Power Quality and Power Factor Correction: A New Focus for Energy Efficiency

By Leon Wasser MBA, P.Eng.

Historically, relatively few facility managers, even those in the health care sector, have given too much thought to the quality of the power in their buildings. Instead, most managers have focused their attention on two critically important factors, ensuring basic availability through system design supported by UPS protection for critical equipment and minimizing energy costs through a variety of energy conservation building retrofits such as lighting replacement programs. While these are very important, many facility managers are now focusing their attention on additional aspects of their electrical supply system, especially the quality of the power in their facilities.

ELECTRICAL UTILITIES AND POWER QUALITY

Unlike most power consumers, the electrical utility sector, both producers and local distributors are highly aware of and sensitive to power quality and power factor issues. Power suppliers work hard to ensure that the power they transmit to consumers, including large institutional clients like hospitals, is high-quality and has a high-power factor. They know that the efficiency of the power grid that they are responsible is highly dependent on their ability to produce and maintain the high-quality power network that we enjoy across Canada.

CONTRIBUTORS TO POWER DEGRADATION

As noted, the power that health care facilities receive at the utility electrical meter is generally in very good condition. The reality is the vast majority of power quality problems are caused by factors internal to a building, almost always as an unintended and almost unavoidable consequence of the power loads in the building. Different forms of power consumption result in a variety of effects on the power that is circulated in the building, and different types of loading result in a variety of forms of degradation of the institution's power supply. Many building engineers are aware that loads such as florescent lighting and the cathode ray tubes used for computers and many other devices generate harmonics, or secondary waves within the main power wave. These secondary waves, operating at frequencies that are multiples of the standard 60 Hz cycle of the primary wave, create interferences that can detrimentally affect motors and other equipment. In addition, inductive loads from equipment such as motors and compressors such as the ones used in HVAC systems, elevators and other mechanic devices normally create other types of electrical wave disturbances that reduce the electrical system's power factor. Variable speed drives installed on motors in order to conserve energy result in further disturbances of the normal electrical wave pattern. Resistive load devices like incandescent lighting and direct electric heating do not result in these types of wave disturbances, but as everyone knows, these technologies are often inefficient from an energy consumption perspective, and as a result are becoming increasingly rare in institutional settings including health care facilities. It may seem ironic that the more institutions invest in their facilities to conserve energy through innovative energy efficient lighting, variable speed drives on motors and increased local smart controls on HVAC systems, the more the power is degraded resulting in power quality and power factor reduction problems.

One important result of the various forms of power degradation is a reduction in the power factor of the building's power system as measured at the entry point of the power supply to the building.

HOSPITALS AS ELECTRICAL CONSUMERS

Hospitals and other health care facilities are by their very nature among the most energy intensive buildings found anywhere in their cities. The vast array of diagnostic, monitoring and therapeutic equipment characteristic of health care facilities ensure that these facilities would be at the upper echelon of building power consumers. In addition, the need to maintain exceedingly high HVAC standards, through frequent air changes, humidity control, filtration and other environmental factors are major factors in elevating hospital power costs. Hospitals and other health care facilities also require high-power factor and power quality to address potentially narrow tolerances for the optimal performance of all types of equipment. Historically, many institutions have protected themselves with capacitor banks to ensure high-power factor in critical areas and have installed uninterrupted power supplies (UPC) to ensure that an ideal power is available to the device at all times. Today, there are more robust and dynamic systems which perform these tasks and obviate many other power quality problems.

FORMS OF POWER DEGRADATION

As noted above, various loadings can generate a variety of forms of power degradation. Because power is a wave form, many of these problems are cumulative and, therefore, can generate unexpected or even unpredictable results. One simple problem that can be associated with these types of wave abnormalities is that motors and other inductive loads do not run at their maximum efficiently. As a result, equipment heats up as it operates, and possibly even overheat beyond the device's design tolerances, causing premature wear and ultimately early breakdown at major costs. This inefficiency also means that the devices consume excess power both to operate and through unintended heat losses. In addition, many pieces of equipment are controlled today by small micro-processors. These control devices are vital to ensure the smooth operation of the overall system, but these small electronic devices can be "tripped" by relatively small electrical surges or interruptions, which can cause them to reset or even trip off, depending on the default programming of the device. Systems are varied as banks of elevators and local environmental controls can be seriously affected by power fluctuations.

POWER FACTOR AND POWER COSTS

One important result of the various forms of power degradation is a reduction in the power factor of the building's power system as measured at the entry point of the power supply to the building. Often the building's power factor can be reduced from near unity, or 100 per cent to as low as 75 per cent, depending on the loading of the building. This is quite important since institutions typically pay at least a portion of their power bill based on 100 per cent power factor. There is considerable variation in how utilities charge for power in different Canadian jurisdictions. Electrical rates charged to larger customers such as health care facilities and hospitals are typically a combination of consumption expressed in kilowatt hours and peak demand expressed in kilowatts, often in combination with some "transmission" or administrative charges. Despite locale variations, in almost all cases, institutions land up paying for power that simply isn't available to them.

SOLUTIONS TO THE PROBLEM

Historically, when facility managers have become concerned with low power factor, they have addressed the problem with either banks of capacitors located in proximity to large devices. Alternatively, the power problems for a whole building could be partially remediated by larger capacitor banks located in the main electrical room. Today, more sophisticated technology is available to address both low power factor and a variety of other power quality issues identified above. Computer controlled comprehensive systems deal with the multiplicity of power problems that modern device laden buildings generate. In all cases, it is critical to start with a complete diagnostic assessment of a building performed in each primary electrical room. This test provides highly detailed results about the building's overall or local power profile and power factor. Just as it would make no sense to proceed with a major operation without proper diagnostic tests, the availability of new computerized diagnostic tools which give a far more detailed view of a building's power system than historically has been available using simple volt meters and amp meters.

OTHER POWER AND ENERGY EFFICIENCY ISSUES

Power conditioning applied at individual buildings is being recognized by governments and utility companies as well as by building managers as a highly effective power demand reduction technology. Because power demand and consumption is tied to the types of power consumption activities inside the building, it is understood that power conditioning is a highly effective local conservation measure. For this reason, some jurisdictions and utilities have already launched specific educational and incentive programs to increase awareness of both power quality and power factor issues. While a power conditioning system can be designed and installed independent of any building system since it is connected to the building's primary supply in the building's electrical room or rooms, work is advancing with building control companies to incorporate this technology into a building's energy system. Power conditioning systems are always designed to run in parallel with the primary electrical supply so that only a small proportion of the building's power runs through the power conditioning equipment in order to balance out or filter the power supply.

As noted above, power quality problems can result in equipment failures due to tripping out of the solid state controls which operate the equipment. One of our customers had the unintended benefit of completely eliminating the regular tripping out of a number of elevators due to locale power surges as subways entered or left a nearby subway station. The elimination of several outages a week was appreciated by the hospital's management, patients and the elevator service company. Another residential institutional client had unexpected power savings when he discovered that he was operating at a significantly lower power factor than expected due to far greater growth in personal computer usage throughout the building. As in many cases, management had focused on the total power demand for the building rather than how power is used in the building, and how that usage evolves over time. Even with the best diagnostics, there is always some degree of uncertainty to how well a building will adjust to the power conditioning measures that are introduced. While typically power consumption can be reduced by 6 to 8 per cent through power conditioning, in one case one institutional client achieved savings of over 10 per cent because the power supply was found to have so many anomalies and problems that turned out to be easily corrected. When a building has major power problems the typical system payback of 2 1/2 can be reduced considerably.

Although the degradation of a building's power might be invisible to the human eye, the effects on building systems and operating costs are hardly invisible. The presence of phases imbalances, harmonics, micro-surges, reclosures and other power anomalies result in under-performance of building equipment to run inefficiently, premature wearing out and breakdown motors and other equipment components and over-consumption of power. ■

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