERs) to new locations and increase their data center capacity in response to the demand. The MER 'blocks' make the data center power topology as consistent as possible across multiple sites and can also help support bulk buyout of equipment.

Cost-effective solution

When the process is correctly implemented, the above benefits will be achieved, re-

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sulting in lower first cost and higher quality. Prefabrication can reduce electrical first cost, but will often reduce the overall footprint of the electrical gear, allowing more space for data halls and lowering cost/MW.

Success measures

To reach success, extensive project coordination and communication between owners, vendors, engineers, and contractors are critical for success. It's important to avoid targeting unrealistic deadlines or releasing manufacturing too late to ensure the benefits of this process are not lost. Additionally, diversifying supply chains and planning for MER flexibility should be well thought out early in the process to allow the team to transition from one supplier to another based on cost or availability. Any changes based on equipment should be noted for coordination and engineering. Lastly, set expectations early before procurement for factory witness test setup and acceptance criteria.

The emergence of this submarket has pulled design-build contractors and electrical vendors to the forefront. Over the past few years, many producers of pre-manufactured power modules have emerged as the market has taken off, and many owners have embraced the modularized approach to project delivery and these pre-engineered systems.

As the market demand for these systems across the U.S. grows, MERs continue to offer many positive impacts for projects and data center owners.

Drew Thomas

Drew Thomas, *senior design engineer, Southland Engineering*

Understand the history of electric motors

Electrical engineers should understand the basic history of motors before specifying them in various applications

This overview of electric motors will start with some background on motors and move into a discussion of the types available, how NEMA classifies motors and what that means to electrical engineers. Electrical engineers should have this foundational knowledge before moving on in any building specification project.

What is a motor? Well, according to the dictionary, it has a couple of definitions. It's basically a rotating machine that converts electrical energy into mechanical energy. We see them everywhere. They come in all sizes and shapes, different configurations, different ways to run them, different ways to control them.

A little history: In 1831, Michael Faraday figured out that when he moved a magnet around a coil of wire, he got a current in the coil. This was big stuff back in the day. And he practiced with that and fooled around with it for quite a while. And then he decided, "Hey, I'm going to put this on a wheel that I can spin and get a more useful result." And I'd like to think that as he was doing this, he was thinking way ahead and saying, "I could run a steam engine to spin this thing for me and generate electricity." And as such, he developed the first direct current generator sometimes referred to as a dynamo. Behind every good scientist is an assistant.

And lo and behold Faraday came out with his equation for electromagnetic force, which as you'll recall from your electrical theory class, basically says, "The electromo-

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tive force around a closed path is equal to the negative of the time rate of change of the magnetic flux enclosing the path."

And at the end of the day what that means is if you move a magnet around a coil or wire, you'll get electricity. What he also discovered is that the frequency of the sine wave generated is a function of the speed and the number of poles of the magnet. When he started of course he only had two but that relationship stays with us. It got really exciting between the mid-1800s and late 1800s. Europe got on board. They got electrified. Thomas Edison electrified New York.

And if you really want some very interesting history, if you're ever in Southern Michigan and visit Greenfield Village, you can see Edison's original invention for generating electricity to provide lights all throughout New York. And lo and behold, George Westinghouse comes on board and he challenges Edison for the best way to proceed because Westinghouse was convinced and he had Tesla in his camp that we should use alternating current distribution instead of direct current distribution. Tesla showed that we can transform AC but we can't transform DC. We can transfer our electricity much farther distances than Edison could with DC.

In the late 1800s, Westinghouse won that battle. And we went with AC distribution like we have right now. However, back then there were no standards. Prime movers were typically steam engines and they were wildly variable. Whatever anybody had is what they used. Reportedly in 1918, London had 10 different frequencies of alternating current power because a 2,000 rpm steam engine producing 133.33 Hertz power was very common. And remember at this point in time, the only thing we did with electricity was use it for lights. We didn't really care about the frequency for the most part.

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Again, across the pond, things were slightly different. Europe began at 40 Hertz but then someone discovered that the lights flickered enough that we could notice it. In the late 1800s, Europe standardized on 50 Hertz because 50 is metric-friendly and allegedly 60 is not a preferred number. And Southern California jumped on that band-wagon and they were originally at 50 Hertz. The United States for whatever reason standardized on 60 Hertz in 1948. This is how we got to where we are.

And remember at this point in time, all we've got is lights. In fact, if you look at the history that the Edison Power Company was really the Edison Lighting Company because that's all they did was provide lights. We didn't care about motors because it wasn't until 1887 that Tesla came up with the first commercial induction motor. Two-phase current, phases are 90 degrees apart and we have a motor. Didn't do a whole lot with that motor other than developed it. In 1889, Michael Dolivo-Dobrowolsky invented the 3-phase induction motor because we all know three is better than two. And his invention pretty much set the standard for AC motors moving forward.

Direct current versus alternating current

We have two types of motors we want to talk about actually two main classes of motors, direct current or alternating current. And they both have uses and they both have required choices. What DC motors typically do well is they have a much higher starting torque. They're quick starting and stopping often used for stepping motors, control motors, things that require very precision movement. They're very easy to reverse, switch the polarity on the leads and the motor typically runs backward. We can control their speed by adjusting their voltage, which is usually simpler and cheaper to control than an AC motor where we have to modify the frequency.

DC motors have been entrenched in the control space for a long time. For those of you familiar with mechanical actuators, they were pneumatic for many years and then they got replaced with high-torque, very precise DC motors for damper control, valve control and those types of things. In reality, we all know that DC motors have been in cars forever. The starting motor on your vehicle is DC. The motors that run the windows up and down is DC. If you have electric windshield wipers, it's a DC motor. DC motors are very well entrenched in the automotive industry where they're becoming more pronounced is the makers like Tesla or Nissan. The folks that are making electric cars are using them to drive the vehicle in ways that we never thought of before.

Also, as solar becomes more and more prevalent, we can use that DC directly in applications rather than transform it to AC depending on our application.

What do AC motors do very well? Well, first of all they're very reliable. They've been around forever (since 1887) and they have been modified, adjusted, tweaked, fiddled with for all that time and they've been around and everybody knows them. They're easy to maintain and do not have a lot of moving parts. It's just the armature that spins around on some bearings. They have a very large installed base. They're easy to find and they match the existing infrastructure because the infrastructure was sort of developed with the motor and the motor developed with the infrastructure and AC induction motors are kind of the thing. The issue — if you want to call it that — is we vary the speed with frequency and that is a little more complicated which is probably why variable frequency drives or closed control devices took so long to develop.

We're going to really focus on AC motors because most of us are working in the commercial building space and even in industry and pump stations and water plants and

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wastewater plants, we're still all going to be AC type motors. But even within that space there's another divide. And that's induction motors versus synchronous motors. All induction motors, which is what Tesla invented and what we're most familiar with, are considered asynchronous. And what that means is the rotor current is induced by the stater current, hence the name induction motor. But because of that these motors will slip or they have a component called slip. Additionally, because of that slip and because of the way these motors run they operate at the lagging power factor.

Everyone remembers power factor. The power factor for the most part is OK, but it can be our enemy. The advantage to induction motors is they're less expensive to manufacture and maintain. Because we've been manufacturing them for 200 years, we know how to do it. And we do it very well. And most of the motors and commercial applications are induction motors.

There are, of course, exceptions. Synchronous motors, the rotor current is supplied in a variety of ways, but it's not by induction. And on the synchronous motor the rotor turns in sync with the state of frequency. So, there's no slip. And that's important because now we can use these motors typically in a variety of ways, but for very small horsepower synchronous motors are used for precision control or timing.

In the past, schools had analog clocks on the wall. And if you ever wondered how they got all those clocks to read the same, it was through little synchronous motor and they tied them all together and they managed the frequency and then they could adjust all the clocks to read the same thing. Synchronous motors of any significant size typically have a higher first cost, which is why we don't see a lot of them. They're more energy-efficient, however, so if we stop and think about the total cost of ownership, may-

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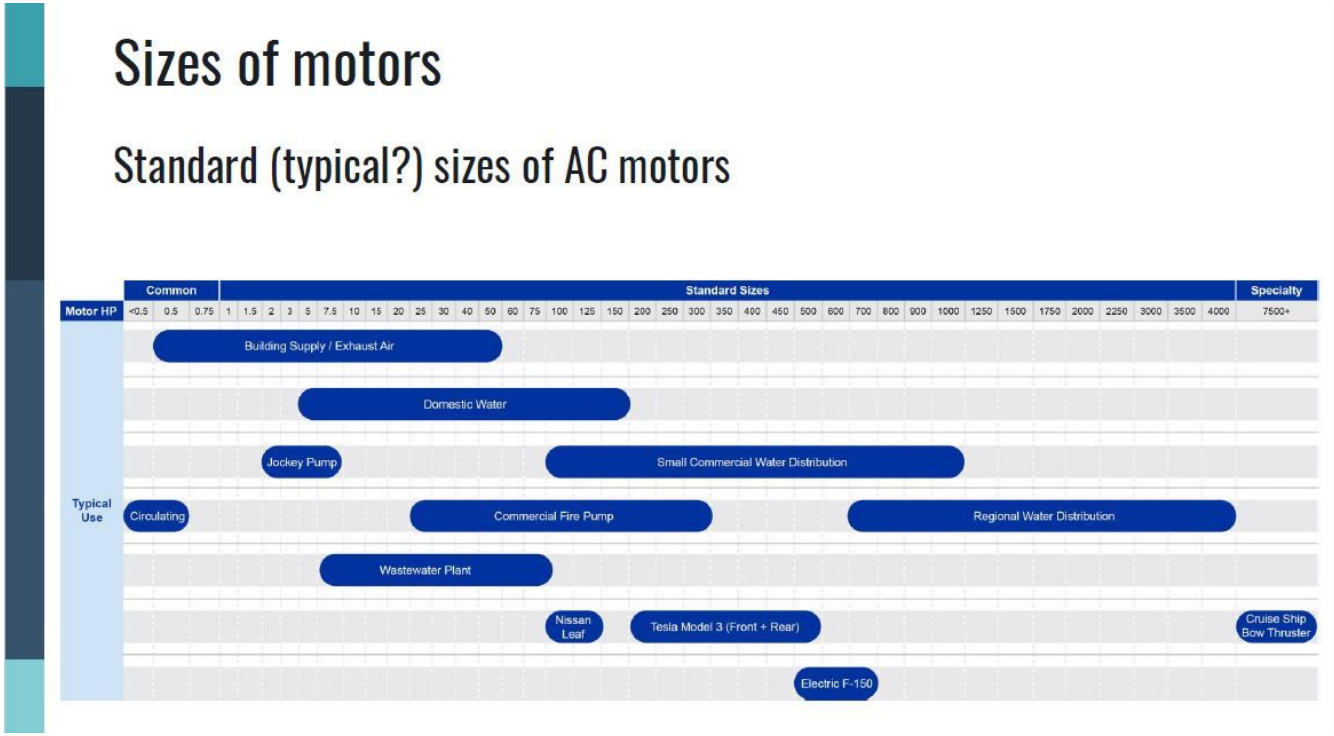

Figure 1: This shows the wide variety of alternating current motor sizes. Courtesy: Consulting-Specifying Engineer

be we can overcome that first cost and use the synchronous motor. The big advantage is they're designed to operate between unity power factor and a leading power factor. This is an opposite to an induction motor which we can take advantage of and we'll talk about that moving forward.

Motor sizing

Figure 1 shows a spectrum of the sizes of motors we see in the world. And this is not meant to be inclusive at all, but it just kind of gives us a feel for the sizes and what they do. If we start at the far left-hand side in a commercial building with a water system or exhaust fan system, we'll see very small motors just used to circulate water, exhaust

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fans in restrooms, they can be sub-half horsepower, half horsepower, below one horsepower. And then as we move to the right, we see the things we typically run into. We see supply fans and exhaust fans. We see domestic water pumps, a jockey pump on a fire pump system, the fire pump system itself. As we move more to the right, we see small commercial water distribution.

Anybody who's ever had to replace a motor on an old piece of equipment has run into this. You get the new motor, you get it out of the box, you take the old one off the air handler, you put the new motor up there and all the holes are gone. What do we do? How do we deal with this?

Fortunately, in 1926, an organization called National Electrical Manufacturers Association was created. And what NEMA does is they try to standardize all of this stuff. They don't like to use the word standard, but they really do develop standards. They are not an enforcement agency. They have no direct control over any manufacturer but what they do is they help the manufacturers make things that are interchangeable and they help the manufacturers rate things in a way that makes it easier for us engineers to figure out which one of the many hundreds of choices we want.

Frame size basically ensures the holes are in the right place. If you get a NEMA frame size, pick your favorite one A, it's going to fit any other NEMA frame size A. A horsepower may not be the same. It may be induction. It may be synchronous. It doesn't matter as long as the frame size matches the holes will be in the right place.

Next, we have motor classes. This one's a little bit more important for us when we're specifying new equipment. There are currently five classes and they're based on start-

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ing torque and the ability to accelerate loads. Sometimes we don't care especially in an air handler situation, the starting torque is pretty low and we don't really care how fast it starts up.

If it takes 30 seconds or a minute, we don't care because typically in an air handler once it's running, it's running. There are currently five classes because as the industry changes, NEMA changes with the industry and adds classes as necessary. Class A extremely high efficiency, extremely high full load speed, they're very rare. Motor class B is more typical. Normal torque motors, low starting torque typically on pumps and fans. It's not a huge locked rotor current type situation. C and D are much higher starting toque, positive displacement pumps or compressors. Air compressors starts against in most cases. It starts against a higher back pressure large pumps where you have big head differential. The pump is going to take a little bit more torque to get started.

You may use the motors class C or D. This is a larger pump driving a water, a larger motor driving a water pump and a water plant. And then there's E, which is the high efficiency version of B. And this would just be something where if we wanted to look at total cost of ownership, save a few more dollars down the road by spending a little more upfront we might consider a motor class E instead of B.

Jeffrey R. Thomas
Jeffrey R. Thomas *is vice president, business group director, Lockwood, Andrews & Newnam Inc., Houston. He's an electrical engineering expert with nearly 30 years of experience as a project manager, energy manager, auditor and certified health care instructor.*

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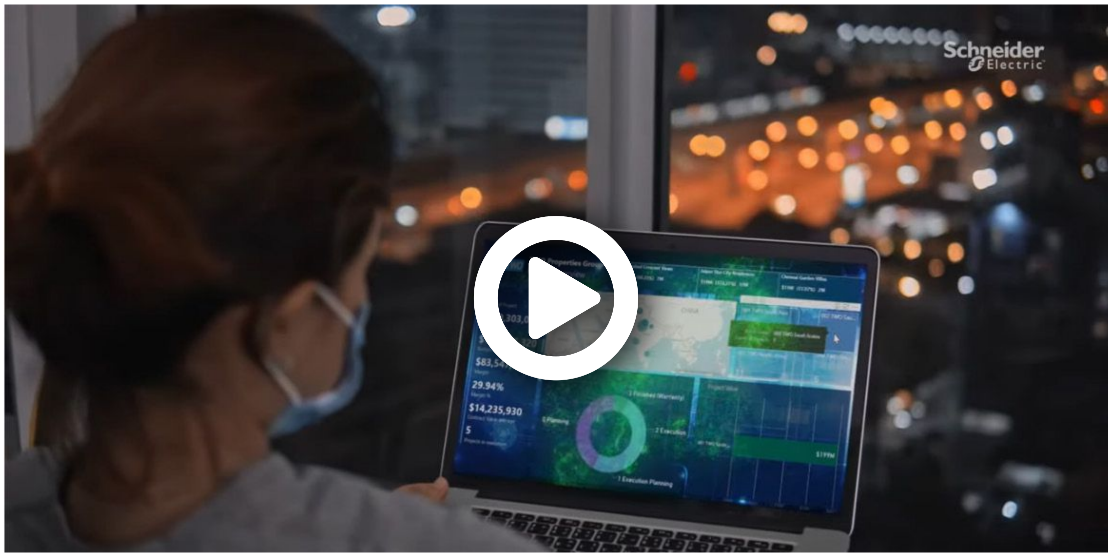
Schneider Electric



Electricity 4.0: Powering the New Electric World | Schneider Electric

When electric meets digital, it becomes Electricity 4.0, giving us new ways of distributing, seeing, and saving energy. The future is Electricity for Zero: zero waste, zero emissions, and zero-carbon.

The new energy landscape: Four ways digitization is creating greener, more sustainable buildings

As the race to net-zero intensifies, pressure is mounting for **commercial building** operators to improve their green credentials. Considering that **buildings generate 40%** of all CO_2 emissions and consume over 30% of the world's energy, the sector's environmental footprint is now under the microscope.

The challenges posed by climate change mean that "business as usual" is not an option. But thanks to digitization, the emergence of a new energy landscape is underway. This digital transformation represents a golden opportunity for commercial building operators to slash emissions and improve their environmental, social, and

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governance (ESG) scores, which investors increasingly use to choose where to invest their money.

In addition to creating resilience against brand reputation and business model risks, putting sustainability at the top of the agenda can deliver bottom-line savings as digitizing buildings can help reduce energy bills through improved operational efficiency.

This post will explain how digitization has altered the energy landscape and why it is a game-changer for commercial building owners and operators.

4 key benefits digitization provides

1. Actionable data

The more meters a building has and the more advanced those meters are, the more insight and potential savings can be found. Our connected products, including **MasterPacT IoT-connected air circuit breakers**, **ComPacT embedded metering molded case circuit breakers**, intelligent sensors, and control and communication devices, provide enormous amounts of data in real-time, enabling commercial building owners to take action and optimize energy. This data can aid decisions that help maximize:

- Electrical safety
- Power availability
- Maintenance

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- Energy efficiency
- Sustainability
- Power system cybersecurity

New energy use data that is now available can also reveal risks and opportunities to unlock your building's full potential. Software solutions such as **EcoStruxure Power Monitoring Expert** utilizes advanced dashboards, energy visualization, and analysis tools that seamlessly integrate for overarching building management and provide the insights you need to make informed decisions to maximize energy efficiency.

2. Simplified reporting and compliance

Globally, **80%** of companies report on sustainability. To continue accessing capital from investors, companies will need to prove they have a solid ESG rating and that their buildings meet sustainability standards. Through digitization, the collection and storage of data points required for tracking and reporting carbon emissions are now easier than ever before. Technology can provide new levels of granularity in environmental data. Meanwhile, carbon emissions can even be represented by tons of CO2 equivalent and segmented by source, scope, and pollutant.

Software solutions from **EcoStruxure Power** include the monitoring and reporting tools and services your sustainability team needs to help follow energy management best practices, comply with local regulations, and achieve green building certifications.

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3. Active management

With the increased amount of data collected from digitally connected devices, it becomes important to have an efficient way of analyzing this data, in order to gain useful insights that can again be utilized by the facility manager. This can be done utilizing **EcoStruxure Power Advisor,** a connected service designed to proactively manage your power management and power distribution systems with remote consultancy, support, etc., and on-site maintenance. Its combined advanced algorithms can provide continuous, remote monitoring of the health of your electrical system and improve performance based on energy audits.

4. Optimized on-site energy with predictive modeling

As the race to net-zero accelerates, the digital transformation makes it possible now for commercial building owners and operators to become ‘prosumers’ and even net-positive by producing their green energy with on-site energy options. Tariff management enables building owners and operators to sell their renewable electricity to the grid when prices are high and consume or store grid energy when prices are low.

Predictive modeling forecasts and identifies new ways to save money by uncovering wasteful energy usage. This modeling can also enable microgrid optimization strategies for tariff management, self-consumption, and demand charge reduction. **EcoStruxure Microgrid Advisor** seamlessly connects to your energy resources to automatically forecast and optimize how and when to consume, produce, and store energy, ultimately helping to improve economic performance, sustainability, and resilience at your site.

Beginning your decarbonization journey

The digital revolution in the built environment is transforming the sector. Thanks to digitization, buildings can be greener and more energy-efficient than ever before, leading to reduced and optimized energy consumption and providing companies with bottom-line savings. Schneider Electric helps provide advanced sustainability solutions from CapEx to OpEx, empowering your customers to make the most of their energy as they turn climate ambition into concrete action.

Partnering with Schneider Electric for sustainability means co-innovating simplified, open, and digital solutions that have a real, beneficial impact on the environment. Visit **EcoStruxure Power** to learn more about our portfolio of digital solutions for building owners and operators, specifiers, panel builders, and contractors.

Hospital emergency power supply systems

Generators and emergency power systems are essential to enabling hospitals and health care facilities to effectively serve their communities

Due to constant changes in medical standards of care, technologies and building systems, hospitals have become more reliant on electrical systems to function properly. As such, the reliability of the hospital building's electrical system is more important than ever.

NFPA 70: National Electrical Code requires every hospital to have two independent power sources that provide a minimum level of reliability: a normal source (i.e., utility) and an alternate source (i.e., generator, fuel cell system or battery system).

Because most health care facilities have traditionally used generators as their alternate source due to runtime and maintenance advantages, this article will focus on generators and essential electrical system (i.e., "emergency power") design.

For the purposes of this article, the NEC Article 517 term "essential electrical system" and Article 700 term "emergency power system" are synonymous because emergency systems are defined in NEC Article 700, which is applied specifically to hospitals in NEC Article 517.

An emergency system is defined by the NEC as "those systems legally required and classed as emergency by municipal, state, federal and other codes."

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NFPA 110: Standard for Emergency and Standby Power Systems defines the various components that makeup an emergency power system and comprises the emergency power supply and emergency power supply systems.

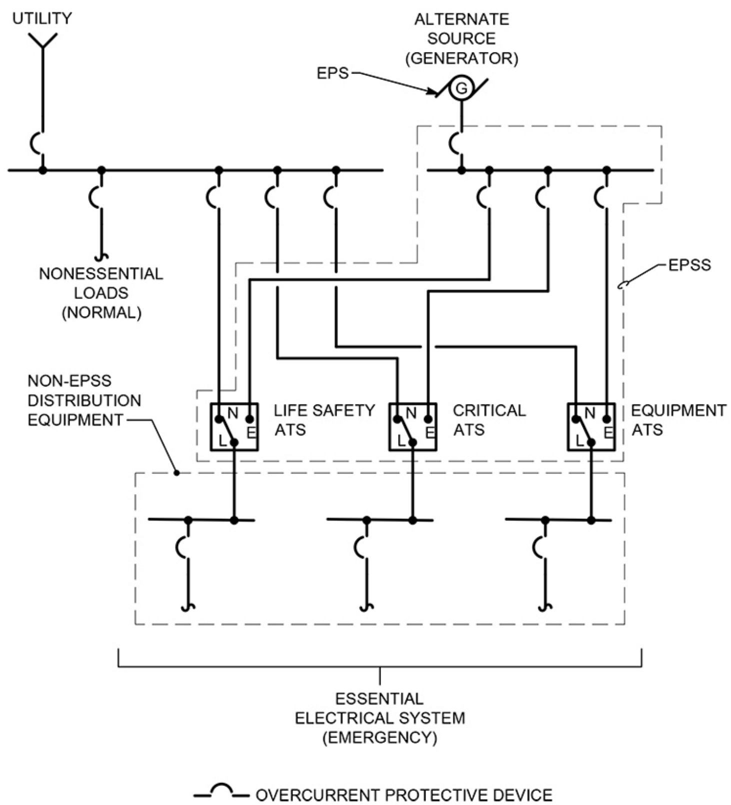

Figure 1: Typical hospital essential electrical system configuration indicating utility, emergency power supply, emergency power supply systems and non-EPSS equipment. Courtesy: WSP USA

The EPS is the alternate power source, which in this case is the generator(s). The EPSS consists of the conductors, distribution equipment, overcurrent protective devices, transfer switches and all control, supervisory and support equipment needed for the system to operate between the generator and the transfer switch. Conductors, distribution equipment and overcurrent protective devices on the load side of the transfer switches are not considered part of the EPSS per NFPA 110, but are considered part of the overall emergency power system (see Figure 1).

A generator consists of two major components: the engine that provides the mechanical power via a rotating drive shaft and an alternator, which converts the mechanical ener-

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gy to electrical energy. A transfer switch is an electrical piece of equipment that is configured to connect two incoming power sources (typically the utility source and the generator source) and one outgoing connection to the load(s) using a switching mechanism to select which of the two incoming sources is connected to the load (see Figure 2).

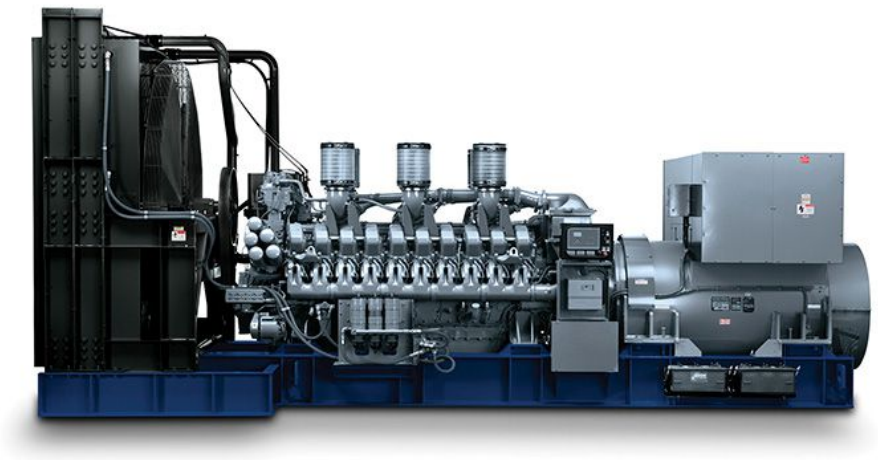

Figure 2: Typical generator set configuration with major components identified (this example is an indoor installation). Courtesy: Curtis Power Solutions

There are other regulatory bodies, codes and organizations that need to be considered depending on where the project is located:

- NFPA 99: Health Care Facilities Code establishes criteria for levels of health care services to minimize the hazards of fire, explosion and electricity to patients, staffs and visitors.
- The Facility Guidelines Institute publishes the FGI Guidelines for Design and Construction, which consists of multiple documents that identify the needs for hospitals, outpatient facilities and residential care facilities.
- Centers for Medicare & Medicaid Services and The Joint Commission require hospitals adhere to the requirements of NFPA 99 in addition to the NEC and often

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times require (depending on the jurisdiction) to comply with the requirements of the FGI Guidelines.

Reviewing the requirements of these regulatory bodies, codes and publications is recommended at the onset of a new project to determine any project specific impacts as the adopted codes vary by state and local jurisdictions.

Emergency power design considerations

Generators are manufactured with two ratings: prime and standby. A prime rated generator is designed to be operated continuously as the primary source of power for the system, typically used where utility power is not available such as extremely rural locations. A standby rated generator is designed to operate intermittently when the main source of power fails or during generator testing. Emergency power systems for hospitals use generators rated for standby use because the generator is functioning as the alternate source of power.

NFPA 110 requires generators and the EPSS to have a Classification, Type and Level. The “Class” defines the minimum run time in hours. The “Type” defines the maximum time, in seconds, to transfer to the alternate source after power loss. The “Level” defines the risk to human life due to the failure of the system.

Hospital emergency power systems typically must be Class 96 (minimum 96 hours of runtime) or have an operational plan to supply 96 hours of fuel to the site, Type 10 (maximum 10 seconds to transfer) and Level 1 (failure of system could result in loss of human life or serious injuries).

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The two common fuel types for hospital generators are No. 2 diesel and natural gas. Typically, hospitals opt to install diesel generators for two primary reasons.

- Hospitals are required to either have 96 hours of fuel stored on-site or an agreement to have the additional fuel delivered to maintain 96 hours of continuous runtime (see the Joint Commission's Emergency Management 96 Hour Plan for details). Natural gas is delivered to the hospital from the utility via underground distribution piping and cannot be stored on-site in the quantities required. Authorities having jurisdiction do not typically consider an off-site fuel source reliable enough to be the sole fuel source for generators (see NEC 700.12(D)(2)).

- Emergency generators and the EPSS for hospitals are required to be NFPA 110 Type 10 systems. This requires the system to restore power to the loads in less than 10 seconds. Most natural gas generators are not able to meet this requirement due to the time it takes the generator engine to start.

Generators can be installed indoors or outdoors. Indoor installations have the advantage of being better protected from weather and vehicular traffic and provide ease of maintenance but are typically a higher first cost. The generator room needs to be designed to account for the substantial airflow required to both cool the generators and provide combustion air to the generator. Ideally the air intake is at the back of the room and air discharge is at the front to promote proper airflow over the engine block to facilitate engine cooling. Rooms with air intake or discharge from above or one side of the room may create cooling issues and should be avoided. Design also needs to consider the acoustical impact of the generators at both the air intake and discharge locations. Generators create a lot of noise and sound attenuation within the room may be required to meet local ordinances or hospital requirements (see Figure 3).

Figure 3: Example of an indoor (left) and outdoor (right) generator installation. Courtesy: WSP USA

Outdoor installations typically have a lower first cost but are not as accessible and may be susceptible to degradation of the equipment over time if not properly protected. Typically, a generator installed outdoors will have a weather-proof enclosure with dampers and heating elements to keep the environment within the enclosure controlled to an extent. The enclosure also may have a sub-base tank for fuel storage, sound attenuation or raised personnel platforms depending on the specific requirements of the project. The self-contained nature of an outdoor generator can be advantageous as the issues with ventilation and fuel oil delivery are simplified.

Emergency power distribution equipment

The complete essential electrical system, as defined by NEC Article 517, consists of the EPSS (i.e., everything between the transfer switch and the generator, including the transfer switch) and the switchboards, panels, transformers, feeders and overcurrent protective devices that are connected to the load side of the transfer switch.

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In hospitals, the essential electrical system is divided into three separate branches per NEC Article 517: life safety, critical and equipment. Each branch has its own automatic transfer switch, or switches depending on the size of the system, to segregate power distribution in the hospital:

- The life safety branch is limited to circuits essential to life safety and include illumination of means of egress, exit signs, select alarm and alerting systems, communication systems, generator set accessories, elevators and select automatic doors.

- The critical branch is primary reserved for systems and equipment that are essential to patient care and safety and include, but is not limited to, task illumination and receptacles patient care spaces, nurse call systems, clinical information technology systems and select power circuits needed for effective hospital operation.

- The equipment branch primarily consists of mechanical equipment required for effective hospital operation and typically includes air handling units, pumps, boilers, chillers, medical vacuum/compressed air equipment, kitchen equipment and any other optional loads the hospital considers necessary to maintain the facility when utility power is lost.

Transfer switches can be either automatic, nonautomatic or manual. Hospitals primarily use automatic transfer switches, which transfers to generator without personnel input. However, nonautomatic and manual transfer switches are used for optional loads when automatic transfer is not required or desired due to available generator capacity.
The difference between nonautomatic and manual is nonautomatic has an automatic transfer mechanism, but transfer requires personnel to initiate; manual requires personnel to physically move a mechanism by hand from one source to the other.

Automatic transfer switches have three transition types. Open transition is the most common in hospitals and disconnects from the primary source of power (utility) before connecting to the alternate source (generator), also known as "break before make." Delayed transition is similar to open transition but has a built-in time delay where it is disconnected from both sources for an extended period and is most commonly used for mechanical equipment to allow time for motors to slow down before connecting to another source of power.

Closed transition is less common due to utility company approval needed before installation because closed transition briefly parallels utility with the generator(s). Closed transition will briefly connect to both sources before disconnecting from one source or "make before break." The advantage is the facility does not experience a brief "blip" in power during monthly generator tests or when transferring from generator back to utility power.

Many hospitals require automatic transfer switches to have bypass isolation. Bypass isolation is a switch provided with two switching mechanisms configured so that one switch can be removed and worked on in a safe manner while the other switching mechanism provides power to the loads. The design needs to consider the increased footprint and cost for bypass isolation switches over transfer switches with a single switching mechanism.

Common emergency power system configurations

There are two common system configurations that most hospitals use: standalone and paralleled systems. A standalone system consists of a single generator with transfer switches separating life safety, critical and equipment branch loads. The generator starts when a start signal is received from any of the transfer switches and each transfer switch will transfer to generator power once the switch senses the generator source has reached system voltage and frequency.

The advantage of a standalone system is typically lower first cost in comparison to a similarly sized multi-generator configuration as well as less complicated controls. The disadvantage is failure of the singular generator results in the facility having no back-up power to essential loads during the utility outage. In addition, the standalone system has no ability to shed less critical loads if the generator is unable to keep up with the demand load of the facility during the utility outage unless a building automation system interface is provided to monitor real-time load on the generator and shutdown select equipment when it senses the generator is reaching peak capacity. This addi-

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tional feature will add cost to the project if implemented, which needs to be considered during design.

A paralleled configuration consists of two or more generators connected in parallel to a common bus with multiple transfer switches. Once a start signal is sent by a transfer switch, the first generator to reach rated voltage and frequency will close to the bus. Transfer switches will start transferring to the generator source and subsequent generators will close to the common bus once they reach voltage/frequency and are synchronized with the first generator.

The advantage of paralleled configuration is it provides equipment redundancy in the event a generator fails to start or is offline for repairs. Additionally, the system is able to load shed lower priority transfer switches (i.e., disconnect them from the generator source) if the generators are unable to keep up with the demand load. This prevents a complete outage to the facility and ensures the most critical loads remain operational.

Electrical system redundancy

Hospitals are constantly preparing for the worst-case scenario to ensure they deliver the highest level of care to their patients. Equipment and system redundancy is a priority. It is recommended that designers discuss equipment and system configurations that provide inherent redundancy with the client to ensure the design meets the client's redundancy requirements and project budget.

For generators, a common configuration is to provide the quantity of generators that provide N+1 redundancy in the event one of the generators fails to start or is offline for repair. For example, if a facility has a peak demand load of 900 kilowatts and the

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hospital wants N+1 redundancy, providing three 500-kilowatt generators in a paralleled configuration would meet the redundancy goal.

Another strategy to improve the resiliency of the essential electrical system is to separate critical or equipment branches of emergency power into "Critical A" and "Critical B," each having its own automatic transfer switch. This limits the potential outage to the facility due to a catastrophic failure to a transfer switch or other distribution equipment on that branch of power. It also allows for critical care areas of the hospital to be connected entirely to emergency power while maintaining two separate sources of power which is required by code.

Generator fuel

As previously noted, No. 2 fuel oil is the most common fuel source for hospital emergency generators. Typically, a hospital will have a minimum of 96 hours of fuel on-site, and may have less if complying with the Joint Commission's Emergency Management 96 Hour Plan or in a local jurisdiction that has a less stringent requirement.

Depending on the utility's reliability, the generators may only run 15 to 20 hours a year to meet the monthly/yearly testing requirements for each generator. This results in fuel that may sit for extended periods before being used. To avoid degradation of the quality of fuel, most hospitals will install a fuel polishing system to remove water and other particulates from the fuel oil. If a centralized tank is installed to serve multiple generators, a fuel oil pumping system will supply and return fuel to the generator day tanks that are located at each generator.

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Modifications, upgrades to existing electrical systems

When designing a generator or emergency power system upgrade for an existing hospital, phasing and outages need to be considered at the outset of the design as they can have a huge impact on hospital operations. Hospitals cannot afford to shut down critical services at any time.

Although outages are unavoidable with a major system upgrade, discussions with hospital administration and key personnel early in the design is crucial as it may require a different design approach to meet the project goals and maintain the facility during construction.

Generators and emergency power systems are an essential system in hospitals to ensure the operational impact of a utility outage is minimal. As health care facilities and staff continue to adapt to the latest standards of care, the need for more robust and reliable emergency power systems will be required.

When initiating the design of a new emergency power system or upgrade to an existing system, owners and design professionals need to be in constant communication to ensure the design aligns with the project goals, budget and hospital's operational priorities.

Emergency generators and the design of power systems play a crucial role in ensuring reliable power is provided at each facility by providing an alternate source of power in the event the utility source is interrupted.

Philip E. Mackey

Philip E. Mackey *is a vice president with WSP USA with more than 15 years of experience in the design of electrical systems for hundreds of health care clients.*

Case study: Hospital emergency power upgrades

MedStar St. Mary's Hospital emergency power upgrades

MedStar Health, a multihospital health system in the Baltimore-Washington metropolitan area, evaluated the condition and configuration of the generator and essential electrical systems (i.e., emergency power systems) at MedStar St. Mary's Hospital. Working closely with the client, a conceptual design was developed by WSP USA, evaluating several potential options to upgrade the existing systems.

After review of the pros/cons and cost estimates for each option, MedStar determined the facility would be better equipped to serve the local community's health care needs with an upgraded generator and associated electrical distribution equipment. The existing installation consisted of two 500-kilowatt diesel generators located adjacent to the central plant that were configured as two standalone emergency power systems.

In this configuration, each generator and associated electrical distribution equipment served roughly half of the hospital when a utility outage occurred. Additionally, the hospital determined there were several pieces of mechanical equipment (i.e., chillers, pumps, etc.) and patient care equipment (i.e., MRI, CT scans, etc.) that were only connected to normal power, which is code compliant that needed to be connected to emergency power for effective hospital operation during a utility outage.

Finally, the hospital identified the need to have the emergency power system configured in a manner that improves the reliability of the system in the event of equipment failure and allowed expansion of the system with future growth of the facility (see Figure 4).

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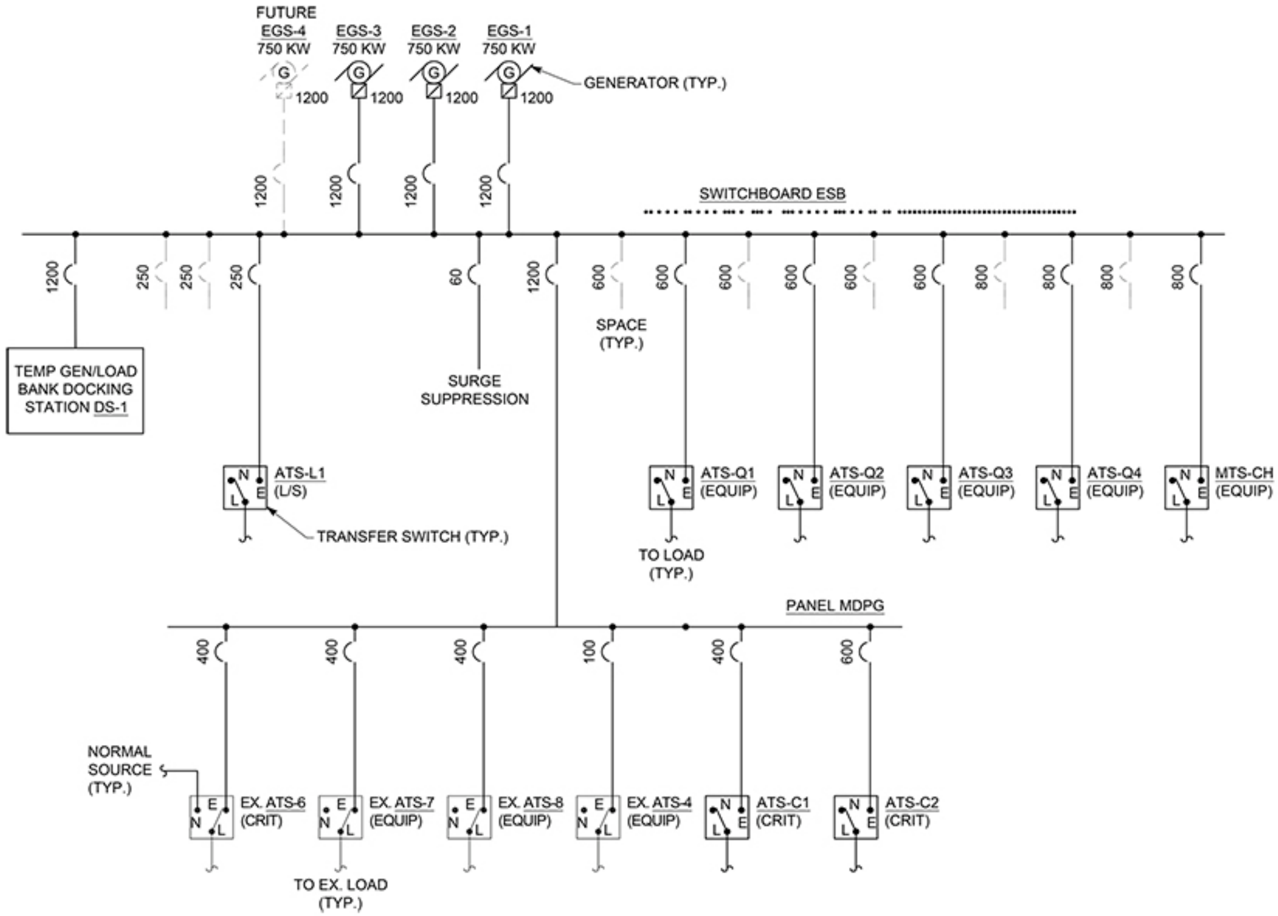

Figure 4: Electrical single-line diagram indicating configuration of emergency power system and major equipment for MedStar St. Mary's Hospital emergency power upgrades project. Courtesy: WSP USA

The anticipated demand load on the emergency power system after the system was reconfigured was 1,830 kVa. This anticipated load included equipment moved from normal power to emergency power. To support the existing hospital emergency loads and added equipment, three 750-kilowatt diesel generators were provided in a paralleled configuration.

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The associated electrical distribution equipment was installed in a 1,100-square-foot emergency electrical building built adjacent to the generators. The system was configured so that a fourth generator could be installed in the future to expand the system's capacity. The new generators have a total rated capacity of 2,800 kVa with an N+1 rated capacity of 1,875 kVa. Therefore, the upgraded generator plant has the capability to support all equipment in the event of a single generator failure which improves the reliability of the emergency power system at the hospital (see Figure 5).

A critical component of the design was to maintain uninterrupted services to the community during this project. For this reason, the design team needed to carefully consider phasing of construction so that the impact to the hospital's existing normal and emergency power systems was minimal. Location of new equipment was coordinated so that the existing generators remained operational until new system was online. An outage/phasing plan was developed during design and further refined with input from the electrical contractor to minimize the quantity and duration of outages.

The existing automatic transfer switches were upgraded, where possible and new automatic transfer switches with bypass isolation were installed to provide an emergency power system that supports the current hospital needs and future growth. The bypass isolation switches allow the hospital to perform preventive maintenance on each transfer switch without experiencing an outage to essential equipment which further emphasizes the importance of limiting disruption to hospital functions and patient care.

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Figure 5: Installation of three 750-kilowatt diesel generators in weatherproof enclosures at MedStar St. Mary's Hospital installed as part of the emergency power upgrades project. Courtesy: CMI General Contractors

One of the major benefits of the new emergency power system configuration is that the chilled water system was connected to the emergency power system as part of this project. Connection of the chilled water system to emergency power allows the hospital to maintain space temperatures during any utility outage. Although the system only has the capacity to operate one of the two chillers while operating in automatic transfer mode, a manually operated nonautomatic transfer switch was provided to support the second chiller and associated pumps.

This provides the following benefits:

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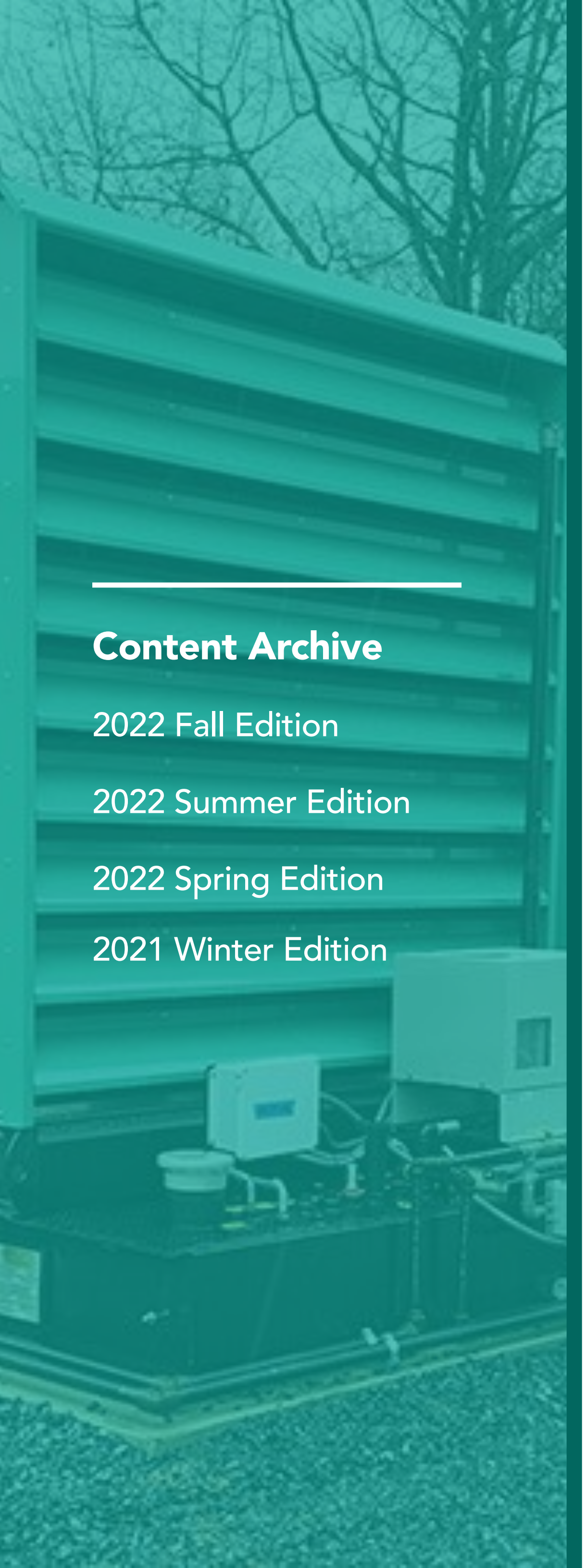
- The system design allows facility personnel the ability to monitor the load on the generators in real time and manually transfer the second chiller if needed for cooling demand when enough capacity is available at the generators.

- In the event the primary chiller is offline for maintenance, it allows facility personnel the ability to manually transfer the second chiller during a utility outage.

- If metering determines the actual peak demand load is less than what was calculated and generators have the capacity to support both chillers at peak load conditions, the nonautomatic transfer switch can be converted to an automatic transfer switch allowing the entire chilled water plant to automatically transfer to emergency when utility power is lost.

The emergency power upgrade project at MedStar St. Mary's Hospital came with its challenges and was necessary so the hospital could continue to provide the highest level of care for the growing community served by this facility. The new generators and emergency power system ensure a reliable source of power is delivered to the hospital and is configured in a manner to allow for future growth and flexibility as the health care industry continues to evolve.

Philip E. Mackey
Philip E. Mackey *is a vice president with WSP USA with more than 15 years of experience in the design of electrical systems for hundreds of health care clients.*



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