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ENERGY MANAGEMENT IN HOTEL FACILITIES

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ABSTRACT
Energy efficiency is recognised as an important response to economic, energy security and environmental challenges. Before the background of a rapidly growing tourist industry the energy efficiency of hotel facilities is of great interest for the countries of South Africa. The paper describes computer aided energy management systems as a part of the facility management in hotels. Energy information systems represent a necessary part of the energy management. The energy data management as well as the essential steps of an energy audit are described. In the case of planning new hotel facilities the energy audit has to ensure that the rules of energy efficient building design and technical installations are fulfilled. The most applications of energy audits focus on the remodelling of existing buildings. Applicable methods are described to improve the energy performance of a hotel facility. Because of the complex structure of the energy management in facilities an integrated system approach is necessary. The paper describes some aspects of multidisciplinary engineering education which inter-changes the ideas, methods, and technologies from different scientific fields. Some experiences with the engineering education in the field of energy saving at the Cologne University of Applied Sciences (CUAS) are presented.

KEY WORDS
Energy management systems, energy efficiency, audit, education

1. Introduction

Energy efficiency is recognised as an important response to economic, energy security and environmental challenges. Because of the limited fossil energy resources in the world the sustainable utilisation of energy represents a common need for both developing and developed countries. The optimisation of the generation and the reduction of the consumption of energy will reduce the emissions of Greenhouse gases which are responsible for the climate change. Additional to the environmental aspects the efficient use of energy becomes more and more important for industrial enterprises as well as for the residential sector. Before the background of dramatically increasing prices for oil, gas, and other fossil resources the energy efficiency must be improved in all sectors of the demand side. That means the ratio between energy outputs (services such as electricity, heat and mobility) and inputs (primary energy) is to be minimized.

The energy consumption by the residential sector in developing countries is low compared to other sectors in developing countries and same sectors in developed countries at present. However, it will increase drastically in the near future, since the adoption and capacity of each home appliance will rise due to the desire of people in developing countries to improve their standard of living. Before the background of a rapidly growing tourist industry the energy efficiency of hotel facilities is of great interest. Energy management systems as a part of the facility management significantly contribute to energy saving and sustainable development.

Energy management describes the process of managing the generation and the consumption of energy, generally to minimise demand and costs [1]. Because of the complex structure of the problems in the most cases computer aided methods are needed. Information systems are the basis for controlling and decision activities. Because of the large number of relevant information an efficient data management is to be used. Multidisciplinary engineering is necessary for the solution of energy management problems with practical relevance. The energy provider as well as the consumer can use the same basic tools for data management, energy analysis, forecast, and optimisation. Thus synergy effects can be used as shown in the following.

The scientific and technical training for the development and application of effective energy management methods is very important for the countries in South Africa [2]. The educational program at the universities must guarantee that well skilled engineers will be able to solve the energy problems in the future. Because of the complex character of the sustainable development a multidisciplinary approach is necessary for teaching energy management. The paper describes some aspects of multidisciplinary engineering education which interchanges the ideas, methods, and technologies from different scientific fields. Some experiences with methods combining project management with engineering

education in the field of energy saving at the Cologne University of Applied Sciences (CUAS) are presented.

2. Energy management systems

2.1 The scope

Computer aided energy management combines mathematical and informational methods with energy generation and saving technologies related to the framework of the energy economy. The energy management has to look for efficient solutions for the challenges of the changing conditions of the international energy economy which are caused by the world wide liberalisation of the energy market restricted by limited resources and increasing prices.

The main objectives and topics of the energy management can be summarised as:

- to improve the efficiency of the generation and consumption of energy
- to build up energy controlling and monitoring systems
- to develop forecast methods to estimate the energy demand [3]
- to build up efficient methods for the energy data management
- to select and apply the most efficient energy saving technologies
- to look for an optimal energy generation mix including renewable energies
- to organize an efficient energy portfolio management

In hotel facilities energy efficiency and energy management options focus on minimising the demand of the main consumers (lighting, air conditioning, heating and cooling, hot water preparation, cooking, laundry, wellness equipment). Energy efficiency includes both improving operating practices and replacing inefficient equipment. The load management contributes additionally to reduce the energy costs. By an analysis of typical electrical load profiles it is possible to avoid expensive power peaks and to shift the power consumption to lower price regions of the day. Last but not least hotel facilities provide best opportunities for distributed generation including all types of cogeneration and the use of renewable energies. In hotel facilities there is a strong coincidence of the power and heat/cooling demand which guarantees a high efficient performance of cogeneration units. Especially in developing countries distributed generation systems can be combined to "virtual power plants" to support the energy infrastructure. [4].

2.2 Energy data management

Energy information systems (fig. 1) represent an essential part of the computer aided energy management. Generally the energy data basis is necessary for load forecast tools and operating schedules for the distributed generation units.

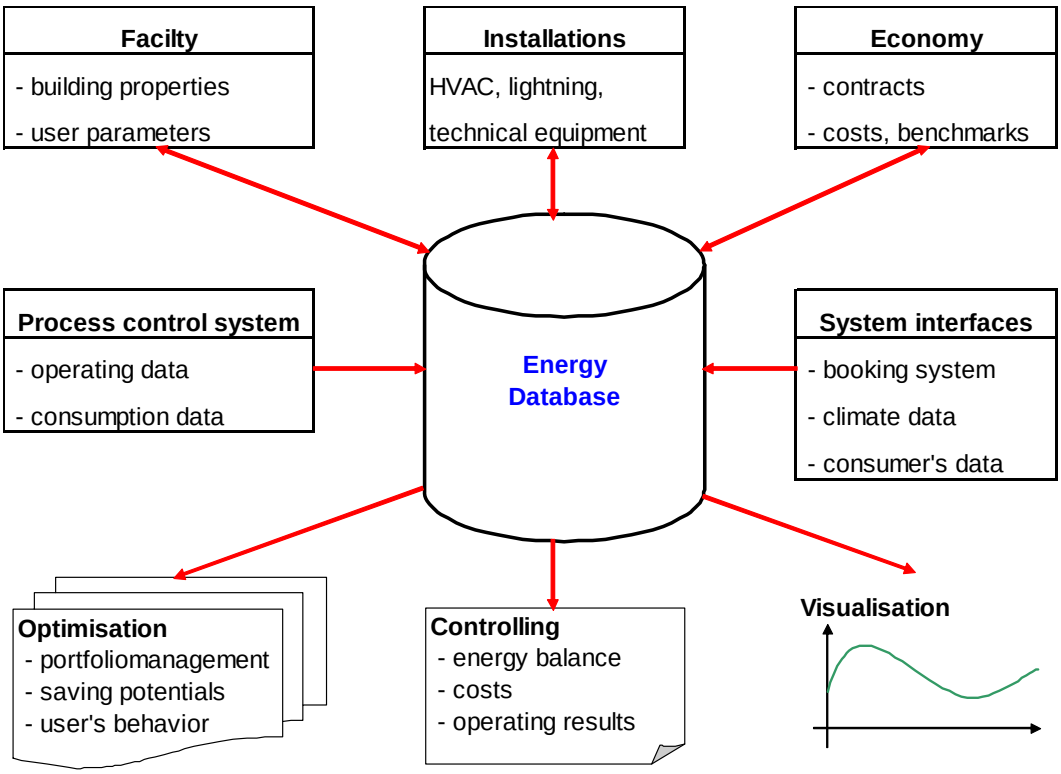

Figure 1. Energy information system

The liberalised electricity market requires a dramatic increase in exchange of information not only between energy providers and customers but also with the members of the grid responsible for the distribution and transport. Thus the energy management must provide tools for the energy data workflow and the design of information systems including all relevant information. The energy data analysis in hotel facilities determines a baseline that reflects the types, quantities, and costs of energy used in each significant component of the system. The energy information system provides the facility management exactly with the information needed to make investment decisions replacing inefficient equipment and to improve the efficiency of operating practices.

The relational data base (fig. 1) containing all relevant energy data represents the centre of the information system. By means of the data base all information exchanges between the modules (technical and economical modelling, optimisation, controlling, and visualisation) of the system are organized. The information system provides also a decision support tool for selecting the most effective energy saving technologies.

Energy data management in hotel facilities includes the following activities:

- analysis of the energy data flow
- entity relationship modelling (fig. 2)
- energy balancing (distribution of the demand to the main consumers)
- analysis and modelling of the energy demand profiles
- energy controlling and benchmarking
- reporting and visual illustration of energy consumption and local generation

The investigation of optimisation potentials for reducing the energy consumption is based on the energy data analysis.

2.3 Analysis and forecast of the energy consumption

The relationship model (fig. 2) describes the impact of climate and season factors on the energy demand. It illustrates the multiple approaches of mathematical modelling methods to different applications of the energy management. The model is to be used for the energy demand forecast as well as for the load management in the hotel facilities.

The energy providers as well as the consumers are interested in a better knowledge of the behaviour of the time dependent energy consumption. The provider could better plan the power generation if detailed information about the customer's behaviour is available. On the other side the customer will get better conditions for the delivery contract if he is able to inform his provider about the power demand. Thus both market members will use similar mathematical and informational methods for the consumption analysis and for the demand forecast. Additionally the load management in hotels needs exact information about the time dependence of the power consumption which is also based on the relationship model in fig. 2.

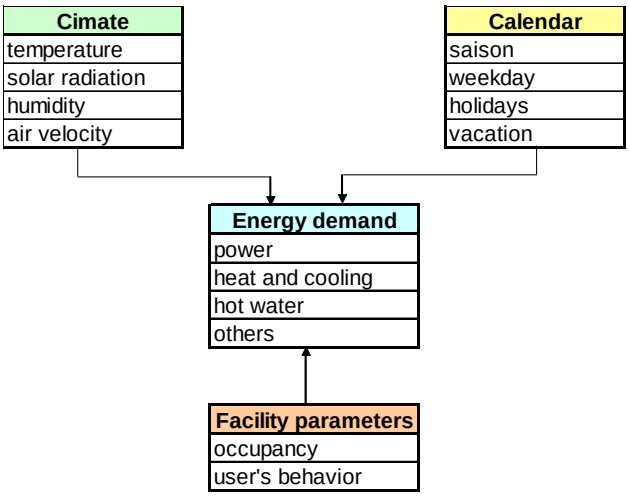

Figure 2. Relationship model

The analysis of the relationships between energy consumption and climate and season factors focuses on the following objectives:

- analysis of the main influence factors (climate, season, facility operating)
- mathematical modeling
- software implementation
- design of typical time dependent demand profiles

Generally a large variety of mathematical models are used: regression models, autoregressive methods, time series, and neural networks (for example [3], [5], [6]).

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3. Energy audit

3.1 Methodology

Energy audits are comprehensive reviews conducted by energy professionals and/or engineers that evaluate the actual performance of a facility's systems and equipment against their designed performance level or against best available technology. The difference between these is the potential for energy savings [7]. Because of the complex structure of the energy management in facilities an integrated system approach is necessary. For example, heating and cooling system components interact with each other extensively. Chillers operate more efficiently if they receive cooler condenser water. However, the cooling tower fans consume more energy to provide cooler condenser water. Optimizing the energy use of the cooling tower/chiller system is one example of using an integrated system approach that can improve the energy performance. The planning process for new generation units represents a second example for the necessity of an integrated system analysis. The dimension and the

technical parameters of a cogeneration system strongly depend on the energy demand of the facility. Therefore all possibilities of reducing the consumption on the demand site are to be analysed before starting expensive investments for new generation units to avoid oversized systems.

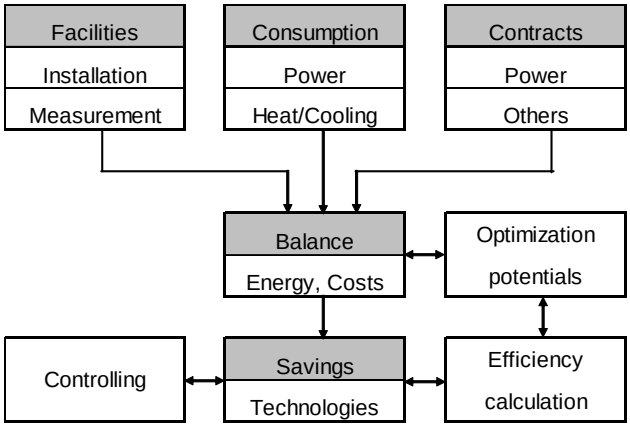

Figure 3. Algorithm of an energy audit

Figure 3 shows the algorithm of an energy analysis. The activities of the data management described in 2.2 are to be completed by an analysis of the building properties, the major energy using processes, and the user's behaviour. The identified optimization potentials are proofed by an efficiency calculation to select such energy saving technologies providing the best ratios between savings and investment costs.

3.2 Energy audits in hotel facilities

In the case of planning new hotel facilities the energy audit has to ensure that the rules of energy efficient building design are fulfilled. That means the planning process follows the "Green Building" standards of energy saving architecture and installation [8]. This includes the whole-building design for optimal energy performance by using energy efficient materials (insulation of the walls and the roof, energy efficient windows). Furthermore the design should meet the possibilities of natural air conditioning, using daylight as much as possible, using renewable energies for heating, cooling and power generation.

The most applications of energy audits focus on the remodelling of existing buildings [9]. There are a lot of possibilities to improve the energy performance of a hotel facility ([2], [8], [9]) which can be classified by the following action fields:

Analysis of the contracts and the economical framework:

- evaluate the tariff against comparable norms
- proof the possibilities of bundling contracts
- portfolio management
- proof the possibilities of energy contracting
- avoid expensive power peaks by peak shifting

Energy saving technologies:

- retrofitting of the energy performance of the building
- insulation, energy-efficient windows
- investigation of insulation and alternative building materials
- cool roofing and elimination of thermal bridges
- test and repair cooling ducts
- heat recovery, heat and air exchange systems
- exchange of non efficient housekeeping equipment
- use of high efficient HVAC systems
- optimization of the lightning system
- use variable speed drives (pumps, motors)
- proof the possibilities of cogeneration
- use renewable energies (e.g. solar heating and cooling, photovoltaic, wind, biomass)
- use energy storage systems
- avoid oversizing of the energy system

Energy controlling:

- installing a building automation system
- built up an energy information system (fig. 1)
- optimization of the operation parameters for heating, cooling and air conditioning
- control lighting with clock timers, delay timers, photocells, and/or occupancy sensors
- avoid standby operating of TV, computers and other electrical installations
- realize continuous maintenance programs
- install power peak watching systems
- compare the energy consumption with benchmarks

User's behavior:

- make the hotel staff sensible for energy efficiency
- make the guests sensible for energy efficiency
- install a controlling and monitoring system
- operate all energy consuming installation strictly depending on the occupancy of the building

The described actions only represent a selection of the possibilities of complex energy audits in hotel facilities. Further energy saving methods can be found in [1], [2], [8], and [9].

4. Teaching energy management

4.1 Multidisciplinary engineering education

The engineering education in the field of the energy management must provide a platform for the interchange of ideas, methods, and technologies related to sustainable utilisation of energy. The qualified training of students as future decision-makers will guarantee the dissemination of energy management methods in the regional practice. The scientific topics of the educational program have to

be strongly related to practical demands. The educational program must fit to the multidisciplinary character of the objectives and methods of the energy management. Thus it is very important that the students learn not only specific technologies of energy engineering but also applicable basic methods for energy analysis and modelling.

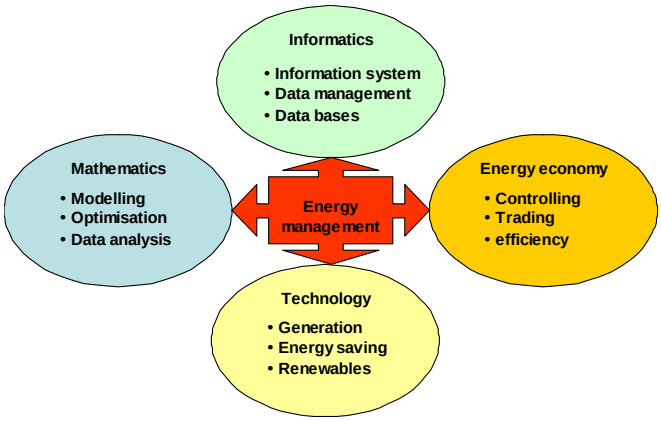

Figure 4. Scientific fields

Energy management problems will usually solved in complex projects by a team work where energy engineers work together with specialists of other technical, economical, and informational disciplines. Therefore the students have to learn the basic ideas and methods of energy management projects including project planning, controlling, and supervising. In the Cologne University of Applied Sciences (CUAS) the project management is trained by "virtual student consulting companies" where detailed tasks of energy management are to be solved. The students have to simulate the whole process from planning up to the realisation of the project. They are working in independent training groups of about 5 students. The training projects are derived from real problems of the university's facilities including energy audit programs, planning studies for cogeneration units, energy saving technologies, and case studies for the use of renewable energies.

4.2 Energy audits in the university's facilities

The students analysed the energy saving potentials of the building properties resulting from replacing the existing windows by energy efficient ones and by the insulation of thermal bridges. Furthermore the lighting system was analysed in combination with an efficiency calculation for the use of improved systems.

The power consumption of the facilities of the CUAS was also analysed by a student team. The main objectives of the project were:

- analysis of the integrity of the energy data base
- comparison of the specific consumption data with benchmarks
- distribution of the power consumption to the main consumers (balancing)
- developing of typical time dependent profiles
- search for power peaks and for possibilities of peak shifting

Based on the results of the energy consumption analysis a planning study was carried out for the installation of a cogeneration system providing the facilities of the CUAS with electricity, heat and cooling. The system consists of a gas motor with integrated heat exchangers, a generator, and an absorption cooling machine.

The results of the student's teams were involved into the certification process for the installation of an environmental management system in the CUAS. The Eco-Management and Audit Scheme (EMAS) represents an instrument provided by the European Union to improve the environmental behaviour of enterprises.

4.3 Energy management in hotel facilities in Cuba

In the frame of an international cooperation German und Cuban students worked together in projects to carry out energy audits in Cuban hotel facilities [10]. For example the hotel "La Pradera" in Havana was analysed to improve the energy performance of the building. Here the students could apply their knowledge and experiences of the training process in the university's facilities. At first an energy information system was built up using the ideas of data management described in chapter 2.2. The information system should support the energy controlling and the decision making process for selecting suitable energy saving technologies.

By the installation of some prototypes of new energy efficient windows a large saving potential could be proofed. The structure of the windows avoids the heat transfer by radiation into the room. Thus cooling energy could be reduced.

With the help of an improved control system the energy consumption for air conditioning could be decreased. The control system is based on micro sensors measuring the room temperature, the air velocity and the humidity. The philosophy of the system consists of the idea to use the ventilation in the room as much as possible and to cool the room only as much is necessary without losses of the comfort for the guests.

As a multidisciplinary project students of the electrical engineering department worked together with students of the design faculty on an energy saving campaign for Cuba. They designed information materials as flyers, videos, TV spots, but also games for children for the energy saving education.

5. Conclusion

The paper describes computer aided energy management systems as a part of the facility management in hotels.

Energy information systems represent a necessary part of the energy management. The energy data management as well as the essential steps of an energy audit are described. Because of the complex structure of the energy management in facilities an integrated system approach is necessary. With the help of the described algorithm of energy audits significant optimisation potentials are to be identified. They can be realised by a large variety of energy saving technologies. An energy information system is suitable to support the decision making process for selecting the most efficient technology.

The paper presents a multidisciplinary approach for the engineering education in the field of energy management. It is described how the computer aided energy management combines applicable methods from mathematics, computer science, engineering and economy. The presented projects of the energy engineering education show how the qualified training of students as future decision-makers will guarantee the dissemination of energy management methods in the regional practice.

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