DEVELOPMENT OF ENERGY MANAGEMENT SYSTEM IN GREEK SCHOOL BUILDING

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Abstract

In the framework of an European project concerning the energy management system, a Greek school has been selected for the development, introduction and implementation of an energy management system. A data acquisition system has been installed and a methodology concerning the energy consumption of the school has been developed. The energy consumption comprises the fuel oil for space heating and the electricity for lighting and for other purposes. Also a transient simulation program was developed to study the energy consumption of the school building. Furthermore it can be used to indicate how energy-efficient the school building is at present and the likely potential for cost-effective energy savings is greatest. Therefore the replacement of the single glass windows by double glazing in the North side of the school has been studied using this simulation. The annual thermal energy consumption was 70 kWh_t/m^2 and this value can be reduced 9% by using double glazing.

Keywords

Energy management, school building, data acquisition system, energy consumption, energy objectives.

Introduction

Energy management may be defined as the control of energy flows through a system, so as to maximize the net benefits to the system. It involves the collection, analysis and monitoring of information on energy use, and the identification, evaluation and implementation of energy saving measures (E.C., 1995). Good energy management in buildings can reduce both energy costs and environmental damage.

Because of their form and use, new school buildings represent the most favorable category of non-domestic premises in which passive solar design techniques could be employed to pursue energy efficiency (Curtis D., 1988), (Crisp V. et al. 1986). A preliminary and largely theoretical assessment of the possible contribution which the application of such techniques to these buildings could make to reducing fuel consumption has been attempted by (Duncan, I. P. and Hawkes, 1983).

In the framework of an European project (Project LIFE, 1998) concerning the energy management system, a Greek school building has been selected for the development, introduction and implementation of an energy management system (Axaopoulos P., 1998). This school is a detached rectangle building, in the city of Karditsa (Greece), with two floors, built of stone with 21 classrooms, 300 pupils and is situated in the center of the City. The pattern of occupation of School consisting of five days per week from approximately 08.30 until 14.00, with substantial holiday periods especially during the summer. It is constructed at ground level, its orientation is South, and has a pitched roof. This school is a heavy construction, uninsulated with a total heated area of 1156 m^2. All glazed openings are single glazing with aluminium frame, and their distribution in each orientation is : South : 70 m^2 , East : 3 m^2 , North : 125 m^2, and West : 3 m^2. A central heating system including a water boiler, burning fuel oil, is used for space heating system, while the lighting is assured by electricity from national grid.

The data acquisition system consist of a personal computer a 25’’ TV monitor and the sensors. In order to be shown by the pupils, the TV monitor has been installed inside at the central entrance of the school building. This system will help the pupils to become familiar with the climatic factors as ambient temperature, relative humidity and solar radiation which play an important role in their daily life (clothing, grade of activity, physical condition). The ambient temperature, relative humidity and total solar radiation on horizontal surface are measured with relevant sensors. The PC system scan automatically all channels in the twenty seconds intervals, averaged them over thirty minutes period and store them in a hard disk for further processing. These averaged values are shown in the TV monitor.

Also a regular recording of energy consumption per ten days has been realized. The energy consumption comprises the fuel oil for space heating and the electricity for lighting and for other purposes. The fuel oil consumed has been estimated using the indication of the storage tank reserve level at the end of each time period. Two electricity meters have been installed in each school building. One for the electricity consumed for lighting and the other for the electricity consumed for other purposes.

Methodology - Results

In order to predict the energy consumption for the school building a methodology has been developed (Axaopoulos P., 2000). We used the climatic data of City of Karditsa and the building parameters, for the calculation of the heating load at a reference temperature of 22 ^{0}C. Reference temperature is the temperature below which heating is required. The method has been applied to school building and the results are shown in fig. 1, for uninsulated and insulated school building.

This method can be used with billing data and local temperature data. In this case it involves studying energy bills and comparing actual consumption with predicted levels. The expected level of energy consumption could be found between them during the periods with the same temperature (fig. 2). If there is a discrepancy, the cause may be investigated, and appropriate corrective action taken to maintain efficient utilisation of energy. The information obtained by this method is useful in understanding school building performance and identifying energy-saving opportunities.

The annual thermal energy consumption was 70 kWh_t/m^2 and the results from the simulation indicate that this value can be reduced 9% by using double glazing (fig. 3).

The reduction of energy bills is often the main reason for managing energy use. Reductions can range from perhaps 10% for organizations already operating efficiently, to up to 60% or more at sites where the potential had not previously been realized (Energy Audits and Surveys, 1991). A study of over 4000 energy surveys by the UK’s Energy Efficiency Office showed that average savings of 21% of each site’s energy bill were identified, with an average pay - back period for recommendations of 1.5 years (Energy Efficiency Survey Scheme, 1985).

Heat loss through a building's shell is the main contributor to space heating demand. Energy use for space heating is particularly important in the northern and central EU countries. The total primary energy consumption of typical office buildings in northern Europe is between 280 and 350 kWh/m^2year (Campbell J., 1988).

The electricity consumption for lighting and other purposes is shown in fig. 4. This figure shows that the lighting energy consumption is considerably higher than that consumed for other purposes. A useful lighting performance index may be obtained by calculating the lighting power per square meter of floor area when the area is in use (W/m^2). The lighting level required in different parts of the building will depend on what they are used for. Recommended lighting levels for different areas and tasks are given in references as (CIBSE, 1996). Energy – efficient lighting systems reduce not only energy use directly, but also indirectly, by reducing the cooling load

It should be noted that the electricity consumption given on invoices does not include energy losses in electricity generation. Given that the average efficiency of electricity generation in EU-12 in 1992 was 37% (Energy in Europe, 1995), the primary energy used in generating 1 kWh of electricity was on average 2.7 kWh. Similarly, the delivered energy content of fuels does not take into account the energy required to extract convert and transport them.

Organisation of energy management

The general guidelines, objectives and programmes concerning the energy management system in school building, will be described briefly in this chapter. Of course all these information can be applied in public and municipal buildings.

The energy program describes how to reach the set energy objectives. As regards content the energy program at least includes the presentation of the energy objective to be achieved and the description of measures to be taken to achieve the set objective. With regard to energy objectives specific, numerically defined performance targets are to be achieved within stipulated periods of time. Whereas the energy guidelines are valid on a long-term basis, energy objectives are updated on a regular basis and implemented in energy programs.

Energy programs are prepared by the working group energy management in co-operation with the energy management representative of the office and are passed by the head of the office as well as by the energy management representative of the municipal authority. The original energy program is submitted

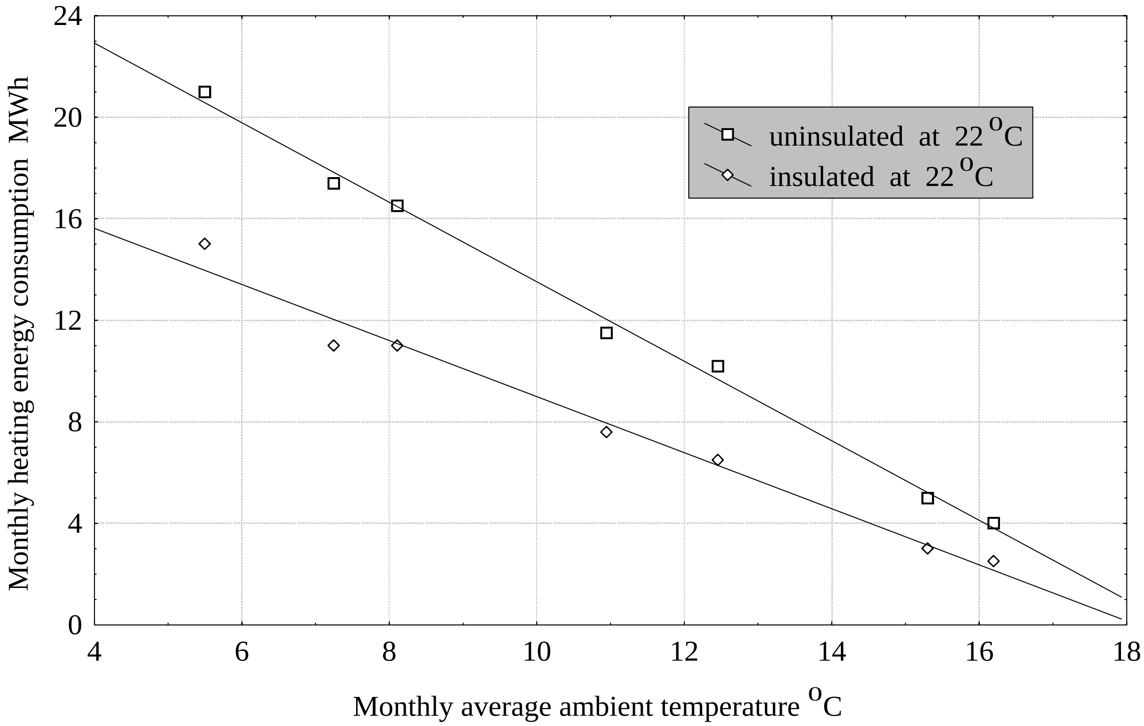

Fig. 1 Monthly heating energy consumption for insulated and uninsulated School

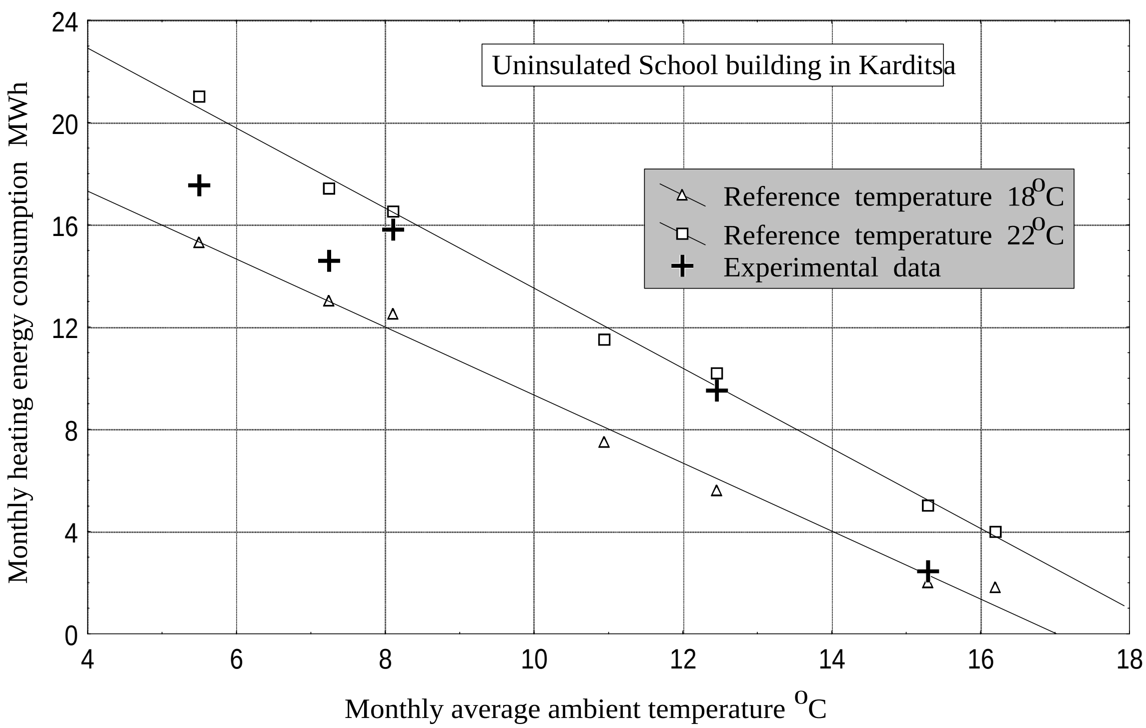

Fig. 2 Monthly heating energy consumption for 18 and 22 ^0C

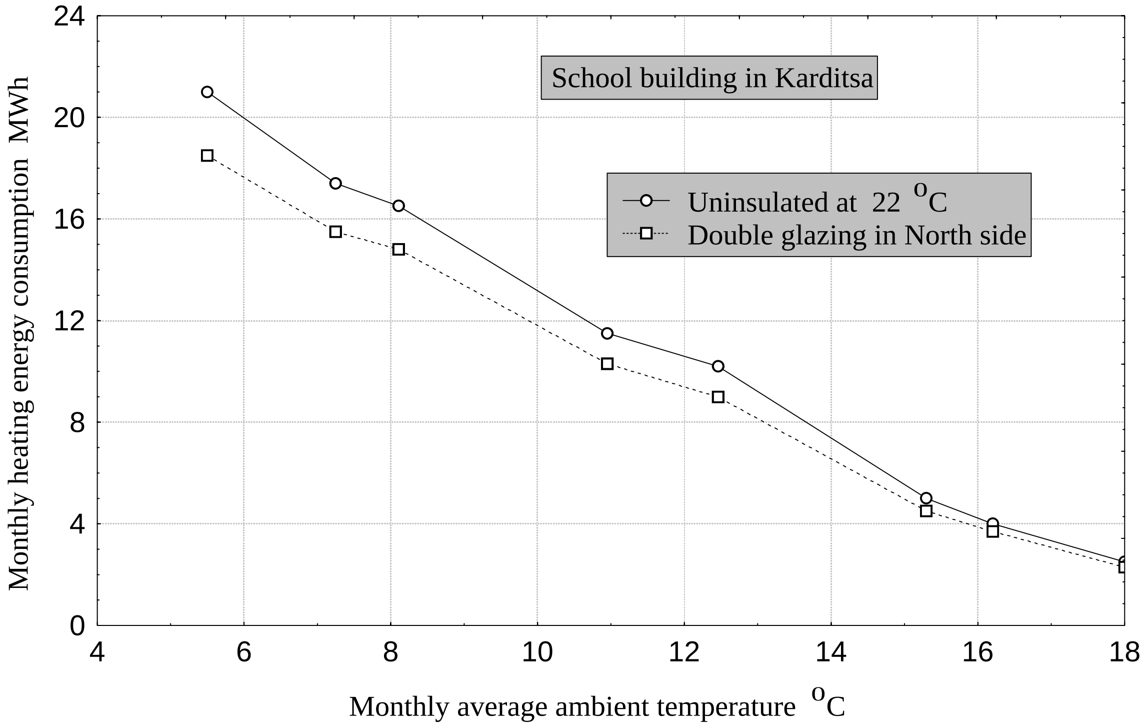

Fig. 3 Monthly heating energy consumption for single and double glazing

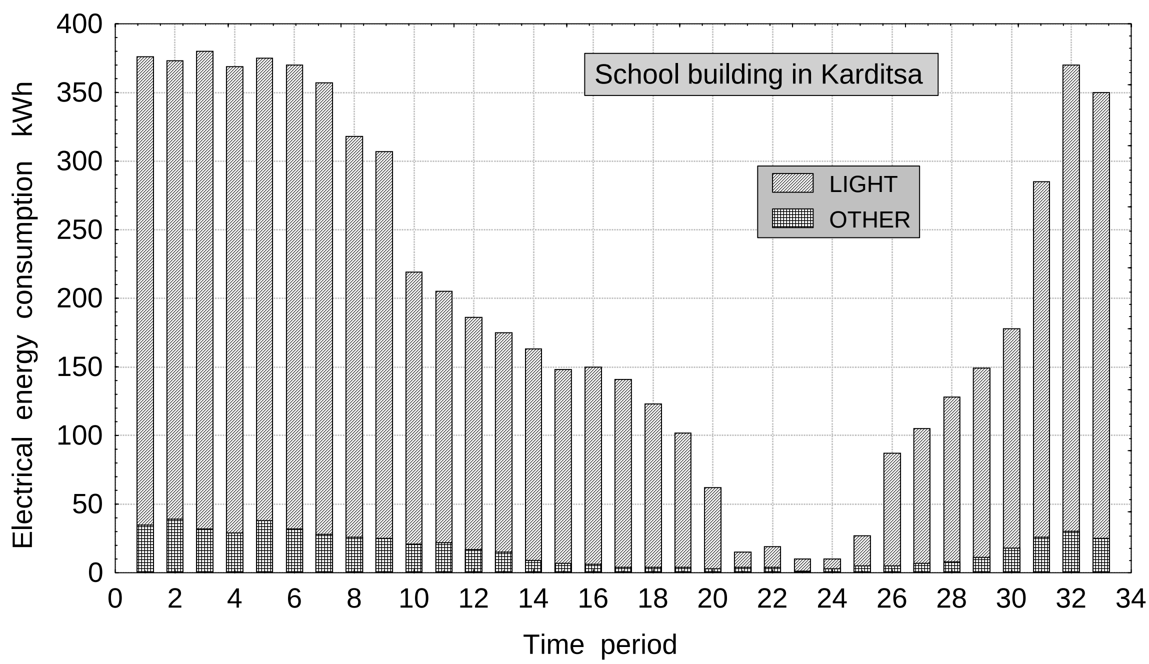

Fig. 4 Electrical energy consumed for the School building

to the energy management representative of the office for supervision and keeping. To the employee, who is responsible for the execution of the measure, a copy as operating instruction is submitted. If there are any deviations with regard to the course of project, which was stipulated in the energy program, the energy management representative of the office shall be informed. This includes, for example, an extension of deadlines, the introduction of additional employees, the integration of external companies or the provision of a larger budget. The energy management representative of the office in agreement with the head of the office determine how to handle any changes. The employee, who is responsible for the implementation of each individual measure within the framework of the energy program, informs the energy management representative of the office about the result of the measure. A list of energy objectives are shown below.

- Organizing information events on variety of different subjects concerning energy management systems to familiarize no just pupils but also teachers and employees
- Data collection and evaluation concerning the thermal and electrical energy consumed, the water, the wastes and the raw materials.
- Development of municipal technical team specialized in the preventive maintenance concerning the central heating system and the lighting.
- Periodic dissemination of information concerning energy and financial savings in the school buildings to councilors, officers of the municipality, decision-makers, and private companies carrying out public works.
- Feasibility studies for the reduction of thermal and electrical energy consumed. The first study will be concern the installation of double glazing in north facing area.
- Periodic information to pupils, with numerical values on the pollutant emissions generated by the consumed fuel oil. These values can be presented in central point in the school.
- Replacement of classroom lamps by low consumption lamps.

The head of the office is responsible for the energy management system. He or she monitors its effectiveness, besides other, with the help of the evaluation of audit results. For this purpose he or she asks the energy management representative to plan and execute internal audits on a regular basis.

The energy management representative of the school prepares an annual audit plan, in which the auditing of all elements of the energy management system is stipulated. This plan is approved by the head of the office.

The energy management representative of the school is responsible for the execution of audits, however, he or she forms an audit team with trained employees, e.g. from the working group energy management. Within this team the audits are distributed. The energy management representative is responsible for the management of the audit team. Employees, who executed an audit, are responsible for the documentation in an audit report. The stipulation of necessary corrective actions is carried out on the basis of the audit result by the auditor in agreement with the energy management representative. The corrective actions are approved by the head of the office. The employees in charge are responsible for the execution of measures and are either investigated by notification of the energy management representative within the framework of a secondary audit (in the case of significant deviations) or in the following internal audit.

Benefits

The benefits resulting from the introduction of Energy management system are numerous and can be separated in direct and indirect. Direct are the currents, the presents benefits, while indirect are the expected in short or long term. Some of the direct and indirect benefits are :

Direct

Reduction of fuel and electricity bills

Identification of energy saving opportunities and environmental compatibility concerning the School building

Energetic retrofitting of the School buildings

Reduction of operation and maintenance costs

Improved public image

Indirect

Rise of energy consciousness

Improved quality of life in the City via a better control of School building and consequently reduction of atmospheric pollution

Progress of a less-energy-consuming behavior

Promotion of local renewable energies

Preparation of the City for sustainable development

Conclusions

The expected rise in energy prices from their current low levels, and the possible introduction of energy taxes to account for the environmental and social costs of energy consumption, are likely to ensure that energy management will become increasingly important in future.

Finally the implementation of energy management system must be adopted by the European Municipalities, for all Public buildings, because is the only way for a sustainable development which can lead to a sustainable society.

References

Axaopoulos P. (2000). Energy management system in Greek School building. International workshop on "Eco - Audit in European Municipalities" May, Regensburg - Germany.

Axaopoulos P. (1998). Environmental management handbook. Technical report submitted to E.U. Project LIFE.

Campbell J. (1988). Use of passive solar energy in offices. In passive solar energy in buildings. Watt committee report number 17. Elsevier Applied Publishers.

CIBSE (1996). Guide, Volumes A, B and C: Chartered Institute of Building Services Engineers, U.K.

Crisp V. H. C., Littlefair P., Cooper I., and McKennan G. (1986). Daylighting as a passive solar energy option. Final report to the energy Technology Support Unit. Garston, Watford.

Curtis D. (1988). Opportunities for use of passive solar energy in educational buildings. In passive solar energy in buildings. Watt committee report number 17. Elsevier Applied Publishers.

Development, Introduction and Implementation of an Environmental Management System in medium-sized municipalities in Europe (1998). Project LIFE.

Duncan, I. P. and Hawkes, (1983). D. Passive solar design in non- domestic buildings. A report to the Energy Technology Support Unit. Martin Centre Building Design Partnership, Harwell.

Energy Audits and Surveys: Applications manual. (1991). Chartered Institute of Building Services Engineers, U.K.

Energy Efficiency Survey Scheme – An energy saving success.(1985). London Energy Efficiency Office, London.

Energy in Europe : Annual energy review (1995). DGXII, CEC.

Energy Management System.(1995). European Commission, Directorate General XII.