Powering a Hospital – it's not just plug and play

An overview of the requirements, application and theory of providing power supplies to major healthcare facilities.

Think about it for a minute. If you were planning a modern hospital, how many electrical sockets would you need around a typical hospital bed? What about an A&E bed? Or a High Dependency Care unit? Do any of those sockets need an uninterruptible power supply? Do any of them need non-standard voltages?

So, you've spent a minute looking at the beds where patients recover from or wait for treatments. What about the places where treatment is given? Surgical theaters, anesthesia and recovery rooms, Radiography and Radiology departments, dental surgeries - the list is endless. And on top of that you also have to provide 24/7 environmental systems: heating, ventilation and air-conditioning (HVAC), lighting, entry control, security and site services such as parking management, CCTV, street lighting, catering and that pretty fountain outside the main entrance. Once you've figured out all that, how do you actually plug it into the electricity grid without blacking out half the surrounding neighborhood?

The Problem

Healthcare facilities, particularly major hospitals, have numerous switch-mode power supplies and inherently high inductive electrical loads.

Networked IT equipment and on-site data centers create significant 'harmonics' in power circuits. Variable speed drives in HVAC systems add further harmonics, and diagnostic equipment (for example, Magnetic Resonance Imaging scanners) can create large transient currents causing stress on the electrical infrastructure. These harmonics cause a poor 'power-factor' which unless corrected, requires larger transformers and cables, and leads to high-energy cost. This can also lead to regulatory 'grid code' compliance issues when connecting to electricity supplies, i.e., break the rules protecting public supplies.

Fortunately, Enspec has the technology you need to solve these issues. So, let's explore some of them and some possible solutions.

Sizing the situation

A typical US hospital uses, each year, about 2.9 kilowatt-hours (kWh) of electricity and 9625 Btu of natural gas per square meter. Lighting, space heating, and water heating represent about 65% of total energy use. But that doesn't make those uses the most important – unless you're looking for energy savings.

This is because hospital environments need to provide at least three sources of electrical power to protect patients.

i) Grid connectivity
ii) Uninterruptible power (battery) storage
iii) Back-up generators

Clearly, on site power switching between these sources is complicated. Should the grid connection fail, you need instant switching for the vital life-dependent circuits and many of the delicate instruments on site.

However, you also need to protect the grid from switching noise created on-site by energizing high-powered equipment. Compliance with grid codes imposed by the Distribution Network Operator therefore requires extensive power management at the point of connection.

In many instances, we would recommend that grid connectivity is managed through Point-on-Wave switching technology, combined with an extensive Harmonic Filter system. Not only will this help manage in-rush and out-rush currents when energizing transformers, it will also ensure that on-site equipment and systems don't interfere with each other by creating large harmonic distortions.

A correctly sized harmonic filter can also help with Power Factor (reducing the current drawn from the grid). This is important to ensure longevity and reliability of both the equipment itself and the power circuitry that supplies it.

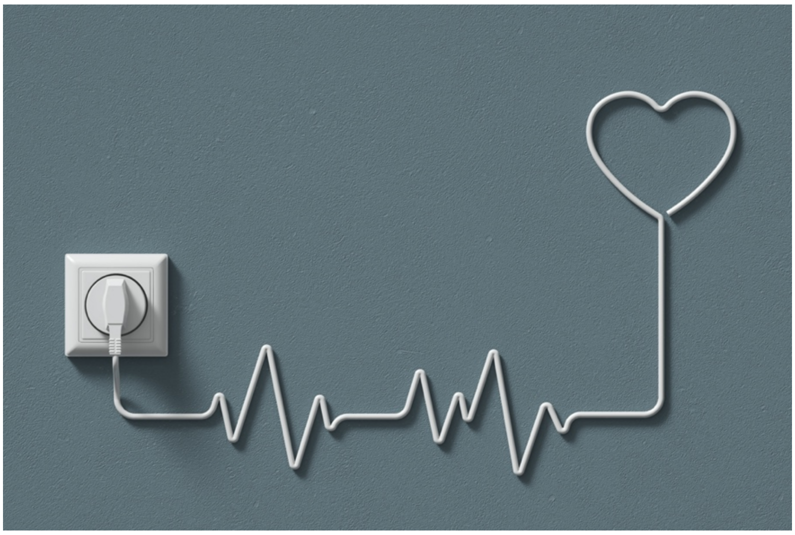
What about the regulations?

It's fair to say that power requirements of a typical hospital are huge and complex. Not only do they have to meet the same grid compliance codes as any other large power consumer, but they have to meet a range of therapeutic standards to ensure continuity of patient care and safe operation of delicate instruments and systems – some of which have huge power consumption requirements in their own right.

The exact requirements vary from hospital to hospital, and the physical layout of a hospital varies greatly. In the UK, many hospitals have evolved and expanded over the years. Most large regional hospitals, such as the Leeds General Infirmary are in busy city centers, often with a main building and specialist units scattered nearby – or even across the city. In other countries, for example Hamburg

EPPENDORF hospital in Germany, specialist hospitals may be grouped together in a campus or 'region' of the city, while in the USA many hospitals are more focused on a single purpose-built building, such as UPMC Children's Hospital of Pittsburgh.

As a general principle, hospital electrical design regulations are all about resilience and continued operability in ever degrading conditions (such as a fire on site or power outage). Regulations therefore point towards a three-source electrical supply system.



UK hospitals (for example) are governed by the Health Technical Memorandum 06-01: electrical services supply and distribution. This 183-page document doesn't offer a model solution. However, it does give a broad basis for designing within the patient environment and UK specific requirements.

Section 6 - Power quality states that:

i) The quality of the electrical supply is the responsibility of the Distribution Network Operator, which will comply with the requirements of the Electricity Safety, Quality and Continuity Regulations (ESQCR).

However, the use of electrical energy within healthcare premises can affect the quality of the internal distribution in terms of power factor and harmonics. The normal supply frequency is 50 Hz with a tolerance of ±1%. The nature of the electrical equipment used throughout the site can create secondary frequencies that cause significant disturbances to the internal distribution and the supply. The majority of the secondary frequencies, known as harmonics, are generated from short surge currents and transient currents arising from non-linear electrical loads such as switch-mode power supplies, rotating machinery and variable speed drives found in a wide range of electrical and electronic equipment.

ii) The designer should make suitable provision for power-factor/harmonic issues to maintain regulatory compliance, for example:

a. Healthcare premises have numerous switch-mode power supplies and inherently high inductive electrical loads and, unless corrected, the power factor will be poor, requiring large transformers, cables and high-energy cost.

b. Where large quantities of IT equipment are present (for example, data centers and human resources departments), significant harmonics may be generated. These result in large peak currents and high crest factors.

c. Where variable speed drives are present, significant odd harmonics in the order of 5th, 7th, 9th, etc. may be generated.

d. Where diagnostic equipment is installed (for example, MRI and catheter laboratories), large transient currents are introduced which will impose stresses on the electrical infrastructure.

iii) Consideration should be given to fixed monitoring and reporting of power quality and harmonics.

European practice is broadly similar, with country specific requirements. And the engineering sections of the American Institute of Architects guidelines for design and construction of healthcare facilities provide useful information on a more global basis.

US hospitals, by code, are required to have an essential electrical system and it must be divided into three branches. Over 150kva it must also have a minimum of three automatic transfer switches (ATS).

The branches are:

i) Life safety is required to feed exit signs; emergency lighting in hallways, stairwells, points of egress; evacuation speakers; fire alarms and medical gas alarming systems, automatic doors used in evacuation, elevator cab lights and lighting/outlets at generator and ATS locations... basically what is required to contain and evacuate occupants from a burning building.

ii) Critical feeds patient room lighting, patient bed outlets, surgical theaters/operating rooms, blood and bone banks, pharmacy dispensing machines, task illumination... basically anything essential to patient care and life support.

iii) Equipment feeds HVAC equipment, elevators, pumps, medical gas equipment... anything that is needed in the continuation of basic medical care but not immediately vital.

UPS or a tertiary system is not mandated by code and only found in some newer hospitals seen when feeding IT equipment, MRIs, etc.

The US code also requires that critical care areas have a certain percentage of receptacles on normal power (typically 1/3 the outlets at a patient bed location, OR, ICU, etc) and that some level of lighting is connected to the normal branch. The idea is that if the critical branch fails during the presence of utility power, the area will not be blacked out. If more than one critical ATS exists, then a critical care area can be fed from both branches and normal power is not required.

So how can Enspec help you?

Enspec can help with your Power Factor Correction (PFC), Harmonic filtration and Reactive Power compensation requirements. In other words, we can help you significantly reduce electricity costs, improve system availability and reduce maintenance and renewal costs.

Enspec is an established and internationally successful electrical engineering company that provides a one-stop-shop for solving some of the biggest and most complex connectivity and grid compliance requirements around.

We provide power system studies to deliver modelling and analysis to check for compliance on both new and expanding sites. And we design, manufacture and supply power factor correction, harmonic filtration, and reactive compensation solutions that reduce energy costs and improve service delivery levels.

If you have any of the issues we've discussed, or any other electrical power supply problems, please get in touch. We would be very happy to offer advice, develop a full system analysis, produce a solution design, or manufacture and commission your bespoke harmonic filter system.

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