Economic risk assessment drives today's standby power system decisions

> **White paper**

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Specifying standby power systems used to be mainly a technical process that evaluated electrical loads and federal, state and local electrical codes for maintaining essential life-safety systems. These codes insured that, in the event of a utility outage, there was enough power to provide minimal lighting, operate elevators in high-rise buildings, and keep alarm systems activated while employees or customers safely exited the building. The solution then was a generator set that met these minimum requirements. But more and more, sizing and specifying standby power systems is becoming a business decision, driven by economic risk assessment and a continually growing dependence on a virtually perpetual source of electric power.

Today, that fundamental design question has expanded to include: how much will a utility outage cost per hour in terms of lost production, lost products, lost revenue, lost data or customer dissatisfaction? And, how much should a company be willing to invest in a standby or on-site power system to reduce these risks to nearly zero?

Outages can be costly

In this new business-model assessment, nearly all facility electrical loads are deemed essential because all are necessary for the normal continuation of the business. According to research by contingency planning organizations, the cost of an electrical outage can exceed $1 million per hour for the average large business. In certain industries such as semiconductor manufacturing, energy production and telecommunications, losses may reach $2-$3 million per hour or higher. Given these high-stake risks, facilities managers worldwide are being forced to evaluate new options for providing a continuous supply of power. Major outages during 2003 in the Northeast U.S., London, Scandinavia and Italy served to focus more attention on the devastating business impact that extended power outages can have. What's more, while extended utility outages are rare—at least in North America—our 24/7 dependence on electric power virtually necessitates that every business have some level of standby power.

Based on a company's exposure to financial risk in the event of a utility outage, the need for standby power can be divided into four categories. As the risk of financial loss due to an outage escalates, so does the justification for standby power systems that meet more than just minimum safety or electrical code needs (FIGURE 1):

CATEGORIES OF STANDBY POWER REQUIREMENTS

Category one	No standby power system required
Category two	Minimal backup power required for life-safety, security and computer systems
Category three	Need substantial standby power system to maintain operations during short outages
Category four	Need near-total standby power to maintain operations for extended periods of time

FIGURE 1

Category one: No standby power generator required. The business is able to tolerate brief utility outages without threat to life and safety or significant loss of production or customer service. Threat of an extended outage is deemed an acceptable risk. However, even the smallest businesses today have battery-powered UPS systems to maintain computer power during short nuisance outages. The UPS system also provides time for proper shutdown of computers to avoid loss of data in the event of longer outages.

Category two: Need minimal backup power for life-safety, security and computer systems (emergency lighting, alarm systems, elevators, building egress, and UPS system for electronic data). This level is typical of code-driven standby power systems.

Category three: Need substantial standby power to maintain all production or business operations during outages of short duration. Facility types likely to be in this category include airports, hospitals, apartment complexes, office buildings, semiconductor manufacturers, and most municipal and government buildings.

Category four: Need near-total standby power to maintain all factory or business operations for extended periods of time. Examples include regional medical centers, Internet service providers, telecommunications, broadcasting, and key government facilities.

Preliminary power system sizing

Once an individual company's risks have been assessed and the degree of standby power protection required has been determined, an initial sizing estimate of the standby power system can begin. The first step in sizing a standby power system is to establish project parameters.

Cirent Semiconductor in Orlando, FL, has a 6 MW standby power system to prevent costly raw material losses during a utility outage.

- **Minimum genset load/capacity:** In general, a standby power system should be sized to provide a 20 percent reserve margin of power for better stability and to accommodate load growth over time. However, running a generator set at less than 30 percent of rated load can lead to engine damage, and reduced reliability.
- **Maximum allowable frequency and voltage dips:** As you reduce the maximum allowable frequency and voltage dips, the size of the specified genset increases.
- **Altitude and temperature:** Based on the geographic location, the size of the genset must increase for a given level of performance as altitude and ambient temperature rise.
- **Fuel:** Diesel generator sets are the most popular for standby power applications, but units running on natural gas or LP are also available, and favored for extended-hour applications.
- **Other factors:** Generator voltage, number of phases and generator frequency should all be specified before selecting a specific power system.

Identifying loads

Typically, a standby generator powers a variety of loads having different operating characteristics. There are linear and nonlinear loads, loads that are extremely sensitive to voltage disturbances, loads like motors that have very high starting current requirements, loads that cycle on and off, and loads that exhibit high peak load demand when operated. In some applications, multiple loads may be required to be picked up by the generator simultaneously, while most applications will allow step sequence loading that can have a big impact on reducing the required generator capacity. The generator must accommodate the highest anticipated starting, peak and running load expected.

Most modern electrical loads are nonlinear in nature. They are electronic loads that consume power in bites, creating load current harmonics. These harmonics cause additional heating in the alternator, and generator output voltage distortion. Untreated, these harmonics may cause alternator and load overheating. Typically, oversized generators are recommended in these instances.

In addition to determining the mathematical sum of all the electrical loads, the following factors also affect the sizing of gensets.

- **Power factor (PF):** Capacitive loads, overexcited synchronous motors, etc. cause leading power factor, where current leads voltage. Generators have a very limited capacity for supplying leading power factor loads. If not controlled, these can lead to loss of voltage control and damage to the generator. Lagging power factor, where current lags voltage, is more generally the case and is a result of the total inductance of the circuit. Power Factor is the ratio of kW to kVA and is expressed as a decimal figure (0.8) or as a percentage (80%). Three-phase gensets are rated for 0.8 lagging PF loads and single-phase gensets for unity power factor loads. Lower power factor loads require larger alternators or gensets to properly serve the load.
- **Single-phase loads and load imbalance:** Single phase loads should be distributed as evenly as possible between the three phases of a three-phase genset in order to fully utilize genset capacity and limit voltage imbalance.
- **Peak power surges caused by loads that cycle on and off:** Such as welding equipment, medical imaging equipment, or motors controlled by some process device such as a thermostat, level control, etc. Taking cyclic loads into account can significantly increase the size of the recommended genset despite painstaking efforts to place loads in a step starting sequence.
- **Motor loads over 50 HP:** Calculating specific motor loads is complex and is best handled by sizing software such as GenSize® available from Cummins Power Generation. When starting large motors across the line with a generator set, the motor represents a low-impedance load while at locked rotor or in a stalled condition, causing a high sustained inrush current—typically six times rated motor running current until the motor reaches rated running speed. This high current demand causes voltage dips that can destabilize the generator. Sizing software typically selects an alternator sized to provide the sustained locked rotor kVA of the motor load that will recover to a minimum of 90 percent of rated voltage. Also, various types of reduced voltage motor starters are available to reduce the starting kVA of a motor in applications where reduced motor torque is acceptable.
- **Nonlinear variable frequency drives (VFD):** VFD's employ rectifiers on the input to covert AC to DC and an output inverter to produce variable voltage and frequency. Although newer technology drives (such as PWM types) produce lower current harmonics, older technology drives induce significant distortion in generator output voltage. Larger alternators are required to prevent overheating due to the harmonic currents and reduce system voltage distortion by lowering alternator reactance.
- **Nonlinear uninterruptible power supplies (UPS):** UPS's use silicon controlled rectifiers or other static devices to convert AC voltage to DC voltage for charging storage batteries. Use the full nameplate rating of the UPS for determining load to allow sufficient capacity for genset battery charging and accommodating full UPS load capacity.
- **Medical imaging loads:** CAT scan, MRI, and X-ray equipment require that the genset be sized to limit the voltage dip to 10 percent in order to protect image quality.
- **Lighting loads:** In addition to lamp wattages, ballast wattages and starting and running power factors should be considered.
- **Regenerative loads:** Elevators, cranes and hoists, require that the power source be able to absorb power during braking. Generally, the regeneration problem can be solved by making sure there are other connected loads or dedicated braking resistors which absorb the regenerative power. Excessive regenerative load can cause a genset to over-speed and shut down.

Multiple-generator systems

A single, large diesel standby generator may have sufficient capacity to supply all your critical loads; however, it is often advisable to divide the load among smaller, multiple standby generators to maximize reliability and operational flexibility. In the unlikely event that one standby generator does not start when needed, the others will start and supply the load by drawing on their built-in reserve capacities. Also, with multiple generator systems, one unit can be offline for maintenance without affecting the availability of standby power for emergencies.

Another factor in the general sizing of a standby power system has to do with the amount of physical space that is available to house the system. Standby systems

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located inside buildings should have a dedicated room with sufficient airflow for cooling and sufficient space for proper maintenance activities. Large standby power systems may also have their own separate building; or they may be located outdoors in weather-tight and sound-attenuated enclosures or ISO style containers. In any of these locations, total system capacity may be limited by space considerations. In general, power generation systems utilizing digital master controls have the smallest footprint in relation to power output.

Managing on-site power use

Increasingly, large businesses are opting for on-site power systems which, in addition to serving as standby power, also serve to control overall energy costs. These power systems are set up to run in parallel with the local utility in order to take advantage of utility incentive programs. Utility "interruptible" programs give businesses a credit on their electric bill for allowing the utility to determine when the standby power system should be operated to provide all or part of the business' load. In this way, the utility benefits from being able to shed part of its load during times of peak demand and reduce strain on its generation and transmission system. In turn, the business benefits from lower electric rates.

Many of these foregoing factors can be determined long before a business owner sits down with a consulting engineer, electrical contractor or generator manufacturer to discuss detailed planning for a standby power system. Before the discussion turns to technical matters and "how much hardware," this business-model thinking will have helped you consider the economic risk associated with a utility outage, and your desired level of response to that risk.

For additional technical support, please contact your local Cummins Power Generation distributor. To locate your distributor, visit www.cumminspower.com.

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