GETTING SERIOUS ABOUT SAFETY AND LOSS PREVENTION EMERGENCY POWER AND STANDBY GENERATORS

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ABSTRACT

Power failures can occur for a variety of reasons. The consequences of such outages range from mere inconveniences to damaged equipment, ruined goods, lost revenue, and diminished safety.

In all buildings lighting is among the greatest safety requirements during a power outage. Depending on the type of facility, other systems and equipment may also be considered critical. Batteries may be used to provide power for emergency lighting as well as computers, telephone and intercom systems. However, they are not an option for powering large users such as HVAC systems and elevators. Backup generators are a viable solution in these cases. They can provide electricity as long as fuel is supplied and can run virtually any type equipment.

This paper will discuss how some schools and other facilities are addressing building safety and functionality during power outages by using backup generators. Issues involving selecting, operating, and maintaining generators will be discussed. Also, several case studies will be presented.

CAUSES OF POWER OUTAGES

Power outages can be triggered by a variety of events. Damage resulting from wind due to thunderstorms, tornadoes, and hurricanes are frequent causes. Ice and snow accumulating on lines causes them to sag and break. Frozen precipitation can make trees snap, thus bringing down power lines. Accidents involving vehicles hitting poles and equipment failures are also common reasons for outages. In today's environment, terrorist activities can be added to the list of possible causes.

Outages, while usually lasting only seconds, can persist for several hours or even days. Power can usually be restored quickly if the outage is limited in area. In these instances utility companies can repair damaged facilities or reroute circuits to get customers back online. At the opposite end of the spectrum, after large-scale outages, several days or weeks may be needed to fully restore all power. Consider the blackout of August 14, 2003, affecting over 50 million people throughout the northeastern United States and southern Canada. (Figure 1) Electricity was restored to some areas in a few hours, but other areas were without power after several days. Hurricane Isabel, after hitting the Atlantic coast in September 2003, caused extensive power outages throughout North Carolina and Virginia. Some customers were without power for up to two weeks.

Figure 1. Sample Headline

AFFECTS OF POWER OUTAGES

Consequences of power outages are varied. Depending on the type of facility affected, a failure may result in lost revenue, ruined goods, safety concerns, or merely an inconvenience. Varying types of systems and equipment rank high in importance to different users. For banks a loss of power to computers and ATMs means an inability to process transactions and collect user fees. In hospitals electricity for life support systems and operating rooms is critical to patient care. Medical laboratories may lose biopsies and other specimens if electric service is lost for an appreciable amount of time. Grocery warehouses require power for refrigeration to keep perishable foods from spoiling. Prisons need power for surveillance, electronic security, and building access systems.

One of the greatest safety needs in all facilities during a power outage is lighting. Emergency lighting guides occupants to the nearest path of egress, helps prevent accidental injuries, and aids in a smooth, quick exit to safety. It can also help rescuers find their way around in a darkened building and let stranded persons see their surroundings. Therefore, building codes mandate the installation of emergency lighting that will come on in the event of a power loss.

EMERGENCY LIGHTING SYSTEMS

The most common method of providing emergency lighting is internal batteries that convert fluorescent fixtures into emergency lights. These lights can be switched or unswitched (also serving as nightlights) or controlled via an energy management control system (EMCS). The batteries used, most often nickel-cadmium (Ni-Cad), do not require maintenance per se. However, to satisfy code requirements, their operation must be tested each month. More extensive testing is required on an annual basis. Records must be kept as evidence that the tests have actually been performed. This testing is usually accomplished with the owner's in-house resources, but, unfortunately, is often neglected due to lack of time and available personnel. Two other common methods of emergency lighting are incandescent, self-contained units and central battery systems. The self-contained units are wall- or ceiling-mounted units (often called "bug eyes") and utilize sealed-beam or quartz lamps. Both the integral and wall-mounted emergency light fixtures cost about $100 to $200. Power supply time from all battery-powered units is generally limited to 90 minutes, the minimum required by codes. Central battery systems use batteries housed in a large cabinet. They supply backup power to specified lighting fixtures from a central location, and can also power some other functions that may be needed. These units must generally be in separate, vented rooms as the batteries often give off hazardous vapors. The batteries generally require some form of routine maintenance and typically furnish emergency power for only about 90 minutes. The cost for a central battery system is approximately $1500 per kilowatt (kW) of reserve power.

BACKUP POWER FOR OTHER SYSTEMS

Communication systems, such as telephones and intercoms, generally have backup battery power. Computers may have a UPS; however, these are generally short-term supplies lasting only 15-30 minutes or so, although some UPS can furnish power for a longer time. In some cases, providing backup power for a longer period of time to these and other building systems and functions may be desirable. Depending on the type of facility, such systems might include heating and cooling, ventilation, refrigeration, cooking appliances, security, and even elevators. Obviously, this equipment does not function without a source of backup power, and batteries are not an option to run these types of loads.

EXTENDED POWER OUTAGES

Should an event occur causing a long-term outage, backup power may be needed for an extended period. In the event of a major disaster or terrorist-type incident, schools may need to provide shelter-in-place for students for an extended time. Along with other public facilities, schools may also be used as shelters for the general population. In both instances, a source of backup power for some or all the equipment noted previously offers occupant safety and some functionality to allow use of the school facilities.

An option for providing emergency power longer-term is an engine-generator (or gen-set), consisting of a generator driven by an internal combustion engine (Figure 2). The engine is typically fueled by gasoline, diesel, propane, or natural gas. The power produced by the generator will have the same characteristics (voltage, etc.) as the power company's electrical service to the facility, and can run all types of equipment. Unlike battery-powered fixtures and systems, generators are capable of providing backup power indefinitely, as long as they are supplied with fuel.

Figure 2. Typical Generator Set

Gasoline engines are normally used for smaller applications (under 100 kw or so), such as homes and recreational vehicles. Gasoline tends to be volatile and to deteriorate over time, so it must be replaced periodically if not consumed. Propane, although clean burning, presents the most problems of all the fuels due to its explosive nature and special storage and handling requirements. Diesel is often chosen for larger units (about 100 - 2000 kw) because it is easily stored on-site, has few long-term storage problems, and allows more operating hours between engine overhauls. Its disadvantage is hard starting at cold temperatures; however, this can be overcome with the installation of a heater. Natural gas is also often used for larger engines. For applications in schools, diesel or natural gas would be the fuel of choice. The installed cost for a gen-set is about $250 per kW of reserve power. For diesel units a storage tank adds an additional $2-$6 per gallon of capacity, depending on whether it is above or underground. A summary of the advantages and disadvantages of each of these fuel types is shown in Table 1.

Table 1. Comparison of Fuels for Gen-Sets

FACTOR	**FUEL TYPE**	
	Natural Gas	**Diesel**
Initial Unit Cost	Increases at larger sizes	Decreases at larger sizes
Operating Costs	Tends to be lower	Tends to be higher
Fuel System Installation and Storage Cost	No storage necessary	Increases at larger sizes
Safety	Slight leak risk	Low risk due to high flash point
Environmental Impact	Clean burning	Exhaust not as clean Risk of leak or spill
Fuel Availability	No storage Supply rarely lost unless curtailed	Delivery and storage required Fuel degradation
Cold Starting	No problems	Hard starting when cold unless jacket heater installed
Engine Life/Wear	Good	Excellent

One concern related to engine-generator sets may be emissions. Since they typically run infrequently for short periods, the engines do not create a large amount of pollutants. In Texas, internal combustion engine used to drive generators supplying emergency/standby power typically do not require a special operating permit. They are permitted "by rule" provided that they do not operate more than 10 percent of the normal annual operating time of the primary equipment. The term "by rule" means that the engines are given a permit by default, and no action on the part of the Owner is required. For other states, checking with the department of environmental quality (or equivalent) before installation is recommended.

Generator sets require periodic inspection, maintenance, and testing to meet code requirements, improve reliability, and lengthen unit life. A comprehensive plan to perform and document the work should be followed. Various tasks are typically performed on daily, weekly, monthly, semiannual, and annual bases. Required activities range from daily checking for fuel, oil, and coolant leaks to annual inspections involving inspecting, cleaning, testing, and adjusting all component systems. An in-house maintenance staff may be able to handle the routine checks; however, the monthly, semiannual, and annual inspections and maintenance are probably more than they are qualified to do. Generator set suppliers and other companies offer service contracts to perform this work. Since regular use keeps parts lubricated, brings fresh fuel into the engine, prevents corrosion, and ensures more reliable starting, the generator controls typically include an "exerciser" to automatically start and run the unit weekly.

Overall dimensions of engine-generator sets in the 100 to 400 kw range vary from about 8 to 12 feet in length and 4 to 6 feet in width and height, depending on their capacity. Space for auxiliary equipment such as fuel tanks would be additional. Typically gen-sets are mounted on a concrete foundation or a fabricated steel base, depending on the size of the unit and the characteristics of the soil. To minimize vibration smaller sets have rubber isolators between the engine and generator assembly and the foundation. Steel spring vibration isolators are normally provided on larger units.

Emergency generators are installed in conjunction with a transfer switch. The switch automatically selects between one power source and another. When utility power fails, the transfer switch signals the gen-set to start. When the generator is ready to accept load, the transfer switch disconnects from the electric utility and connects to the generator. After normal utility power has been restored for a given period of time, the transfer switch then reselects it as the source. A time delay prevents returning to utility power before it is stabilized. After allowing it to continue running and cool for a while, automatic controls shut down the generator.

Besides operating essential equipment, generators offer other benefits. They can also be used for peak shaving, a load management tool intended to reduce energy costs. The concept is to replace energy from the electric utility with less expensive energy produced by an onsite generator. One effective way to do this is to operate a gen-set when the building is drawing the highest level of utility electricity. Controls automatically start the generator when electric usage reaches a predetermined level. The generator then supplies a portion of the building's electric demand until it falls back below the preset level. Running the generator in this way reduces the consumption of utility electricity, and, therefore, can lower utility charges. Due to comparatively low energy prices in most areas of Texas, peak shaving typically is not an attractive option. At this time electricity can be purchased for about $0.10 or less per kwh. The cost of generating it is $ 0.10 to $0.15 per kwh, or more, depending on the generator size, fuel type, and hours of use. In other areas of the country, where energy costs are higher, peak shaving may warrant consideration.

Standby power sources are required for safety, essential for some functions considered critical, and desirable to operate other systems and equipment. A common source of backup power is batteries. While useful for running lighting, communications, and computers for a limited time, they cannot operate motor-driven equipment such as heating and cooling, ventilation, and refrigeration. An engine-generator set is capable of running all categories of electrical equipment for a much longer period of time.

ALTERNATE SOURCES

Technologies creating electric power from renewable resources – primarily wind and sun – are mentionable as backup power sources. Photovoltaics convert sunlight directly to electricity through the use of arrays of solar cells. While a collection of cells large enough to power an entire school would be the size of a football field at a minimum, smaller setups could supply a portion of needed electricity. Wind turbines generate electricity as air turns their propeller-like blades. Units can be purchased that produce from fractions of a kilowatt to thousands of kilowatts. However, minimum wind speed characteristics must be met to make wind power a viable option.

Fuel cells and microturbines, while not necessarily falling in the renewable energy category, are both considered low emissions producers and may also supply backup power. Much like a battery, fuel cells create electricity via a chemical reaction. They require hydrogen, usually extracted from natural gas, and give off mainly water and heat. Microturbines are compact, high-speed turbines typically powered by natural gas. Neither of these systems is capable of producing instantaneous backup power. They both require a warm-up period before being capable of producing electricity.

The greatest caveat regarding all of these alternative sources is their initial price. The cost of each is currently several times that of a battery or engine-generator set. However, as production increases in response to raised demand for environmentally friendly on-site generation, prices are likely to drop.

CASE STUDIES

<u>Tom Hicks Elementary School – Lewisville ISD, TX</u>

Lewisville ISD requested that an emergency generator be installed at the new 100,000 square-foot Tom Hicks Elementary School. District officials wanted backup power available to run emergency lighting (including exit lights), selected HVAC units, and a cooler/freezer in the kitchen. Computers, communications, fire alarm, security, and energy management control systems were not selected for connection to the generator. The generator will be strictly for emergency power to the equipment noted and not for peak shaving. Lewisville ISD expects to see a savings since periodic testing and replacement of battery packs in emergency fixtures will no longer be required. The specified generator is a 65 kw, diesel-powered unit. Installed cost was $17,500, or about $270 per kw.

<u>Loudoun County Schools – Loudoun County, VA</u>

Loudon County Public Schools are routinely requires that their new schools have standby generators. The generators power emergency lights, telephones, data systems, and controls, as well as selected air conditioning units and refrigeration.

Figure 3. Smith Co. 911 Center

In recently constructed high schools averaging some 245,000 square feet, the typical generator is 300 kw, 277/480 volt, 3-phase. Diesel was chosen as the fuel since natural gas is sometimes curtailed in the winter when the generators are most likely to be needed. A 1000-gallon tank gives about 50 hours of generator operating time at full load.

Technology Center – Hurst-Euless-Bedford ISD, TX
The H-E-B Technology Center contains classrooms for computer learning classes and houses the district's main computers. Here information on attendance, finances, and other critical data is kept. To ensure availability of these important systems, a backup generator was installed at the site during construction. The generator serves the computers as well as air conditioning and emergency lighting. A 250 kw unit was required to provide backup power to the desired equipment.

Oñate High School - Las Cruces, NM
The Oñate High School campus is located near the edge of the city of Las Cruces. In case of fire the site is equipped with fire pumps to maintain water pressure. To ensure power for these pumps, a backup generator was also installed.


Figure 4. Oñate High School

911 Communication Center - Tyler, TX
The new 911 Communication Center will house calltakers, dispatchers and support personnel for the Tyler/Smith County 911 system. The communication center will support the entire Smith County region and will combine services with the fire and police headquarters. The building will be staffed 24 hours a day, 7 days a week, with dispatchers, supervisors, management, and technical support personnel.

An electric utility outage would leave critical equipment in the facility without power. The Tyler/Smith County area would then be without 911 emergency services. A UPS can supply power, but only for a short time. Therefore, to deal with extended service interruptions, an emergency generator was installed. To make the center fully operational, the generator is set up to provide power for the entire building.

The generator selected was a diesel-powered, 250 kw, 120/208 volt, 3-phase model. An optional 700-gallon tank provides up to 36 hours of standby power at full capacity. The total cost of the generator installation was approximately $56,400, or $226 per kw.

SUMMARY

Power failures can occur without warning and for a variety of reasons. The effects from loss of electrical service can range from life safety to financial to inconvenience. Being prepared for an outage by choosing and installing appropriate backup power systems is essential. Options include batteries for individual users, central battery systems, engine-generator sets, and alternate fuel sources. One of these options, or a combination of them, may be appropriate for a building owner. Each of the choices has its advantages and drawbacks. The final decision depends on the types of loads involved and the desired duration of standby power.

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