ELECTRIC POWER SYSTEMS AND RELIABILITY OPTIONS

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In today's competitive market, facilities typically require operation at a greater reliability than they have ever before. Most facilities are designed based on the economic criteria established for the particular use of the facility.

A variety of basic power distribution arrangements are available for facilities. Selection of the best system or combination of systems will depend on the needs of the facility and it's use. In general, system costs increase with system reliability.

Often the facility's electrical distribution and emergency backup systems are initially engineered and constructed for the type of use and reliability anticipated with the original facility design. However, over time, the use of the facility and production can and often change. As these changes occur, the electrical system is modified or expanded.

The capital costs associated with the electric system improvements are usually included in the overall project estimates. If the electrical system improvements are to increase system reliability, then the cost of the electrical project should be viewed and evaluated separate from any other project costs.

By treating the electrical distribution system as a separate infrastructure that is planned and expanded independently of other projects, this will allow the system to evolve over a period of time, using sound engineering practices.

No two electrical distribution systems are exactly alike. Individual facility requirements should be analyzed with the system designed and planned accordingly. All facilities should develop an approach to the power system planning that includes the following basic considerations:

1. Safety
2. Reliability
3. Flexibility
4. Maintainability
5. Efficiency

While each of these considerations is important, particularly safety, this article will focus on reliability.

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Reliability = Profitability

Most decisions in facility operations are based on economic criteria, tied to market expectations. Evaluation of the electrical infrastructure is often included with the economic analysis of production from the facility. Many facilities do not produce an item, which can lead to decisions that cause the reliability of an electric power system to suffer. If reliability is a key focus of the power system, the electrical budget should not fall victim to cost cutting without an analysis of the probable impact to reliability.

Budget cutting measures that compromise reliability include:

1. Hiring an electrical contractor to act as an engineer to design and install the power system and related components.
2. Hiring less experienced installation contractors to save costs.
3. Selecting less expensive and inferior electrical equipment and construction materials.
4. Limiting maintenance and eliminating redundancy.

Costs associated with unplanned failures include: lost opportunity cost from production, electric and process equipment damage, penalty for environmental violations and safety liability. Facility downtime will include time to restore electrical service and restart the facility. Total costs of a failure from a power outage lasting fractions of a second can result in substantial economic losses.

Electrical Power system configuration affects the time required to restore power following a failure event. It also influences the duration of power interruption to the load for planned maintenance of equipment. Configurations commonly used in facility electric distribution systems include; simple radial, primary selective and secondary selective. Others are available and depend more on size of load and voltage level available.

Simple Radial Distribution System

In this system a single incoming power service is received and distributes power to the facility. There is no duplication of equipment and very little spare capacity is typically included. Failure of any one component in the series path between the source and the load will result in a power interruption to the load. The system investment is usually the lowest of all arrangements. See Figure 1 for a representation of a simple radial distribution system.

Primary Selective Distribution System

Figure 2 is a representative of a primary selective system. The load is fed by two different power sources. Source 1 normally feeds the load and Source 2 is available for emergency use. It gets its name as a “primary” arrangement because two or more transformer primary (high voltage) feeders are provided.

When one primary circuit is out of service, the remaining primary circuit has sufficient capacity to carry the total load of the facility. The outage time is reduced and is a function of isolated, the failed component and perform switching between primary sources.

Secondary Selective Distribution System

A secondary selective distribution arrangement has become a very popular system for facilities requiring a very reliable power source. Figure 3 is a diagram representing this system arrangement. Half the load is connected to one incoming source and the other half is connected to a second power source. The systems are tied together through a normally open tiebreaker, with both power sources energized. The electrical equipment is designed to accommodate 100% of the facility load. When a failure occurs, after it is isolated, the main circuit breaker to the faulted source is opened and the tiebreaker closed allowing the completed facility to be served from a single source until the problem is corrected.

Understanding how planned and unplanned electrical outages will affect the facility is necessary to define reliability requirements. Factors that contribute to the severity of a shutdown and increase average facility restart time include the time required to perform the following:

1. Remove defective products.
2. Reheat or repressurize the system.
3. Repair equipment damaged.

Planned electrical outages are required to perform preventative maintenance of electrical equipment. Redundancy provides the flexibility to de-energize portions of the electrical system to perform maintenance with minimal load interruption. The value and cost of the redundancy-compared with shutting down the load for maintenance must be reviewed and considered.

To support their power needs, power critical businesses typically have one or more feeds coming from the utility into their facility. Some form of standby generation and a transfer switch with transfer scheme between the utility and generator. Because the generator typically cannot startup instantly when needed, other forms of mitigation equipment such as UPS or battery systems are used between transfer from the normal source to the generator source while allowing the generator to start, come to speed and handle the load. These are connected by a variety of electrical distribution equipment including transformers, circuit breakers, conduit cable etc. All of this equipment ultimately serves power to the many types of sensitive loads such as data centers, communication switches or process machinery.

RELIABILITY

Electrical distribution system reliability is often measured with the number of nines (9's) a facility requires to ensure continued operation without interruption. In the past to support an unplanned power failure a reliable design was considered and planned to achieve three (3) nines of reliability or 99.9% reliable. Engineer's designed these reliable power distribution systems using stand-by generators and uninterruptible battery power supplies (UPS's) with the primary power being supplied from the utility company. The utility was considered a more reliable connection than is viewed and operated today.

Three nines of reliability translates into almost nine hours of power outage in a year. This would be considered completely inadequate for today's dot coms, financial institutions and tel-co facilities. The standard is now six (6) nines of reliability or 99.9999%, which allows for just 32 seconds of outage exposure per year. This demands technology and equipment with the highest of proven reliable use with redundant systems and connections.

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Full-scale power failures and/or rolling blackouts have become more frequent as demand growth has surpassed supply growth. In response, some companies opt for onsite generation as the primary source of power supply to ensure their power reliability. This on site generation is known as distributed power and is modular electric generation or energy storage located at or near the point of use. It ensures continued electricity during system outages, maintaining electric reliability and can allow customers to save money by switching to distributed generation during high cost peak periods or take advantage of peak shaving incentives offered by utility companies.

There are many types of distributed generation technology available, however the systems that have been receiving more use has been micro turbines, diesel generators and fuel cells. Each of these sources can either be connected to the electric utility for parallel operation or operate independently for stand-by operation. The initial cost of design and installation can be expensive, however many distributed generations customers believe the mission critical nature of their electricity needs justifies the high initial cost. The silver lining of the deregulation nightmare is that all of these new technologies are getting more attention and should become more cost effective in the near future.

A Few Ways Distributed Generation Can Improve Reliability

- On-site generation for either backup and/or base load.
- Energy/Utility Company can purchase electricity during peak periods.
- Assets for sale to the Utility Grid.
- Utility provision of premium power.
- Locate distributed generation to circumvent transmission and distribution constraints.
- Properly installed and operated distributed generation can increase both end-user and grid reliability.

To achieve the high level of power reliability required, all of this equipment must be designed, managed and coordinated with a system.