HealthManagement
Promoting Management and Leadership

Volume 16, Issue 1/2014 - Medtch

Monitoring Equipment to Reduce Energy Consumption in Hospitals:

Ongoing Research by the Low Energy Hospital Project

Authors:

Tarald Rohde

cand.oecon

SINTEF

Robert Martinez

Norconsult

Tarald.Rohde@sintef.no

The Low Energy Hospital research project started in 2010 and will end in April 2014. It is funded by the Norwegian Research Council and public and private sector partners. The project goal is to describe the ways in which new Norwegian hospitals could be designed for half the energy consumption compared to the situation in 2010. There are several ongoing Norwegian research projects studying how to make buildings more energy-effective. The Low Energy Hospital project concentrates on hospitals; what are the specific characteristics of hospitals that designers should take into account when aiming for low energy consumption?

One of the many topics studied during the project is the role of user activity and the use of hospital equipment. It has proven to be a difficult task to get an overview of all equipment in a hospital and how this equipment is used. This effort will hopefully fill the gaps in our understanding of how users and their equipment affect the energy balance in hospitals, and make it possible to suggest ways in which designers and equipment suppliers can help optimise energy performance, while maintaining quality in the delivery of health services.

Why Study Equipment Energy Consumption?

Hospital designers and engineers are typically not aware of the energy demands and usage patterns related to most hospital equipment, with the exception of only a few large imaging units. The majority of hospital-specific equipment is the domain of medical professionals, not engineers or architects. In large and complex hospitals, this lack of awareness leads to problems with sizing the electrical, heating and cooling needs, and missed opportunities for storing and recycling of waste heat. A literature survey in the first phase of the research project showed a large variation in assumptions about energy and power to lighting and equipment, and that many engineers were using standard values similar to other building types.

Analysis of energy consumption data from the country's newest, large university teaching hospital showed that electricity accounted for almost 40% of the whole building energy use. In this case, it was 163 kWh/m2. Splitting up the electrical energy in one of the studied hospitals revealed that 35% of this electrical energy went to lighting, 20% went to pumps and fans, and the remainder 45% to all equipment, including 8% exclusively to power ICT equipment in the large server-rooms. Waste heat from the use of electrical energy must be removed, leading to a large secondary consumption of cooling energy, even in the cold Norwegian climate.

We found relatively few published articles dealing with electrical energy to hospital equipment. Some of our many questions were: how much equipment is present in a hospital, how energyintensive is it? Is the equipment being used in an energy-efficient way, and to what extent has the equipment been designed to be used in this way?

Data Collection and Analysis Methods

Questionnaires were distributed to key personnel at the hospitals involved in the study, and their response was very valuable to the project. The main source of energy consumption data came from Akershus university hospital (Ahus) on the outskirts of Oslo. Detailed room-level equipment inventory and usage pattern data came from the country's 500 bed national hospital (Rikshospitalet), now part of Oslo University hospital.

Ideally, we would have preferred to have had both energy data and the equipment details from the same hospital but the older Rikshospitalet did not have detailed energy metering. To compensate and correct for this, we measured actual daytime electrical power levels in many of the treatment areas at Rikshospitalet. Power levels to that hospital's ICT rooms were not available for measurement.

Analysis started with a database of all purchased medical-technical equipment (MTE), autoclaves/decontaminators/ventilated benches (BE, so-called 'building equipment'), and desktop ICT equipment. A total of 18 700 electrical medical technical equipment (MTE) units were registered. ICT desktop and portable units, including screens, were 11 400. In the category of building equipment (BE) there were 46 biological safety cabinets, 85 decontaminators and 17 autoclaves.

This database showed the rooms where each item was located, and the room areas were also available. Excluded from the analysis due to lack of data were 'household equipment' like refrigerators and dishwashers. Ultra freezers are also not included. For each equipment type, the average power level in continuous use and in standby (where available) was determined based on the supplier's information. This analysis provided a picture of installed electrical equipment power, but we lacked usage data to calculate detailed energy consumption. Due to the size and complexity of a large university hospital, it was decided to focus our efforts on the following areas:

- The radiology department;
- Operation 1 with 8 surgical units;
- The ICU for the thorax department, 11 beds including one isolation unit;
- One bed ward, the heart medicine department;
- The laboratory of biomedical chemistry;
- The surgical outpatient and day treatment department.

Questionnaire answers from these departments helped to determine the actual inventory of medical equipment, how it is used and when it is used.

We also measured electrical power to each of these departments during a weekday morning. For the laboratory of biomedical chemistry we registered the use during a week, but these results have not yet been analysed.

Preliminary Results from Activity Study

The study is not completed; this article describes what we have discovered so far and what answers we hope to have at the end of the day, but is not yet fully analysed. The results relating to equipment usage patterns apply to Rikshospitalet. Results showed a large variation in the percentage of MTE inventory that were in use at some point during a typical week and weekend. This figure was almost 100% for radiology, operation and the bed ward, but was only 50% for the outpatient unit and for the biomedical laboratory. The database was, for some of the equipment, outdated, so therefore our analysis included only equipment that was actively used in departmental procedures. On a normal weekday, 76% of the equipment at the biomedical laboratory was in use. The percentage for radiology was 52%, for the outpatient clinic it was 25% and for the bed wards only 2%. However, when an equipment item in the bed wards was in fact used, this was around the clock.

Only a small percentage (from 0 to 7%) of the MTE had functionality for automatic power- down after some time of non-use and such equipment was only found in the radiology department. In the biomedical laboratory about 15% of equipment had a standby function; this shows that by far the largest portion of the MTE in a hospital must be turned off manually by the staff.

Testing by one of the partners, a medical equipment supplier themselves, of radiology imaging equipment, showed that peak power use was of short duration, and that standby levels were high but varied a great deal. For MRI it was 40% of peak effect, it was 25% for PET/CT and 10- 15% for CT and angiography.

Another interesting result is that close to 40% of the MTE in the biomedical laboratory are said to require full power24 hours 7 days a week, with long periods when no personnel or patients are present. Some equipment in radiology may be turned off on weekends, but due to long startup time the users choose to keep the equipment powered up throughout the week. Of the MTE not running continuously (24/7) in the biomedical laboratory close to 40% is running only in daytime, while 10% is running evenings and 10% is running during the night.

With the exception of the laboratory area, the results show a general pattern of very low activity during the nights and weekends. The activity in the weekends is very low, only 2-3% usage in daytime. The activity profile for the radiology department showed that 94% of the laboratory area is active during daytime, while 20-25% is in use during evenings and nights. In the weekends close to 40% is active in daytime, 25% in the evening and almost no activity during the night. The bed wards are either in full use, or zero usage, while the outpatient clinic starts about 9 AM and closes down around 3 PM. The ICU runs continuously. Around 70% of the eight surgeries are in activity day and evenings while 20% are active during the night.

Preliminary Results from Power Measurement

Power measurements from a weekday for a time period around 10AM showed that, in these areas, lighting consumes only 20% of the momentary power to all equipment, excluding pumps and fans. When large imaging equipment is excluded, then the percentage for lighting is 30%. Large imaging equipment in this intensive area accounted for 28% of the total power.

Logging of power measurement in the laboratory area over a period of one typical week showed a relatively high baseload of about 70% of the peak load. This high baseload supports the result from the activity questionnaire for this area, with 40% of all equipment at continuous full power. The peak loads occurred only during 6 –hour intervals and only on weekdays. Another interesting observation is that the baseload remained the same throughout the entire weekend, with no change from baseload during the week.

Future Work on Data Collection and Analysis

We are still working on the analysis that connects usage data from the questionnaires with the supplier's power information for each equipment type. There is still more critical data to collect; we hope to collect energy consumption data on biological safety cabinets, autoclaves and decontaminators from the technical division's central building control system (BCS). Other data from the BCS will also allow us to calculate fan and pump electricity consumption by hospital area, thus completing a detailed picture of all electrical consumption by hospital area.

The power measurements have yet to be analysed to show energy intensity per square metre of floor space. This will allow us to generalise about which ICT units use most electrical power. Presentation of final results in form of tables and graphs is also planned.

Recommendations for Hospital Designers and Equipment Suppliers

In an earlier scientific paper of this research programme it was described how changing energy delivery systems to an "on-demand" model could dramatically reduce energy consumption in hospitals. This design applies mainly to ventilation energies (electrical and thermal), but our results suggest that it has theoretical potential also in the area of hospital equipment. Putting this into practice, however, will require suppliers to build in functions which allow their equipment to safely enter a low-power standby mode and to power up quickly when needed. Automatic power-down functions need to be equipmentspecific; for example, if a piece of lab equipment has no sample loaded, then it should go into standby after some minutes. Many of these powersaving functions are now incorporated into other portable IT devices such as smartphones. Most hospital equipment with display screens should at least have functions which turn off the screen after 10-20 minutes without user input. For equipment types such as patient monitors this may not be desirable; in such cases the screen should at least have adaptive backlighting and go into low-light mode.

Suppliers can also reduce overall power consumption by choosing low power CPUs and screens in their more advanced devices. High power equipment such as autoclaves should have automatic monitoring at the plug level, so that technical staff can receive warnings when such equipment has exceeded a predetermined run time and can investigate. All of these strategies can be complemented with staff energy awareness programmes and good routines at the end of shifts for shutting off unnecessary equipment.

Our planned report on equipment and energy consumption will give a profile of the actual usage patterns going on inside a hospital. This will provide new knowledge that can be used by hospital planners, design engineers and those responsible for buying equipment for the hospital. This information will include guidelines for designers and suppliers to help achieve the low energy hospital in the near future.

Published on : Thu, 10 Apr 2014