

Reliable power could have prevented Fukushima disaster

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Recently, we witnessed the disastrous earthquake and tsunami that has devastated the Japanese economy. The loss of life, property, and infrastructure was on such a large scale that it was incomprehensible. Yet Japan was more prepared for a large earthquake than any other country.

The blow that was dealt to its power generation and distribution system has the potential to delay the country's economic recovery more than any other loss of infrastructure. Prior to the disaster, Japan's decision to reduce its oil dependency by implementing nuclear power generation was admired throughout the world. Now the name Fukushima may setback the worldwide nuclear power industry for decades as witnessed by Germany's decision to shut down all of its nuclear power plants over the next 11 years. The cleanup of the Fukushima facility alone could end up costing Japan hundreds of billions of dollars and take decades.

Through hindsight, we are beginning to realize the chain reaction of events that could have been prevented through a few design changes in the plant. The disaster's root cause was the tsunami since the plant was designed to survive the earthquake. Per recent news reports on what appears to be the plant's root design flaws — had they been addressed prior to the tsunami — could have prevented most of the ensuing disaster.

Simply put, the plant did not have a reliable source of power. First, the backup power generators were rendered useless because they were installed at or below ground level and were flooded due to the tsunami. Next, the tsunami damaged the power transmission lines feeding the plant, as it appears that they were above ground. Had the backup generators been installed above ground and located several miles inland, on higher ground, their operation would have been more assured.

Additionally, if all of the backup power transmission lines had been installed in

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vaults deep underground, there would have been a good chance the plant would not have lost critical power to the reactor, storage pond cooling, and circulation pumps. Barring any other unknown conditions, the nuclear-related disasters that ensued might have been lessened or even averted. The total loss of power left the plant staff with a very limited number of options which they executed with selfless determination and valor.

Fukushima is not unique. The same set of conditions was true in New Orleans when it was hit by hurricane Katrina. The main hospital suffered a loss of both utility and backup generator power for several weeks. The hospital survived the main force of the hurricane, only to have the basement where the backup power generator was located flooded by the tidal surge that followed.

Since that lesson, FEMA has issued new backup power guidelines for key installations like hospitals, police, and fire departments. FEMA recommends power backup generators to be installed on the facility's roof. They also recommend a third means of supplying power to these facilities. This would consist of an external building power interface connector that would facilitate connecting a drive-up or fly-in, large generator to provide power to the facility as a last resort.

Industrial productivity depends on a reliable, clean source of AC power. The fact is that natural or manmade disasters can happen anywhere and at any time. Fortunately, they are rarely of the magnitude of those in Japan or New Orleans. Unfortunately, power-related problems are very diverse in nature and cost industrial companies billions of dollars yearly through lost productivity, scrap, and equipment damage.

For example, one study reports that a large company that experiences a computer outage lasting for more than 10 days will never fully recover financially and that 50 percent of companies suffering such a predicament will be out of business within 5 years.[1] A ten-day outage represents a rare event as most power-related problems in the domestic industrial environment are very short in duration but have a higher occurrence rate.

Their cost to a company depends on the nature and severity of the power event, the critical nature of the process that would be affected, the susceptibility of key equipment to the power event, and the nature of any resulting equipment damage. The good news is, barring a local disaster, the majority of power-related problems can be mitigated by conducting a facility-wide power audit.

The audit should start at the building's service entrance electrical panel and its related ground rod. This panel can be the doorway to some of the most serious and equipment-damaging power problems. Voltages consisting of thousands of volts can be inadvertently fed from the utility side (high side) of the facility's power transformer to its low voltage secondary side supplying power to the entrance panel, often referred to as "high siding".

High siding can result from power lines becoming crossed or a utility power transformer becoming shorted as a result of storm activity, traffic accidents, a

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defective transformer, and natural disasters. Without high-level Transient Voltage Surge Suppression (TVSS) protection installed inside the entrance service panel, a high side condition has the potential of damaging most of the equipment and lighting operating in the facility.

TVSS will also help suppress high voltage transients caused from lightning strikes. In areas subject to lightning activity, an NFPA 780 compliant lightning rod system should be installed in combination with a low impedance earth ground rod system. The ground rod must be located near the entrance service panel since it reduce the risk of lightning damage and enhance the TVSS protection.

Excessive harmonics in a facility's power distribution system is a major concern. Due to the ever increasing amount of computer equipment powered by switch-mode power supplies, variable speed drive motor controllers and other non-linear loads, the level of harmonics generated on the facility's power system can become too high. The level of harmonics should be measured and if too high, steps must be taken to reduce the level.

Harmonic levels should be in compliance with IEEE Standard 519-1992. Should harmonic levels exceed the maximum specified levels, excessive current can cause to flow through the building's wiring, increasing the potential of overheating the wiring, possibly resulting in an electrical fire. Harmonics can cause voltage sags, which increases the current demand of equipment operating in the building. The increase in the equipment's operating current will result in more heat being generated inside the equipment and shortening its service life.

Telecommunications and data cabling are often run close to power cables. If harmonics are above normal tolerances, high frequency harmonics can be induced into phone lines and data cabling. The end result is noisy phone lines and unexplained data lose or data corruption and computer hangs.

Harmonic problems can be treated in three ways: elimination, filtering and cancellation. A major source of harmonics is computer-based, specifically, computer and network equipment. By adding an online topology UPS or active power conditioner with input power factor correction (PFC) ahead of the equipment, harmonics are eliminated and the overall power factor is increased. Both devices provide a tightly regulated output voltage irrespective of the input voltage level, reducing the equipment's internal temperature. The UPS also provides necessary backup power when utility power is lost, prior to backup generators coming online.

As the number and type of loads being connected to the facility's power system is dynamic, harmonic filtering can be difficult to implement. Filtering is best accomplished on a power system having a fixed load as the filter is effective over a limited harmonic frequency range. Should large three-phase loads be the major source of harmonics, a harmonic cancelling transformer may be installed as a solution. This type of transformer has patented built-in electromagnetics technology designed to remove high neutral current and the most harmful harmonics from the 3rd through 21st.

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In the industrial environment, large motors, variable speed drives, pumps, robotic equipment, heaters, ovens and any other equipment having large instantaneous current demands often generate power problems with other power sensitive CPU-based equipment operating within the same facility. During the startup of the offending equipment, its initial high current demand can cause voltage sags and transients on other power circuits in the same facility.

Extreme voltage sags and high voltage transients often cause microprocessor based PLCs, laboratory equipment, computers and data networks to operate unreliably resulting in costly down time. To minimize these problems, wherever possible the sensitive equipment should be powered from a dedicated circuit. Again, installing an active power conditioner or online UPS ahead of the sensitive equipment will eliminate both problems and assure reliable operation.

In hindsight, a lack of foresight becomes painfully obvious and is often costly. In all industries, critical processes rely on key equipment that is only as reliable as its power source. Taking the necessary steps upfront to assure a high level of power quality throughout the industrial facility will minimize lost productivity and profits and in some cases prevent a disaster.

{1} Jon Toiga, Disaster Recovery Planning: Managing Risk and Catastrophe in Information Systems, (Yourdon Press, 1989).

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