Energy effective solutions for buildings with BEMS use

K.P. Papageorgiou and A.M. Papadopoulos

Laboratory of Heat Transfer and Environmental Engineering, Dept. of Mechanical Engineering, Aristotle University Thessaloniki, Greece

N.P. Kallergis

Tellogleio Foundation of Arts Museum, Aristotle University Thessaloniki, Greece

ABSTRACT

Developments in the construction sector of a country consist of an unbreakable part of the changes that take place in its energy sector. The beginning of the imposition of the Kyoto Protocol, the implementation of the European Directive on the energy efficiency of buildings the need of the harmonisation of the Directive with the national legislation and finally the dramatic increase of oil's price, demonstrate that the issues that should be in the first line of interest and must focus on the sustainable growth of the society are the rational use of energy and the promotion energy that is generated by renewable sources.

Therefore aiming to achieve higher goals, new progressive methods and improved construction products are frequent for use. Building's energy management is a complex issue. It presupposes knowledge of constructional solutions and right combination of construction materials. The result is a complete approach of the internal environment, heating, cooling and ventilation systems, and all the particular characteristics of a building, (materials used and construction methods)

Simultaneously, the new age of information technology amplifies the growth of "Smart Buildings" which can fill all requirements of someones needs, which operate with energy saving criteria, using automatic systems.

In this paper is presented, beyond the theoretical background of "Smart Buildings", an implementation that combines higher gumption, and was applied in the Tellogleio Foundation of Arts Museum, of Aristotle University of Thessaloniki, with an installation study of a new Building Energy Management System (BEMS). The system combines all the advantages that arise from new technology advances with the special characteristics of the Museum, too. That emphasizes the flexible character that this system has. According to that, BEMS can be applied in each type of building. According to the bioclimatic design and the need to estimate and to maintain an energy efficient environment they will offer the required comfort of the indoor environmental conditions to the building's users.

1. INTRODUCTION

During the last years the building sector has focused on the use of automated systems. An imperative need in the construction sector became the utilisation of new technologies. The use of new technologies will offer to its users better living conditions and will give them the opportunity for energy saving.

Taking into consideration, that building sector consumes 30% of primary energy, it becomes articulate that the rational use of energy is essential. The energy saving will be accomplished by using both traditional and modern methods in existing or in new buildings.

Building energy management systems (BEMS) are able to satisfy the energy saving demands in current buildings, particular in those with special needs and with controlled conditions, like museums. Such a BEMS was applied in the Tellogleio Foundation of Arts Museum, of Aristotle University of Thessaloniki, which constitutes a characteristic example of museum in the Hellenic space.

2. BUILDING ENERGY MANAGEMENT SYSTEMS (BEMS)

The BEMS (Building Energy Management Systems) or, as they are widely known, BMS (Building Management Systems), are systems that supervise and control the electrical-mechanical installations of a building, focusing in energy conservation through their ability to monitor with a high level of accuracy. Generally, BMS are reported as systems that supervise and control the buildings infrastructures, with a view to amplify the factors that are responsible for the profitable and the safe operational use of any electromechanical system that is inhered in a building. In that way the above electromechanical installations operate in order to execute their operation as scheduled, according to their operation-time plan, between the limits that have been forecasted based on the conditions (control commands), which have been drawn by the study. Besides, it becomes possible to record the energy consumption of the building in regular time basis (daily, monthly, annually) and to create an observe-file.

Furthermore, the safe operation factor of the whole system possesses a distinguished role. The automatic activation of alarms (moved graphic in the PC, sound signals, e-mail messaging, telephone calls e.t.c.), informs the one responsible for the proper function of the BMS for a possible overshooting of the operation. Access in the system, mainly when there are more than one control stations (PC units), is being made by following level access arrangement, for better observation aims, and control of the installations, for safety reasons.

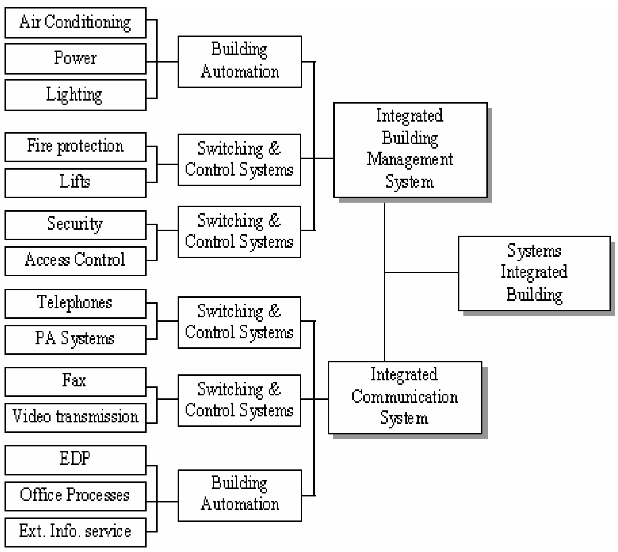

Figure 1: BEMS configuration.

BEMS are integrated systems, which are structured by a large number of sensors, activators, controllers and calculating provisions that regulate the operation of energy systems based on desirable values of given parameters in order to form the indoor microclimate environment of a building.

The function ability of such a system is based on four consecutively stages: the detection or measurement, the control, the supervision and finally the user's interaction. In the first stage the parameters that influence the indoor environmental conditions are detected or measured with sensors, e.g. temperature, humidity and also the air supply of the air conditioning system. In the stage of control, suitable correctional and directive operations take place. These operations depend on the parameters' values that have been detected, measured, or they depend on the control strategy, that has been selected for application. In the supervision stage, applied strategies and their performance are being recorded in order their evaluation and optimisation, to be attainable. Also, in the stage of user interaction, the user can intervene to the control strategy in order to take proper measures for the circumstance decisions of the preventive maintenance and the general adjustment of the system. Finally, in the safety level, the user has the opportunity to handle directly any malfunction of the systems handling, through a network system.

The building digitalisation capability, with computer-based design tools offers increased flexibility in order to monitor and manage all individual systems of a building infrastructure. The control, the adjustment and the maintenance of the supervised systems can be done effectively in short time as the technical personnel can recognize and repair easily any problem. Especially, it is quite easy:

- To control the cooling and thermal energy production units.
- To control the amount of energy that is distributed to the consumption points.
- To control the energy consumers.
- To control the air distribution and control systems (fresh and conditioned air).
- To control all electrical installations.

- To monitoring malfunction situations in various systems such as: elevators, telephone centre and movement detectors.
- To control the fire safety system.

In the case where a PC is used, the technician's prospects are:

- Adjustment of parameters.
- Storage of parameters.
- Comparison of controller's parameters with the basic set-points.
- Recording and storage of the measured values and ability of graphical representation.
- Creation of commissioning report.
- Malfunction history report.

Finally, it must be stressed that there is a potential of remote monitoring and control of the installation through internet based tools. In addition the automatic creation and mission of mobile messages (or fax), indicates the malfunction point and the maintenance need. In this case, the technician is aware of the damage and he has the possibility to run control tests on the system and to change the network's operation parameters, in order to stabilise the system.

With the above process it is being carried out a full-scale approach of the building's control project and also the energy management is achieved in the best possible way, according to the development demands of the energy market.

3. CENTRAL CONTROL UNIT

The "heart" of the automatic control system is the central possessing unit (controller), which is programmed to receive and to record the sensor signals. With suitable possessing, after careful programming, messages are transported to the actuators, which are responsible for controlling a functional part of the installation (motors, automatic control system for closing down the windows. Messages, also, are responsible for the cutting of a PV system's installation, which stops the electrical supply from the PV panel and activates a battery storage system, etc). This unit possessing functions can be structured in a simple or in a much more sophisticated and integrated way.

The controllers are the main part of the control system. They receive and decode the signals that are sent from the sensors. Later, they send the commands to the actuators. The size of the central control unit depends on a lot of factors, some of them are:

- Economic, they depend on the allocated capital.
- The indoor conditions that prevail in the building.
- The complexity of building.
- The requirements for adjustment and control.
- The network constructional capability.
- The outdoor environment conditions.

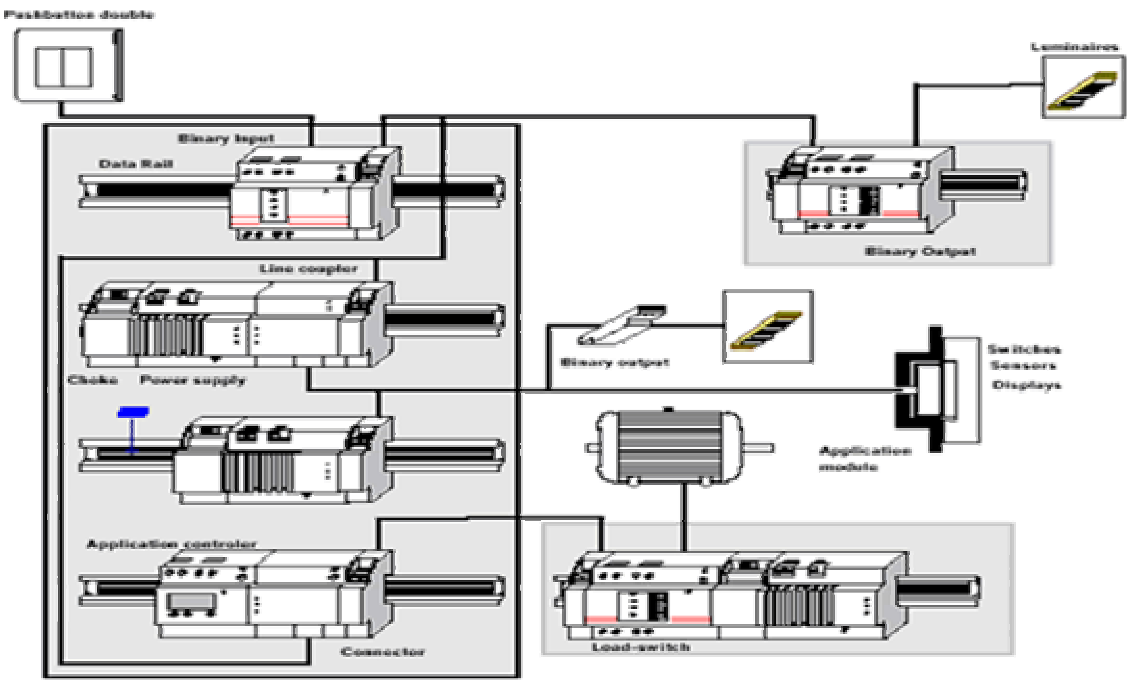

Figure 2: The configuration of the system management.

Photo 1: Modular PLC.

In large multifunctional buildings and in complicated industrial applications the systems that are used are mainly systems with the integration of PLC units (Programmable Logic Controller). In those cases there is an increased need for control because there are many parameters that enter into the system's operation.

A PLC is an autonomous programmed unit which decodes various signals, with digital or analogue entries. Those control a number of valves and relays and they are connected to the various points of the electronic network. In that way they are able to control all of the electrical and mechanical installations.

They are classified in two categories depending on the cross-correlation of its functional pieces (electrical supply, processor, input/output):

- Modular PLC. In those, the functional pieces are installed separated on a special base (Photo 1).
- Compact PLC. In those, the functional parts are placed in a common unit.

4. SPECIAL BUILDING

The museums are multiuse buildings and multi gathered places. In that way, they should be in position to satisfy the visitor's needs and requirements. This aim is achieved through an increased utilization of energy systems which consume great amounts of energy. The needs that must be covered are: the safety, functionality of the infrastructure, the services, the preservation and the conservation of the exhibited items. In a few words, energy consumption is reported in: lighting, safety system, systems of intercommunication, electric appliances, heating and cooling systems and also in systems that offer the chance to the user to have direct interaction with the exhibits like electronic maps, digital exhibits, etc.

Furthermore, the sensitivity of the exhibits imposes the creation of special indoor climatic conditions, which should be fully controlled during the whole season by sensors with a view to the proper conservation of the exhibits. Lighting, indoor temperature, humidity, indoor air flow, are some of the factors that define the indoor microclimate.

In order to maintain the above conditions in the limits that are determined by museum's standards, it is necessary the determined operation and the electromechanical equipment rendering to be ensured from accordingly specific design study.

The system that will be installed should operate by receiving as parameters the energy conservation, the safety, the easy monitoring from the personnel, the easy maintenance and of course the compatibility of all the building systems.

Such a system was applied in the Tellogleio Foundation of Arts Museum.

5. CASE STUDY

The Tellogleio Foundation of Arts Museum is accommodated in an architectural pioneering building of 5,500m^2. The buildings' construction was completed in 1998. A basement, a ground floor and two floors constitute the whole building. In the basement there is only the engine room, the museum storehouse and spaces of common use. In the ground floor, first and second floor is the museum's exhibition. Also, in the ground floor the amphitheatre, the library and the offices of the technical department, are situated there, too. In the first floor there is also a souvenir shop, a buffet and some other certain auxiliary spaces. In the second floor stand, the offices of the museum and the boarding's council hall. The total volume of the building is 7274.17m^3.

In the internal spaces electric lightning elements of high output are being used because the natural lighting causes a not well distributed lighting and glare phenomena. Furthermore aging effects are being caused to the exhibits. There is a mechanical ventilation system in order to maintain the indoor conditions in desirable temperature and humidity levels, beyond 20-25°C and 40-45% equivalent. In the building it is also installed a central heating and cooling system, which consumes big amounts of energy because it has to operate for long time intervals under special circumstances.

An energy audit that was been held in the museum, indicates that big amounts of energy are being consumed according to the lack of insufficient energy management of building systems.

The equipment of museum includes:

- 2 boilers of capacity 700 and 200 Mcal/h, the smallest works as a backup, for the covering of the thermal needs during the heating period.
- 2 cooling towers with 113 KW each, the one covers the building's needs and the other is a backup.
- 1 pump-room, which constituted by 9 circulators.
- 6 air-conditioning split-units.
- 1 ventilation unit, which produces fresh air for all the essential air renewals in all the spaces.
- 1 electrical substation, which can cover the increased requirements in electric energy of the mechanical equipment, the lighting and other various appliances that consume electric energy.
- 2 transformers.
- 1 series of capacitors for "cosφ" correction.
- 1 UPS that provides protection and the possibility of continuous operation of the centre control of the building that includes the computers and the safety system.

In the building operates an old system, which should be replaced. The new BMS, that will be installed, is called to not only to manage and to check the electromechanical equipment, the fire safety system, the other security systems and lighting (natural or artificial) but also to supervise the operation of various systems, as the elevator, the telephone centre and the photovoltaic windows' system that is going to be installed in the future. Also, a BMS is installed with a view to provide the possibility of remote control and intervention.

The energy consumption in the museum is increased, because of the special type of the building and it is characterized by complexity in the operation and in the control of the energy systems. The basic factors that determine and form the energy consumption are the required indoor conditions that should follow specific standards, mainly because the exhibits are influenced even by small indoor changes.

Furthermore, the attendance of visitors in the space is an important factor that should always be taken into consideration as it appears variability proportional to the exhibition that is presented.

Concerning the present study, the oil consumption was 300,500 kWh and the consumption of electric energy was 318,000 kWh, and so the total consumed energy corresponds in 619,000 kWh and the specific consumption reaches 112.5 kWh/m^2. It is high enough due to the fact that the heating and air conditioning systems are over dimensioned in order to operate with any kind of needs and to save energy at the same time. In addition, the system was over dimensioned because of the museum's extension of museum that has been forecasted in the future.

The energy savings that can be achieved with the use of BEMS is 20 - 30%, by taking into consideration the seasonal character of the presented exhibitions. According to that, the Museum could save about the 120,000 kWh of energy, allocating the proportional sum in other activities.

Taking into consideration the savings that can be achieved; the board of the Museum has decided to place a new BMS system. The objective of this is the control of all the energy systems in order to succeed in the rational use of energy, the improvement of the indoor environmental quality and the proportional reduction of operating costs.

6. CONCLUSIONS

It is explicit that upgrading the control systems of the building or placing new ones, there will provide an efficiency increase for 20 - 30%, which affects drastically the reduction of operational expenses of the building resulting to the stable operation of its systems in all levels, from its energy independence, to the provision of better services to its users. Regarding the personnel of the museum, their working conditions will be improved, and their productivity will increase too. Also, in this way the preventative maintenance can be scheduled, offering the ability for ideal effective maintenance of the system and its directed impact to the general management of the infrastructure.

The building energy management system (BEMS) installation is a wise investment. It provides the possibility of reinvesting the amount that might have been spent for the payment of energy expenses. Specifically, in public buildings, where budgets are limited, it provides big flexibility in the disposition of financial resources in other deliberate investments. Furthermore, the objective value of the building is increased; and this resulting to its social and institutional profile. Gathering all the above thoughts it is concluded that public buildings should be guiding examples for all the rest of building types.

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