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Energy Efficiency Approach to Intelligent Building

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Abstract: Energy efficiency has nowadays become one of the most challenging tasks and this has boosted research on fresh fields, such as Ambient Intelligence. Energy consumption in the housing and tertiary sectors is especially high in developed countries. There is a great potential for energy savings in these sectors. Energy conservation measures are developed for newly constructed buildings and for buildings under restoration. However, to achieve a significant diminution in energy consumption apart from the standard energy-efficiency methods, pioneering technologies should be implemented, including renewable energy.
Now, buildings are increasingly anticipated to meet higher and more complex performance requirements. Among these requirements, energy efficiency is renowned as an international goal to promote energy sustainability. Different approaches have been adapted to concentrate on this goal, the most up to date relating consumption patterns with human occupancy.
Energy efficiency is keywords that can be originate these days in all domains in which energy demand exists. A significant aspect that can improve the energy efficiency in buildings is the use of building automation systems. Alternatively, building automation systems are usually not considered for energy conservation, as they are mostly used for comfort and safety. This consistently causes immense problems due to an fruitless use of these systems and unawareness of energy consumption. It is therefore essential that the existing system solutions are adapted to focus on energy conservation. Our research approach in developing an intelligent system to improve energy efficiency in intelligent buildings, which takes into account the different technical infrastructures of building.

Key Words: Energy Efficiency1, comfort2, Safety3, and Building Automation System4.

I. Introduction

Residential and commercial buildings represent one of the highest energy consumption fields in the world. This trend is predominantly well-defined in developed countries, where between 20% and 40% of the total energy consumed is related with buildings. International actions to progress energy efficiency in buildings have already been proposed. Decline of the carbon footprint on a global scale as well as ensuring energy efficiency of buildings are key goals of high superiority for multi-disciplinary researchers in the fields of building engineering and energy policy.

It is predicted that by the year 2020, over two-thirds of the world's population will be living in urban areas. Rapid urbanization in recent years has caused cities to be overloaded and heavily polluted, but with this brings the need for space. Society's distressed attempt to resolve this problem comes in the form of the high-rise building also known as the skyscraper. This is just one of the reasons explaining the need for large buildings. Supplementary reasons include the population outburst and the increased scale of large corporations and institutions. For whatever reason the building might be built, one fact cannot be disputed: Large-scale buildings are here to stay. However, they do bring with them their share of problems that need to be solved. These include air circulation and control, temperature control, lighting, and large amounts of energy usage and wastage as a result of inefficient and ineffective policies and procedures. Intelligent buildings provide a solution to not necessarily dispose of the problem altogether, but to curtail it to the lowest level possible.
The technological aspect of such a system is composed of operations that can be divided into four categories, Energy efficiency, Life safety systems, telecommunication systems and workplace automation. It is assumed that an ideal intelligent building integrates all four of these aspects into one computerized system.
According to Akin Adejimi [1] Energy efficiency continues to be a top priority in Building and Facility Management. This is because it forms the largest chunk of the building's running cost. The goal of energy-efficiency in Intelligent Building is therefore to reduce the energy consumption or cost to the barest minimum without sacrificing occupants comfort. Intelligent buildings are designed and managed to meet changing environmental conditions, businesses, and other human needs. For this, computerized systems are used extensively. Such systems come in different names e.g. Building Automation System (BAS), Energy Management System (EMS), Energy Management and Control System (EMCS), Central Control and Monitoring System (CCMS) and Facility Management System (FMS). In all these systems, energy is managed to achieve maximum output for the minimum cost. Light is switched on or off or dimmed as the need arise. Energy saving in an intelligent building is realized by controlling heating, ventilation, air-conditioning (HVAC), lighting, and anything that uses energy. Examples include lights that are automatically switched off, and the room temperature being adjusted appropriately in an empty room. Enhancement of customer value is realized through taking into account the desiderata of the people in the building, for instance, by adapting the conditions in the room e.g. temperature and light intensity according to each person's personal preference. Series of computerized thermostats

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provide automatic control on the building's temperature based on mode (Day, Night, Away, etc.). The technology ensures the ultimate comfort and at the same time saves money and time.
Energy efficiency is the use of less energy to provide the same service. Energy conservation is the reduction or sacrifice of a service to save energy. Devoid of looking too far, businesses can find an abundance of lists and information offering smart ideas on building energy efficiency. However, many small to medium size organizations are challenged to find the necessary time, resources, and understanding of energy management.
Save Energy Systems recognizes the impact that time, resources, and smart building myths have on small to medium size organizations throughout the development and execution of smart building energy efficiency strategies.

Building Energy Management Systems:

According to Environment and Green Technologies Department (Enterprise Ireland) [2] Buildings account for about 40 % of total energy consumption and contribute significantly to overall carbon emissions worldwide. Commercial buildings make up a large part of this. In the U.S. alone businesses spend in the region of $100 billion on energy for their buildings. In Asia, economic growth and a shift towards service based economies will expand the need for commercial buildings. This provides scope for substantial cost savings – for the U.S. estimates predict that smarter buildings could save $ 20 -25 billion in annual energy costs.
There are a number of different ways companies can reduce the energy consumption of their buildings. Buildings can be designed more efficiently at the planning stage, which even as ideal is not always an option. Existing buildings can be retrofitted to improve energy efficiency - which can be capital exhaustive and troublesome. Another option is to use software to ensure buildings utilize energy efficiently. Building Energy Management Systems (BEMS) are computerized systems that enable building operators to monitor and control building systems including heating, ventilation, air conditioning and lighting. They often require minimal capital investment and result in little site disruption.
The opportunity BEMS can provide for energy savings is largely untouched today as many building owners and operators are not aware of how data driven optimizations can reduce energy consumption. As per Analytics software [3] can help detect and address many sources of waste such as:

- HVAC (heating, ventilation, and air conditioning) equipment that is simultaneously heating and cooling a given space due to a failed sensor or other fault.
- Technicians dealing with low priority or false alerts about building anomalies, while the notification system fails to highlight other issues of greater impact.
- Default configurations for all systems and pieces of equipment, meaning they run at suboptimal set points and are rarely updated after initial configuration.
- Lack of visibility and attention to energy waste on the part of occupants and building engineers.
- HVAC and lighting systems running at full capacity during periods when buildings are largely unoccupied.

II. Result of the study

The utilizable literature sources clearly indicate significant potential for optimization regarding reduction of the energy consumption by the use of modern electrical installation systems: [4]
The average value of all the sources results in a saving potential in the range of:

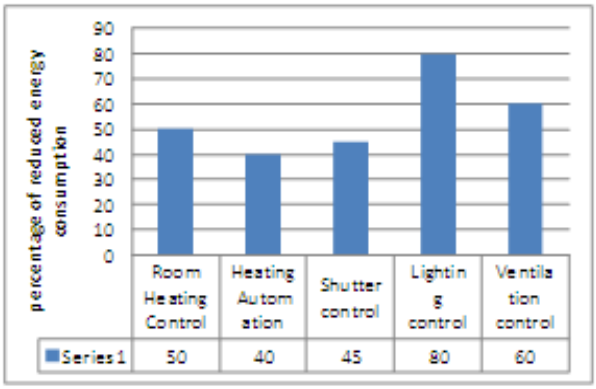
Room Heating control	approx. 14 - 25 %
Heating automation	approx. 7 - 17 %
Shutter Control	approx. 9 - 32 %
Lighting Control	approx. 25 - 58 %
Ventilation Control	approx. 20 - 45 %

Table 2.1 Potential Savings According to Scientific Studies. [Source: Energy Efficiency with ABB ibus-KNX]

In total, this results in an average energy saving by general measures and optimization of the control engineering in the order of approx. 11 to 31 %.
In principle, optimization of the energy consumption
in buildings means:
– Energy is only consumed when it is actually needed
(For example through the usage of presence detectors)
– Only the amount of energy actually required is used
(for example through the use of constant lighting control)
– The energy used is employed at the highest possible degree of efficiency (for example through the use of electronic ballasts)
Using the versatile functionality that intelligent building control offers real energy savings can be made.

Reduced energy Consumption

Reduced energy consumption through utilization of intelligent building control in houses and buildings Maximum values in the study "Energy saving potential using modern electrical installations"



Graph 2.1 Reduced Energy Consumption [Source: Energy Efficiency with ABB ibus-KNX]

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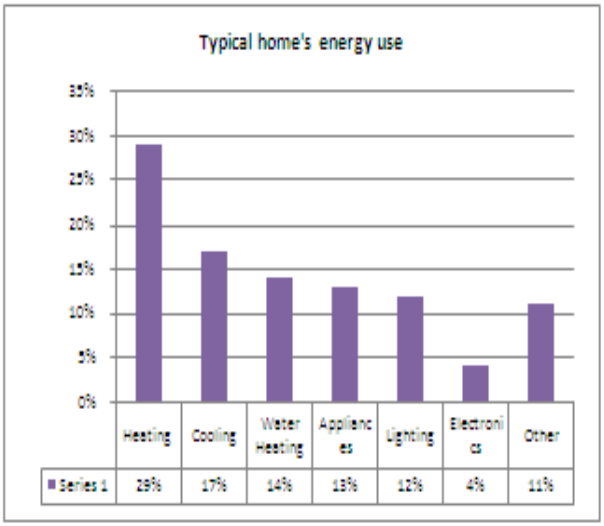
2.2 Saving energy with temperature control

Heating and cooling accounts for more than 40% of a typical home's energy use. Controlling temperature with a programmable thermostat can help you save 16% of the energy used on HVAC.



Graph 2.1: Typical home's energy use [Source: Typical House memo, Lawrence Berkeley National Laboratory, 2009 and Typical house_2009_Reference.xls spreadsheet.]

III. The European Standard EN 15232

Around the world new legislation is promoting the use of energy efficient technologies. The European Standard EN 15232 ("Energy performance of buildings – Impact of Building Automation, Controls and Building Management") was compiled in conjunction with the Europe-wide implementation of the directive for energy efficiency in buildings (Energy Performance of Buildings Directive EPBD). The standard describes methods for evaluating the influence of building automation and technical building management on the energy consumption of buildings. Four efficiency classes A to D have been introduced to this purpose. After a building has been equipped with building automation and control systems, it will be assigned one of these classes. The potential savings for thermal and electrical energy can be calculated for each class based on the building type and building purpose. The values of the energy class C are used as the reference for comparing the efficiency.

The following diagram shows the differences in energy consumption for three building types in the energy efficiency classes A, B and D relative to the basis values in rating C. For example, by using class **A,** 30 % of the thermal energy can be saved in office. [5]

efficiency classes to EN 15232	Efficiency factor for thermal energy			Efficiency factor for electrical energy		
	Office	School	Hotel	Office	School	Hotel
A	0.70	0.80	0.68	0.87	0.86	0.90
B	0.80	0.88	0.85	0.93	0.93	0.95
C	1	1	1	1	1	1
D	1.51	1.20	1.31	1.10	1.07	1.07

Table3.1 Building Automation and Control (BAC) efficiency classes to EN 15232 [Source: A new European standard EN15232: "Energy performance of buildings - Impact of Building Automation, Control, and Building Management"]

- **A-** High energy performance building automation and control system (BACS) and technical building management (TBM)
- **B-** Advanced BACS and TBM
- **C-** Standard BACS
- **D-** Non energy efficient BACS

IV. Building management systems and intelligent buildings - energy savings

According to Kourosh Mousavi Takami [6], until recent years, energy efficiency has been a relatively low priority and low perceived opportunity to building owners and investors. on the other hand, with the dramatic increase and alertness of energy use concerns, and the advances in cost-effective technologies, energy efficiency is fast becoming part of real estate management, facilities management and operations strategy. The concepts are also now making significant inroads into the domestic residential house building sectors.

For lighting, energy savings can be up to 75% of the original circuit load, which represents 5% of the total energy consumption of the residential and commercial sectors.
Energy savings potential from water heating, cooling, or hot water production, can be up to 10%, which represents up to 7% of the total energy consumption of the domestic residential and commercial sectors.

Experiences from studies in Austria suggest potential heating and cooling energy savings are up to 30% in public buildings. Even allowing for the fact that buildings used in the study may have been those with particularly high energy usage, the figure is an impressive one.

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Intelligent Buildings and Building Management Systems technologies contribute directly to the reduction in energy use, in commercial, industrial, institutional, and domestic residential sectors. In short, Intelligent Buildings and suitably applied Building Management Systems are good for the environment. Careful interpretation is required. In the UK, adoption of controls technologies into the new build and major refurbishment sectors is relatively high: Estimates a few years ago of the UK market for Building Management Control Systems for new build and major renovation, all sectors, suggest market adoption of (as at 1994 - Source UK1 An Appraisal of UK Energy RTD, ETSU -1994):

- Heating controls 70%.
- Hot water system controls 90%.
- Air conditioning controls 80%.

However according to European Commission as many as 90% of all existing buildings have inapplicable or ineffective controls, many of which require complete refurbishment of control systems. Moreover, conventional control systems stop short of automated Intelligent Buildings full capabilities. A significant human element is required for optimal effective operation even if control systems correctly specified and installed. Given typical installations and equipment there is often a difficulty for building occupants (residential) or managers (commercial) to operate them correctly. Usage and correct operation are vital for effective results. Education of users; improved systems-design user friendliness, and the provision of relevant instructions and information are all critical to enable theory to 198 translate into practice, and for potential effectiveness and savings to be realized.[5]

Building management systems and intelligent buildings - practical benefits

Energy-effective systems balance a building's electric light, daylight, and mechanical systems for maximum benefit. Enhanced lighting design is more than an electrical layout. It must consider the needs and schedules of occupants, seasonal and climatic daylight changes, and its impact on the building's mechanical systems. [7]

Lighting systems

Adding daylight to a building is one way to achieve an energy-effective design. Natural daylight 'harvesting' can make people happier, healthier, and more productive. And with the reduced need for electric light, a great deal of money can be saved on energy. Nearly every commercial building is a potential energy saving project, where the electric lighting systems can be designed to be dimmed with the availability of daylight. **Up to 75% of lighting energy consumption can be saved.** In addition, by reducing electric lighting and minimizing solar heat gain, controlled lighting can also reduce a building's air conditioning load.

Mechanical systems

The HVAC system and controls, including the distribution system of air into the workspaces, are the mechanical parts of buildings that affect thermal comfort. These systems must work together to provide building comfort. While not usually a part of the aesthetics of a building, they are critical to its operations and occupant satisfaction.
The number one office complaint is that the workplace is too hot. Number two is that it's too cold.

Many people cope by adding fans, space heaters, covering up vents, complaining, conducting 'thermostat wars' with their co-workers, or simply leaving the office. Occupants can be driven to distraction trying to adjust the comfort in their space. Improper temperature, humidity, ventilation, and indoor air quality can also have significant impacts on productivity and health. When we are thermally comfortable we work better, shop longer, relax, breathe easier, focus our attention better. [6]

In order to provide a comfortable and healthy indoor environment the building mechanical system must:

- Provide an acceptable level of temperature and humidity and safe guard against odors and indoor air pollutants.
- Create a sense of habitability through air movement, ventilation, and slight temperature variation.
- Allow the occupant to control and modify conditions to suit individual preferences

Simple measures- massive savings

Energy used in buildings typically represents about 40 % of all energy used in society. Existing technologies such as proper insulation and windows with low heat loss substantially reduces energy. Furthermore, undertaking energy renovation when buildings in any case are in need of repair makes it even more financially beneficial. Simple measures carry massive savings.

Building Management Systems and Intelligent Buildings - Environmental and Greenhouse Gas Benefits

According to Frank Bisbee [7] Greenhouse gas emission reductions depend on and correlate to reductions in energy use. Intelligent Buildings and Building Management Systems technologies contribute directly to the reduction in energy use, in commercial, industrial, institutional, and domestic residential sectors. In short, Intelligent Buildings and suitably applied Building Management Systems are good for the environment.
Legislation and environmental standards; health and safety regulations; and global trends towards improving indoor air quality standards are all significant drivers of - and provide a continuous endorsement of the need for - Building Management Systems and the Intelligent Buildings technologies.
Government Initiatives around the world are also driving the development and adoption of Building Management Systems technologies. For example, the UK Carbon Trust allows Enhanced Capital Allowance (ECA) to be offset against taxation on energy efficient systems, which enables savings of

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around 30% for all energy-related Building Management Systems and Intelligent Buildings equipment, and the associated installation and design costs.

V. Conclusion:

1. Energy efficient buildings can contribute significantly to energy savings and thus global climate protection.
2. Manage and promote optimization of energy use.
3. Install energy efficient equipment to reduce overall energy consumption.
4. Maintain, repair and automate existing HVAC, lighting, water and power systems as well as other essential equipment.
5. Track consumption and analyze market data for better understanding and control of your facility's energy usage.
6. Use actionable recommendations for energy improvements and savings.
7. Intelligent energy-efficient buildings are expected to be an important part of future energy systems. There are practically no limits to the number of functions that can be incorporated. Measurement, analysis, and control are important prerequisites for effective energy management. Integrating energy-consuming components with energy-producing ones and incorporating intelligent buildings into the energy system saves energy costs and reduces CO2-emissions.
8. Efficiency in respect of receiving the highest possible output from the lowest available input. One example could be the energy supplied to a building. The efficiency of the energy usage must be at or very close to 100%. Most previous researches conclude that intelligent building is in fact highly efficient rather than intelligent. If a building is 100% efficient, then it could be said to be intelligent.

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