Supervisory control of an intelligent building in Greece using EIB – KONNEX technology for energy performance improvement

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ABSTRACT

The paper describes the design and control methods for many aspects of energy consumption in a building, mainly lighting and heating / cooling, using the EIB / KONNEX technology. The basic objective is to present a modularly expandable and generally adaptable technology in order to progress from the stage of individually designed systems towards to wide range reliable integrated systems. It is shown that this technology provides the most reliable solution for controlling such systems, because of its standardization. Supervisory control and energy management of an intelligent building using EIB – KONNEX technology can be sent by the exploitation of EIB Power Line Communication. Finally, an energy saving of 50% can be achieved by using this technology.

1. INTRODUCTION

The concept of an intelligent building is, and will probably remain, ill-defined. In its most general sense it should mean a building that in some way can sense its environment, reach decisions about the state of that environment and communicate those decisions. In practice this should mean that a building can adjust some aspect of the interior or exterior environment in response to a change in some other aspect of that environment.

As trends in modern residential building construction tend to energy conservation and higher efficiency, the passive solar airtight home (R2000 in Canada) is fast becoming a standard. One such home is analyzed in [1] using a two-year set of measurements from a high temporal resolution data logging station. The overall energy-conserving performance of the home is determined and related to other previous structures. Short-term effects are investigated with a view to relating them with owner/operator control of the home's airhandling systems. It is found that in these structures, setback thermostats may be counterproductive and manual dehumidistat control leads to a complex set of interactions much beyond the scope of even knowledgeable home owners to predict. This suggests the requirement for intelligent automated control of residential air-handling systems. Another study [2] deals with two methods for modelling and estimating the daily and annual variation of soil surface temperature. Soil surface temperature is an important factor for calculating the thermal performance of buildings in direct contact with the soil as well as for predicting the efficiency of earth-to-air heat exchangers. The two estimation methods are a deterministic model and a neural network approach. The two methods are tested and validated against extensive sets of measurements for bare and short-grass covered soil in Athens and Dublin. Finally, the comparison of the two models showed that the proposed intelligent technique is able to adequately estimate the soil surface temperature distribution. This work can be incorporated in a Decision Support System handling energy management of an intelligent building.

A new approach for short-term load prediction in buildings is shown in [3]. The method is based on a special kind of artificial neural network (ANN), which feeds back a part of its outputs. This ANN is trained by means of a hybrid algorithm. The new system uses current and forecasted values of temperature, the current load and the hour and the day as inputs. The performance of this predictor was evaluated using real data and results from international contests. The achieved results demonstrate the high precision reached with this system. This work can be incorporated in a Decision Support System handling energy management of an intelligent building too. Another study [4] presents a multi - criteria decision-making model for lifespan energy efficiency assessment of intelligent buildings (IBs). The decision-making model called IBAssessor is developed using an analytic network process (ANP) method and a set of lifespan performance indicators for IBs selected by a new quantitative approach called energy–time consumption index (ETI). In order to improve the quality of decision-making, the authors of this paper make use of previous research achievements including a lifespan sustainable business model, the Asian IB Index, and a number of relevant publications. Practitioners can use the IBAssessor ANP model at different stages of an IB lifespan for either engineering or business oriented assessments. Finally, this paper presents an experimental case study to demonstrate how to use IBAssessor ANP model to solve real-world design tasks.

2. EIB – KONNEX TECHNOLOGY

In this paper another strategy is adopted for energy management in intelligent buildings. It uses the EIB building installation technology [5]. EIB is an innovative building installation technology ("bus system") which has been promoted since 1990 by the EIBA group of manufacturers (EIB association) which has its headquarters in Brussels. EIBA is involved with issuing trademarks, testing and quality standards, standardization and marketing activities.

The flexibility and modularity of European Installation Bus (EIB / KONNEX) [6] technology using twisted pairs, power lines and radio frequency media in combination with the availability of compatible components by a growing number of large manufactures are some of its major assets.

Various methods have been developed in facing the traffic congestion in domestic networks so far. However, all these methods can be applied through the EIB / KONNEX technology. Especially, compatibility is achieved by using EIB / KONNEX standard interfaces. The advantages of this solution are high reliability, simple expandability as well as simple installation, use and maintenance.

Furthermore, exploiting the communication via power lines, a low cost energy management for lightning can be integrated in it, achieving significant energy saving by using dimming scenarios at certain time periods.

The Advantages of EIB are:

Increased safety

Economic use of energy during the operation of buildings

Simple adaptation of the electrical installation to the changing requirements of the user

Higher degree of convenience

The above arguments are evaluated differently from the point of view of the client or the user of the installation e.g. functional building compared to residential building, able-bodied people compared to disabled people, young people compared to elderly people Devices from different manufacturers and functional areas that are supplied with the EIB trademark can easily be linked to form a functioning EIB installation.

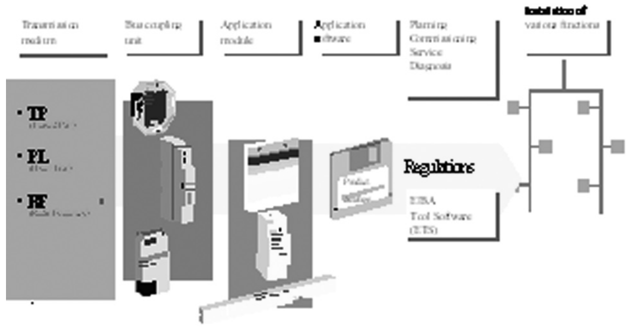

Figure 1: The EIB (bus system) architecture.

EIB installations can easily be looked after by any trained EIB installer as there is only one uniform, PC-based project design and maintenance tool called ETS (EIB Tool Software). This tool does not require any programming knowledge. Any installer/ planner who has been trained in accordance with EIBA guidelines can use the EIB partner logo and is held on a list. The Success Rate is:

more than 4,000 registered and certified EIB products

more than 100 EIBA members

more than 70 recognised training schools

more than 6 European test sites

more than 10,000 implemented projects

more than 10 million installed EIB products (as at middle of 2000)

3. RESULTS

The aforementioned technology was applied to the Georgiadis building [7].

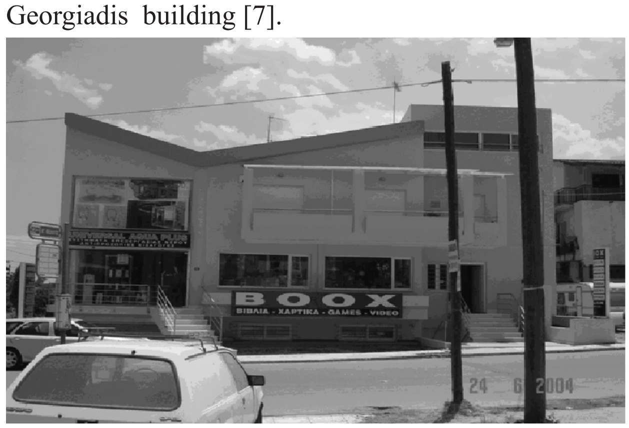

Figure 2: The building of application (Georgiadis, Athens).

The Georgiadis building is located in Athens, near the airport and consists of: an apartment in the first floor; an attic; a bookshop (Boox) and a shop that sells desalination plants in the ground floor; and an office room with a DVD club in the basement. The KNX/EIB system has been installed in all the building for controlling the lighting and the heating/cooling system of each area. The conventional security system has been interfaced to KNX system for activation/deactivation of the heating/cooling system of every room.

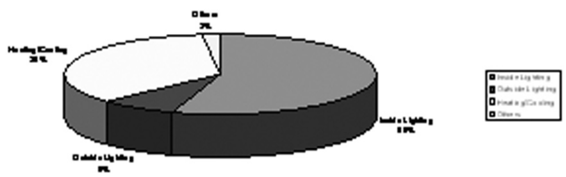

Figure 3: Boox Energy Consumption

A Supervisory Control and Data Acquisition (SCADA) monitors the Boox energy & power consumptions, and all the inside and outside temperatures. The SCADA acquires also the beam & diffuse solar radiation on horizontal level. The Finite Difference Calculation Method (FDC) has been programmed and operates in on-line mode under the SCADA. An Energy Management System based on FDC has been implemented, achieving energy saving especially during summer with higher degree of convenience. Furthermore, lighting and heating/cooling control have been also integrated. The SCADA in co-operation with an ADSL line accomplish remote control and increase safety issuing web cameras video through Internet – SMS and Phone Call in the case of an alarm.

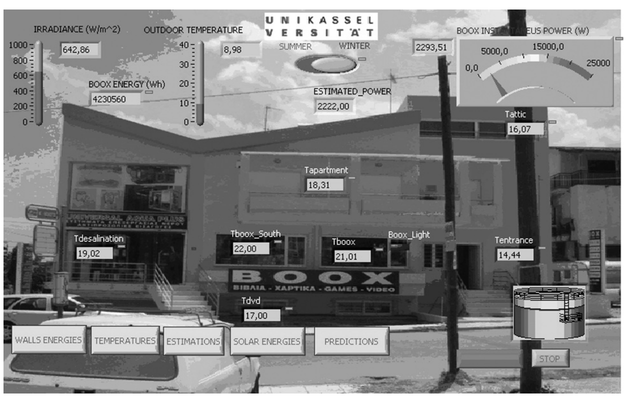

Figure 4: The Georgiadis Building SCADA.

Lighting Control

Lighting control has been implemented in the Boox and DVD Club as follow:

Boox

A Presence Detector, a dimmer for controlling digital electronic ballasts and a binary input for the connection of the conventional alarm system have been installed in the Boox. When the Boox is opened and a customer is inside in it, the lights are controlled by the presence detector according the solar radiation in the boox. The brightness value of the presence detector is set by the user through the SCADA. The switch off time is set by the user via the proper potentiometer of the Presence Detector.

When the Boox is opened and no any customer is inside except the employee, the presence detector switch off the lights after a certain period, while at the same time the SCADA measures the outside solar radiation and dims the lights to a minimum brightness. This helps the customers outside the shop to realise that the shop is opened, while achieving energy savings.

When the Boox is closed, the alarm system gives this information to the KNX/EIB. The SCADA exploits this information by the OPC Server, and when the outside solar radiation is above from a threshold, the lights are switched off, while in the opposite case (during night), they are dimmed to 10%. It is noted that the presence detector controls the lights independently if the Boox is opened or closed or if it is day or night.

The quality of the lighting is increased considerably making both customers and employees to be impressive by this functionality The energy saving is more than 35%, and the pay back period is 1.9 years resulting energy savings 4,290KWh/year and saved 3,432 Kg CO2/year.

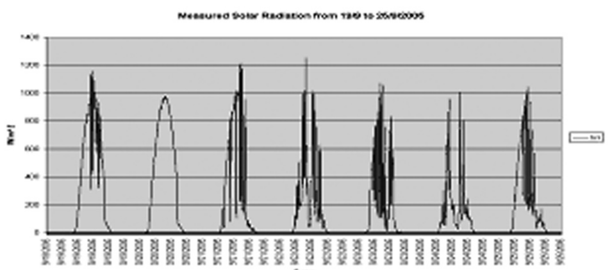

Figure 5: Typical solar radiation profile.

DVD Club

A Presence Detector, a Binary output for switching On/Off the electronic ballasts and a binary input for the connection of the conventional alarm system have been installed in the DVD Club. The DVD Club is in the basement and so the solar radiation which comes inside the shop is not considerably enough in order to use dimming control. When the presence detector is activated by a customer the lights are switched On and. when there is not any customer but only the employee, or when the DVD Club is closed the lights are switched off after a certain time. The switch off time is set by the user via the proper potentiometer of the Presence Detector. The energy saving is more than 40% by this functionality as it is depicted in the figure below and the pay back period is 3.9 years resulting energy savings 1,284KWh/year and saved 1,028 Kg CO2/year.

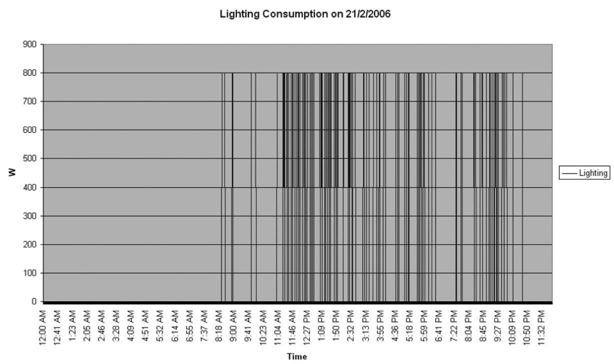

Figure 6: DVD Lighting Consumption

Heating and ventilation Control

Every heat pump in the corresponding room for heating/cooling operation is controlled through KNX/EIB devices. A thermostat, a binary output for switching on/off the heat pumps and binary input for the connection of the conventional alarm system have been installed in every room. In the most cases the thermostat has been programmed so that the range of the setpoint to be from 18 until 21 degrees centigrade during winter and from 24 until 27 degrees centigrade during summer. Taking into account that a temperature change from e.g. 21 to 20 degrees centigrade the energy savings are up to 10%, therefore more than 10% is achieved by this functionality. Furthermore, during normal operation of the building, the heating/cooling system is switched off in the corresponding area, when a window or a door opens for a certain time. This information is received by the conventional alarm system through the corresponding binary input. The monitored measurements from the SCADA, by using this strategy, proved energy savings of about 20%.

The SCADA using the Finite Difference Calculation Method (FDC) evaluates the efficiency of the heat pumps. On the other hand the efficiency of the insulations of the building is monitored continuously and the repair can be made at the right time. For this reason, the SCADA issues an Alarm to the user informed him that should maintain the heat pumps or the wall insulations. The control of this can result energy savings of more than 50% when the maintenance is accomplished at the right time.

The total energy saving by this functionality in the Boox is about 35%, and the pay back period is 6.8 years resulting energy savings 1,470KWh/year and saved 1,176 Kg CO2/year. However it could be more than 50% exploiting the FDC method for the maintenance of the heat pumps at the right time.

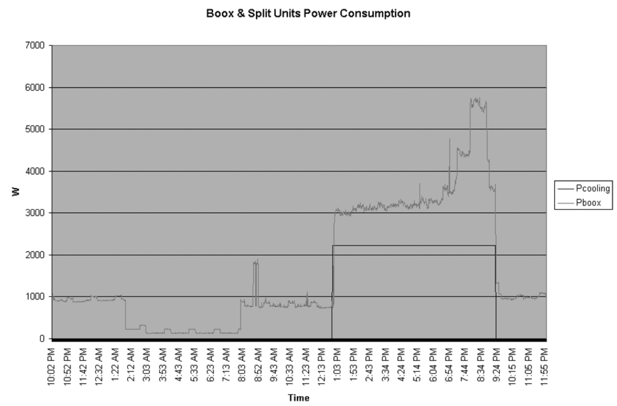

Figure 7: Typical Boox daily load profile and heat pump consumption.

In the DVD Club there is a ventilation system where it cleans the air from a smoke pollution. Usually, the employee used to switch on this, forgetting to switch off after some period. By using a push button and a properly programmed binary output, when the ventilation system is switched on it will be switched off after 10 minutes resulting considerably energy savings.

4. CONCLUSIONS

The advantages of the European Installation Bus (EIB / KONNEX) Technology is presented in this paper for supervisory control and energy management of an intelligent building using EIB – KONNEX technology. It is shown that this technology provides the most reliable solution for controlling such systems, because of its standardization. Furthermore, the communication through OPC Server makes possible the supervisory control and energy management of an intelligent building using EIB – KONNEX technology via several Visualization Software packages. Supervisory control and energy management of an intelligent building using EIB – KONNEX technology can be sent by the exploitation of EIB Power Line Communication. Finally, an energy saving of 50% can be achieved by using this technology.

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