Conference topic: Environmental health

HOSPILOT - INTELLIGENT ENERGY EFFICIENCY CONTROL IN HOSPITALS

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Introduction

The concern of European society for the well being of its residents and the sustainability of the environment has led to the consciousness that energy savings need to be at the top of the political agenda.

Until recently, the focus of energy reduction has been on schools and offices. Hospitals, however, also use large amounts of energy. Also, conditions of the hospitals in a country have large consequences to the moral of the country population and are strongly perceived as a reflection of well being of the country. Therefore, the HosPilot project has started with the aim to addresses specifically the hospital domain. HosPilot addresses the two main technology areas - Lighting and HVAC (Heating, Ventilation and Air Conditioning), thus covering the largest part of the energy consuming areas. By adding intelligence, ICT (Information and Communication Technology) plays a vital role to achieve significant energy reduction in the complex environment of a hospital. Additionally, introducing the state of the art monitoring solutions will give the knowledge to the medical staff about their energy spending practices and influence their behaviours towards more energy consciousness.

HosPilot will prove the potential of the proposed service by means of three pilots executed in hospitals during normal operation. HosPilot, being a demonstration project, will provide the most advanced combination of lighting, HVAC and corresponding ICT technologies for future replications at European level.

The HosPilot project started in March 2009 and it is intended to last three years, meaning that almost half of the project has been executed. It is possible to roughly divide the project in three phases, each lasting one year. In the first phase the HosPilot methodology was made. In the second phase pilot sites will be built and in the third phase they will be monitored and the methodology will be proven and fine tuned based on the measurement results.

Background

Buildings are responsible for more than 40% of the energy consumption in Europe (see Figure 1.), outnumbering the transport and industry domain. Buildings are also responsible of about one third of the greenhouse gas emissions in Europe.

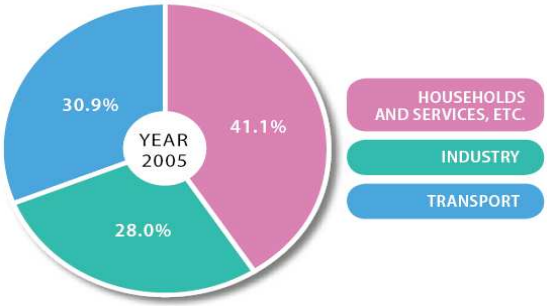

Figure 1. Distribution of the energy consumption in Europe

Hospitals are a small, but steadily growing application domain in construction. Due to the aging of our population, society is becoming more and more dependent on healthcare services. Hospitals consume large amounts of energy in their daily operation due to high level of comfort and air quality required, due to their size, due to the fact they are in operation for 24 hours and due to the use of several energy hungry devices: i.e. lighting, HVAC systems, appliances and health-care equipments.

The operation requirements and behaviour of different type of users is a key factor that affects the energy consumption. The patients need a cosy environment in order to speed up their recovery. For the medical staff conditions should be created in order to perform their tasks in an efficient and optimal way. Visitors should feel welcome, being potential future users. Therefore, the energy balance in hospitals is even worse than in general utility buildings. Heating and lighting account for the largest part of the energy consumption. Furthermore, the use of ICT for improving the energy efficiency is not extended well in the hospital domain.

Energy Efficiency in hospitals

Hospitals buildings are usually large energy consumers. The typical breakdown of energy usage for a hospital at a European northern location is presented in the Figure 2. The thick line through the pie chart tries to separate electricity use from thermal energy use (fuels). The precise split depends upon the type of hospital and the extent and complexity of equipment and services. New hospitals often have proportionately more air conditioning, with its associated chiller plant, and more extensive ventilation systems. [1]

Hospitals often present high potential for energy savings. A simple visit to them is usually the way to detect areas where lighting or other equipment are left on even if the room is unoccupied, where doors or windows are kept opened all day long, or eventually where lighting or HVAC levels could be reduced without compromising comfort.

On the other hand, it is obvious that hospitals have complex energy systems and must comply with well-established

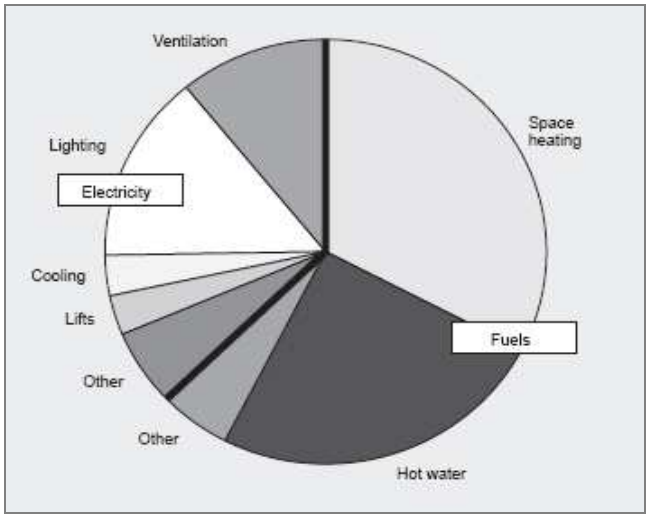

Figure 2. Breakdown of energy usage in a hospital at a European northern location [1]

norms. Any energy efficiency operation needs to be well-thought and prepared, especially taking into account current energy management processes and habits, maintenance procedures, and planned renovations. It is also crucial to assess the needs of all "users", that are often contradictory: for instance, there is general difficulty adapting temperature to personal requirements due to the fact that patients are ill and not moving while the medical staff is healthy and active.

The role of ICT for Energy Efficiency

It is agreed that Information and Communication Technologies (ICTs) will be widely used in a near future to support energy efficiency in buildings. ICTs can be used for energy optimisation during the whole life cycle of buildings.

In the appraisal phase, CAD tools now include modules dedicated to energy flows simulation. These tools therefore support a holistic building representation including energy efficiency. The decisions made in the conception and design stages of new buildings, as well as in renovation stages of existing buildings, influence about 80% of the total life cycle energy consumption.

ICTs also can be used to reduce energy consumptions during the operational stage, where most energy usage is consumed (~80%). Energy-positive buildings are transforming buildings from pure consumers to "prosumers" (producers and consumers). Usually designated as "smart buildings", the REEB [2] project forecasts that the next generation of buildings will be empowered by ICT in the context of the merging "ubiquitous computing" and the "Internet of Things": the generalisation of low-cost sensors, actuators, micro-chips, micro- and nano-embedded systems will allow the building manager to collect, filter and produce more and more information locally, to be further consolidated and managed globally according to business functions and services.

These new generation components also give a valuable accumulation of data, that can be then used by graphical user interfaces targeting different stakeholders: for instance, the medical staff can be sensitized to eco-behaviour through energy awareness, and hospital facility managers get access to accurate and real-time monitoring dashboards.

Two Communications to the Institutions have already been adopted by the European Commission. While the first Communication of May 2008 identified the many ways in which ICT can contribute to energy efficiency gains, the second Communication adopted by the Commission in March 2009 identified concrete actions for the ICT industry, for EU Member State governments, and their regional and local administrations. It highlighted the importance of close working partnerships between the ICT, the energy and the energy-intensive sectors such as construction or transport logistics. [3]

HosPilot concept and service

The HosPilot project will support the decision makers with an ICT based service that will drastically reduce the energy consumption of existing hospitals being refurbished, increasing well being and comfort. The user (hospital) can address one expert to get advice for the complete solution, instead of contacting a number of experts for the various technologies. The user will get one integrated system, instead of separate systems for lighting and HVAC.

The HosPilot project will take into account the full set of requirements and will put its emphasis on the building, its surroundings and its usage. This will be achieved by combining the expert knowledge of construction builders, system suppliers and the requirements of end users, i.e. patients, staff and visitors. Off-the-shelf technologies will be integrated into one system to implement the energy saving service.

The proposed service will tailor, install and tune an ICT based system that will significantly reduce the energy consumption – regarding lighting and HVAC – in a hospital environment. The tailoring will take into account the building, its surroundings and its usage. This service will be disseminated to the open market, so the total service can be exploited as one package by the consortium and/or other organizations, e.g. SMEs, consultancy agencies specialized in energy efficiency, etc.

The service provides the following added value for the hospital:

1. Reduction of the energy consumption, and therefore costs;
2. More flexibility to change the floor plan of the hospital e.g. during renovation;
3. Increase of the comfort level for patients, staff and visitors, thus creating a healthier healing and working environment;
4. Proven technologies integrated in an overall solution, resulting in a low risk and improved quality of the refurbishment;

Analysis of hospitals

In order to create the HosPilot methodology, the first task was to identify the current situation of the hospitals in Europe, in terms of energy management and consumption, based on the main technological areas, Lighting, Heating, Ventilation and Air Conditioning (HVAC). Therefore, a state of the art analysis has been made as the first step and also audits in six hospitals were conducted. The main objective of this task was to get a representative sample of European hospitals from the standpoint of the various situations that can be found in relation to energy use performing in lighting and HVAC. Finally, the results of those audits were analyzed and generalized in order to obtain an overview of the energy consumption practices in hospitals, regarding lighting and HVAC.

The state of the art analysis and the detailed results of hospital audits can be found on the HosPilot web site www.hospilot.eu. [5] Here is the summary of the findings, clustered in four topics:

General conclusions:

- Hospitals are always aware of their total energy consumption. Nevertheless, it is very seldom to have a break-up of the consumption and to know e.g. partial consumption for each department, floor or area. Hospitals are interested in this data, thinking that it could improve the awareness of medical staff and lead to decreased energy consumption.

- Hospitals have some kind of central control for energy management (lighting, HVAC) in some cases, but not all of them work properly. Some others do not have it, but in general, they would like to have a central control for all these utilities.

- Apart from the standard electrical supply, hospitals are obliged to have an UPS (Uninterruptible Power Supply system) that should be able to maintain vital activities in the hospital during a limited period of time: reanimation, surgical theatre, laboratories must be working with no interruption.

- There is a trend to invest in new hospitals all over Europe: Cannes, Nice, Monaco, Madrid, Galicia, Alicante… In all these cities at least a complete new hospital is being built which can lead to the most energy sensitive projects.

- There are also high investments on huge refurbishments of the existing hospitals: Madrid, Barcelona, French Riviera…, what means that this is a good moment to propose energy saving alternatives.

- Most often, there is a decision management council in hospitals that takes a decision about new investments after receiving the proposals and checking the subsidies they can get.

- It is not common to have complaints about lighting in hospitals. However, patients are more sensitive to heating and AC and there are often complaints about that.

- It is common to use tenders for refurbishments or new projects. In this case the cheapest solution is chosen from the companies that answer the call. Nevertheless, there is an increasing awareness of the long term costs, that include reduced energy consumption and maintenance, thus gaining shorter payback time for the undertaken refurbishment.

- Subsidies from local and international entities in refurbishments that save energy in buildings reinforce the criteria of cheapness based on long term solution and payback.

- There is a trend and actions in progress to save costs in hospitals. They are becoming more like private companies and in some cases an outsourcing contracts are developed to manage the hospitals.

- Coming from the European Directive 202/91/CE, in France there is an Environmental Standard certification for buildings called HQE (haute quality environmental), according to the complying of some criteria. Also in Spain all new buildings, from November 2007 onwards, must be classified under these criteria, from A to G from the most efficient to the least.

- Different nature of their work makes that involvement in the building management is clearly different between medical staff and the rest of the hospital employees. Their different tasks and needs make also that sensitivity about reducing energy consumption is more supported by the technical staff than by the medical one, who is more concerned about well-being for patients than energy consumption.

- Maintenance in most of the hospitals is outsourced due to cost reasons.

Conclusions about lighting:

- The use of light during the day and night is almost permanent in corridors, halls, stairs. There is hardly any automatic control or presence detector. Sometimes, there is a manual switch for controlling the lights.

- Daylight control is almost never used.

- If domestic saving energy lamps, E-14 or E-27 socket, are used in a hospital there is a prominent problem of stealing lamps.

- The majority of Spanish hospitals have recessed luminaires installed with linear fluorescent lamps. The ballast is electromagnetic and the TLD is standard type, leaving a lot of room for reduction of energy consumption.

- In the most representative areas (entrance hall, restaurant, some corridors…) it is also usual to have installed downlights as the most common luminaire.

- The main reasons in hospitals to upgrade lighting installations is to reduce the energy consumption. In some other cases, the comfort related to lighting is also mentioned.

- Normally hospitals have installed some sun shading on the windows that are managed by people in the rooms, that can be patients, medical staff, administrative, etc, depending on the kind of the room about. It is also common that the sun penetration is low in the corridors and hallways.

Conclusions about ventilation and air-conditioning:

- The control of the AC is usually centralized although there are some exceptions with local control in rooms.

- There are some special requirements for the quality of air in specific rooms of the hospitals called “clean rooms”. Also there are often special requirements for the luminaires, e.g. in some areas they must be closed.

- There is national entity in France called HAS (Haute Authorité de Santé) dedicated to quality in hospitals. For this entity, the radiant ceiling heating/cooling system is very appreciated since it reduces the risk of infection due to the AC.

- General complaint from maintenance and technical responsible are that corridors, patient rooms and many areas have always open doors, which makes it very difficult to control the temperature and avoid extra expenses on heating or AC.

Conclusions about heating:

- The control of the heating is usually centralized although there are some exceptions with local control in rooms.
- The main reason to refurbish a heating installation is apart from saving energy to increase thermal comfort and air quality.
- As the previous case, the general complaint is that many areas have always open doors, which makes it very difficult to control the temperature.
- There is general difficulty to adapt temperature to personal needs due to the fact that patients are ill and not moving and the medical staff are healthy and more active, so they have different needs.

Hospital requirements

It was decided that the HosPilot methodology would be organised around the room types. In this way a highly universal methodology is gained, which can be applied to any hospital in Europe. Therefore, a list of the room types with the inherent requirements is composed. To obtain this list a very large number (around 400) of different hospital rooms is identified, then clustered and scrutinised. As a result, a list that contains +/40 rooms is obtained. This list is very unique - it consists of all the room types that can be found in European hospitals and is a very valuable achievement by itself. Furthermore, to every room type requirements inherent for this room are identified and attached to it. Those requirements are based on the formal requisites (legislations), as well as practical demands that arise in everyday usage of hospital buildings. As the final result a large table containing all room types with all the requirements inherent for those room types is obtained, and later on used as an input for making the HosPilot methodology.

The available space in this paper does not allow to present the full table with all the requirements, but it can be found at the project web site. Here only the room types are listed as an illustration: Archive, Bedroom, Chapel, Control room (medical equipment), Copy room, Dark room, Dressing room, Drying room, Education rooms, Family room, ICT room (active infrastructure equipment), ICT room (server room), Intensive care, Intensive care (children), Kitchen room (central), Kitchen room (local), Laboratory, Laboratory 24h, Meeting room, Observation room, Operations rooms (no plenum), Parking (indoor), Personnel/staff rooms, Pharmacy (shop)(drugstore), Reception (general), Reception (nurse station), Recreation rooms, Restaurant, Sanitary rooms (bathroom), Sanitary rooms (toilets), Sauna, Shaft (technical infrastructure), Staff Office room, Staircase (traffic room), Sterilisation room, Storage for chemicals (Normal), Storage for cleaning equipments, Storage room, Storage room (cold), Storage (medicine), Storage (sterile), Technical infrastructure room, Therapy treatment room, Traffic room, Traffic room (air lock department), Traffic room (air lock room), Treatment – consulting, Treatment - examination - emergency – xray, Waiting room, Waste / storage, Welfare room, Working closet, Workshop.

HosPilot methodology

The main result of the HosPilot project is the methodology, which is able to propose the best energy efficient technical solution for a refurbishing hospital. This methodology is the basis of the proposed HosPilot service and the first version of it is developed in this phase of the project.

Requirements identified for all hospital room types, as well as legislations and rules, are used as an input for creating the HosPilot methodology. The methodology consists of a questionnaire, list of the technical solutions and decision part which chooses the best technical solution for the given hospital. It is able to provide a hardware description for an energy efficient system for any hospital, based on specific requirements of that hospital, i.e. the building and its usage. This is a unique methodology, which considers energy efficient installations in all the domains (lighting, heating, cooling…) and it is made by combining the expert knowledge of construction builders, system suppliers and requirements of end users. It also defines the best method for auditing a hospital, in order to obtain the most relevant data for the methodology to be applied to this particular hospital.

In order to deploy the methodology properly it is needed to have guidelines for analysing the needs, as well as the current situation in the hospital, in order to get the most appropriate input for applying the methodology. Therefore, as an integral part of the methodology a questionnaire is defined, which should identify energy practices, activities and constrains in various areas of the hospitals. Additionally, it makes an inventarisation of the technologies already installed in the hospital. Applying such a questionnaire every hospital is analysed in the same standardised way and a relevant input for the methodology is obtained.

In this phase of the project the first version of the methodology is created. As planned, it will be improved and tuned during the course of the project. Eventually, this methodology will be transferred in a form of an expert system, that would be the basis for the service developed by the project.

At the end of the project, the methodology will be a tool that will be used by the potential customer (a hospital or energy advising company). By answering a questionnaire, the tool will be able to analyze the current situation in the hospital in terms of HVAC and lighting energy use, and provide possible improvements to this situation. Depending on what option the user selects, the tool will give the user the expected energy savings and an estimation of the installation costs.

Pilots

To prove the HosPilot methodology pilots will be built in 3 different hospitals. They are: Universitair Medisch centrum Groningen (The Netherlands), Hospital District of South Osthrobotnia (Finland) and Hospital de San Pedro, Logroño (Spain). Those hospitals will be surveyed accordingly to the questionnaire provided by the methodology, in order to identify

requirements specific for those hospitals. The methodology will be applied then to the obtained results and for each hospital a description of the optimum hardware will be defined. Those systems, which will be built into different pilots, will not be the same – they will address the specific needs of each hospital and they will differ accordingly.

Those systems, defined as an outcome of the methodology, will be physically built into the pilot hospitals, then tested and monitored during the testing period. Results will be compared with the predicted and systems will be tuned to achieve the smallest energy consumption.

Figure 3. Pilot sites

Learning from pilots will be used for validation and consolidation of the methodology. Those results should prove that the methodology is capable of proposing the energy most efficient system and will be compared with the predictions and expected results. Also, the methodology will be improved using the experiences from the pilots. As the result, the final methodology will be obtained. This methodology, applied across the whole Europe, will be able to address the specific needs of any hospital and to define the optimal system in regard with energy efficiency. It is planned that the installations will be ready end of 2010, while the monitoring and validation phase will take place during the last year of the project.

Conclusion

The HosPilot project is meant to help hospital decision makers to choose the most appropriate technical solutions when refurbishing their hospitals. Those solutions are oriented to both energy efficiency and increased comfort of hospital users: patients, medical staff and visitors.

This paper presents the global HosPilot approach, its envisaged strategy and expectations as well as the intermediate results that the project has achieved so far – analysis of the European hospitals, identification of the hospital room types with their requirements and the most important achievement – creation of the HosPilot methodology.

Acknowledgements

The work leading to these results has received funding from the European Community's ICT Policy Support Programme as part of the Competitiveness and Innovation Framework Programme, under grant agreement n° 238933.

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