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An Integrated Approach to Optimize the Energy Consumption using Sensors in a Climate Friendly Building

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Abstract—*Climate change, caused by the release of greenhouse gases mainly carbon dioxide into the atmosphere, has been recognized as one of the greatest threats of the 21st century .Being the largest primary energy consumers, buildings make the world's biggest contribution to this growing menace 1. World studies have acknowledged, buildings were responsible for 7.85Gt, or 33% of all energy-related CO2 emissions worldwide and these emissions are expected to grow to 11Gt or15.6Gt by 2030.In developed countries such as US and UK, energy use in the building stock is responsible for producing about 50% of the nation's CO2 emissions. India is also emerging as a large consumer of electricity, not only at industrial level but also as a domestic consumer due to continuously improving life style. This paper emphasizes on providing best comfort levels to building occupant with low energy consumption and Light control system not only for economic reasons but also to keep the environment clean and healthy. Energy conservation and environment control is the need of the day keeping good compromise with occupant comfort levels.*

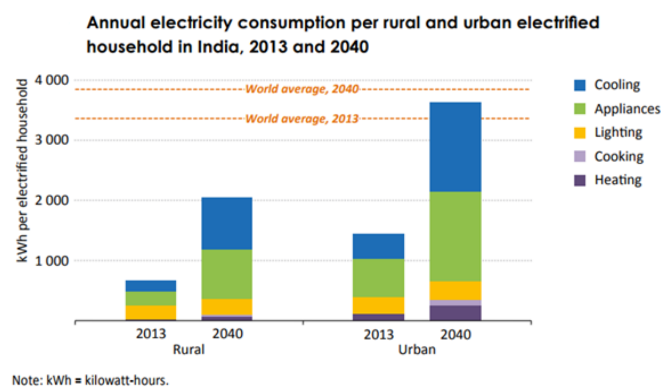
Keywords*: HVAC,PCM,BGB,GHG,EMS*

1. INTRODUCTION

India continues to develop; by 2030 it is likely to have GDP of 4 trillion USD and a population of 1.5 billion. Energy consumption in India and China is also on the raise due to sharp urbanization, population explosion, and intensive growth of IT and related business[3]. Buildings account for more than 41% energy consumption in developed countries. Energy consumption in building is mainly for building services like, HVAC, lighting, water heating, pumping and fan amount to 40%. It is said that 18-20% of primary energy and 40% of total consumption takes place developed countries like US and USA, office buildings use about 16% more.

The total amount of energy used by commercial buildings has risen significantly since the 1980s, reflecting a 50% growth in the total amount of office space available and a 33% increase in energy consumption per square foot of space(Rocha et al., 2015). The result is a 70% overall increase in the amount of energy used by commercial buildings since 1980.

Bright Green Building(BGB). Bright green building is one that is both intelligent and green. It is a building that uses both technology and process to create a facility that is safe, healthy and comfortable, and enables productivity and well being for its occupants another concept in the area of energy efficient and environment friendly building is the emergence of. It provides timely, integrated system information for its owners so that they may make intelligent decisions regarding its operation and maintenance, and has an implicit logic that effectively evolves with changing user requirements and technology, ensuring continued and improved intelligent operation, maintenance and optimization. A bright green building is designed, constructed[(4)], and operated with minimum impact on the environment, with emphasis on conserving resources, using energy efficiently and creating healthy occupied environments. Sustainability is measured in three interdependent dimensions: environmental stewardship, economic prosperity and social responsibility. Bright green buildings exhibit key attributes of environmental sustainability to benefit present and future generations.



2. STEPS TOWARDS CLIMATE FRIENDLY BUILDING

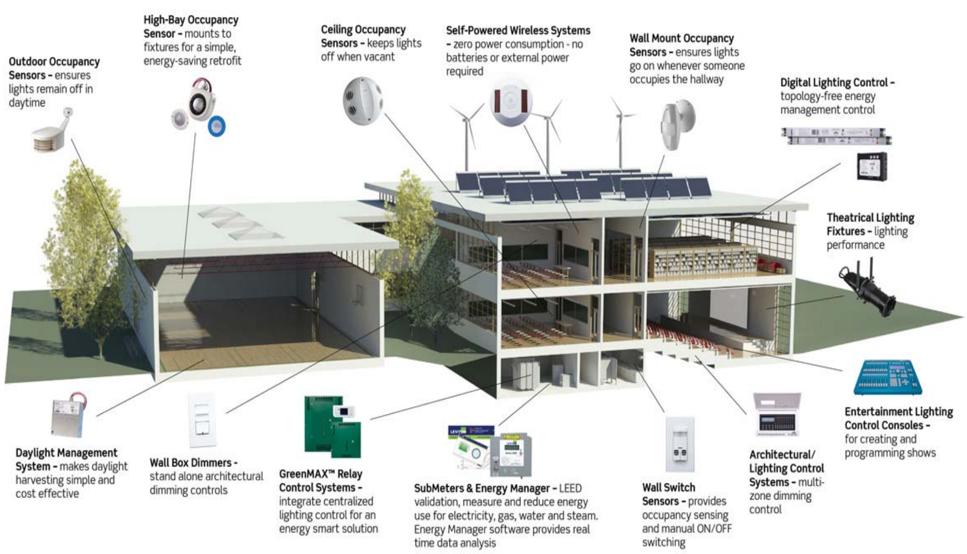
Phase change materials (PCMs) represent an innovative solution that can contribute to the improvement of the energy performance of buildings. Recently a trend towards integrating PCMs into transparent envelope components is observed. This study aims to present the main solutions proposed in the literature for applications in the past few years for PCMs integrated into transparent buildings elements. The temporal development of this application as well as the fundamental principles of its operation is described in detail. The concept of the existing transparent PCM systems is presented, and the rationale of selecting appropriate materials is discussed. This is followed by the current practices in testing the thermal performance of transparent PCMs. The future trends in terms of the current barriers and the potential improvements are discussed.

The promotion of buildings' energy efficient design is one of the main priorities of the research community in the building sector. A novel approach, which in recent years gaining more and more ground, is the use of phase change materials (PCMs). PCMs have the ability to change their phase (typically from solid to liquid and vice versa) at room temperature. This results to the storage of the amount of latent energy which is required to change the phase of the material. PCMs represent a highly efficient solution, as their use improves building shell's energy management. In particular, the use of these materials enables the better management of the energy flow to and from the building, decelerating in this way the rate of thermal losses. PCMs thermal performance is a challenging scientific field as the phase change is accompanied by a change of the materials 'key properties, such as the heat capacity and thermal conductivity.

PCMs are used in a range of applications in the technical and building sector. In the latter case, they are mainly use din opaque components, typically in walls and ceilings. Lately, the use of PCM-doped infrared reflective coatings was reported. However, in the recent years, a trend towards integrating these materials into transparent envelope components or employing transparent PCM in building systems is being observed. This review work focuses on the transparent glazing systems that incorporate PCMs, and considering the fact that these building components, particularly in warm dominant climates, are more vulnerable to thermal losses due to their higher thermal transmittance and higher radiation losses, this incorporation is of special importance.

3. USE OF SENSORS IN BUILDING FOR ENERGY SAVING AND CLIMATE CONTROL

As buildings become more energy efficient, small power equipment such as computers are an increasingly significant source of energy end-use. A study published by the New Buildings Institute, suggests that plugs loads can represent up to 50% of the electricity use in buildings with high efficiency systems. Office buildings are likely to have higher cooling demands in the future due to climate change, emphasizing the need to better understand(and reduce) the impact of internal gains from IT equipment. Predicting internal heat gains accurately is of great importance in order to ensure that building systems are designed and operated as efficiently as possible. The use of nameplate electrical power ratings significantly overestimates the internal heat gains, which results in the specification of chillers with a higher capacity than needed. This can result in increased capital cost as well as higher operating costs through longer periods of inefficient part load operation. Nevertheless, detailed estimates of small power consumption are rarely undertaken and designers often rely on published benchmarks in order to account for small power demand in office buildings]. A review of published benchmarks for small power demand and consumption undertaken by the authors revealed that these are sparse, often out of date and broadly unrepresentative of small power equipment currently being used in UK office buildings. Overall, the approach of using benchmarks inherently fails to account for the variability of small power loads in different buildings, presenting an additional shortfall.



4. LIGHTING CONTROL SYSTEM

A lighting control system is an intelligent network based lighting control solution that incorporates communication between various system inputs and outputs related to lighting control with the use of one or more central computing devices. Lighting control systems are widely used on both indoor and outdoor lighting of commercial, industrial, and residential spaces. Lighting control systems serve to provide the right amount of light where and when it is needed. Lighting control systems are employed to maximize the energy savings from the lighting system, satisfy building codes, or comply with green building and energy conservation programs. Lighting control systems are often referred to under the term Smart Lighting.

The term lighting controls is typically used to indicate stand-alone control of the lighting within a space. This may include occupancy sensors, time clocks, and photocells that are hard-wired to control fixed groups of lights independently. Adjustment occurs manually at each devices location. The efficiency of and market for residential lighting controls has been characterized by the Consortium for Energy Efficiency. The term lighting control system refers to an intelligent networked system of devices related to lighting control. These devices may include relays, occupancy sensors, photocells, light control switches or touch screens, and signals from other building systems (such as fire alarm or HVAC). Adjustment of the system occurs both at device locations and at central computer locations via software programs or other interface devices.

Lighting control systems typically provide the ability to automatically adjust a lighting device's output based on:

1. Chronological time (time of day)
2. Astronomical time (sunrise/sunset)
3. Occupancy using occupancy sensors
4. Daylight availability using photocells
5. Alarm conditions

Energy Management Software (EMS) is a general term and category referring to a variety of energy-related software applications which may provide utility bill tracking, real-time metering, building HVAC and lighting control systems, building simulation and modelling, carbon and sustainability reporting, IT equipment management, demand response, and/or energy audits. Managing energy can require a system of systems approach.

Energy management software often provides tools for reducing energy costs and consumption for buildings or communities. EMS collects energy data and uses it for three main purposes: Reporting, Monitoring and Engagement. Reporting may include verification of energy data, benchmarking, and setting high-level energy use reduction targets. Monitoring may include trend analysis and tracking energy consumption to identify cost-saving opportunities. Engagement can mean real-time responses (automated or manual), or the initiation of a dialogue between occupants and building managers to promote energy conservation. One engagement method that has recently gained popularity is the real-time energy consumption display available in web applications or an onsite energy dashboard/display.

Nergy Management Software collects historic and/or real-time interval data, with intervals varying from quarterly billing statements to minute-by-minute smart meter readings. The data are collected from interval meters, Building Automation Systems (BAS), directly from utilities, directly from sensors on electrical circuits, or other sources. Past bills can be used to provide a comparison between pre- and post-EMS energy consumption.

Electricity and Natural Gas are the most common utilities measured, though systems may monitor steam, petroleum or other energy uses, water use, and even locally generated energy. Renewable energy sources have contributed to the spurred growth in EMS data collection markets.

Reporting tools are targeted at owners and executives who want to automate energy and emissions auditing. Cost and consumption data from a number of buildings can be aggregated or compared with the software, saving time relative to manual reporting. EMS offers more detailed energy information than utility billing can provide; another advantage is that outside factors affecting energy use, such as weather or building occupancy, can be accounted for as part of the reporting process. This information can be used to prioritize energy savings initiatives and balance energy savings against energy-related capital expenditures.

Bill verification can be used to compare metered consumption against billed consumption. Bill analysis can also demonstrate the impact of different energy costs, for example by comparing electrical demand charges to consumption costs. Greenhouse gas (GHG) accounting can calculate direct or indirect GHG emissions, which may be used for internal reporting or enterprise carbon accounting.

Monitoring tools track and display real-time and historical data. Often, EMS includes various benchmarking tools, such as energy consumption per square foot, weather normalization or more advanced analysis using energy modelling algorithms to identify anomalous consumption. Seeing exactly when energy is used, combined with anomaly recognition, can allow Facility or Energy managers to identify savings opportunities.

Initiatives such as demand shaving, replacement of malfunctioning equipment, retrofits of inefficient equipment, and removal of unnecessary loads can be discovered and coordinated using the EMS. For example, an unexpected energy spike at a specific time each day may indicate an improperly set or malfunctioning timer. These tools can also be used for Energy Monitoring and Targeting. EMS uses models to correct for variable factors such as weather when performing historical comparisons to verify the effect of conservation and efficiency initiatives.EMS may offer alerts, via text or email messages, when consumption values exceed pre-defined thresholds based on consumption or cost. These thresholds may be set at absolute levels, or use an energy model to determine when consumption is abnormally high or low. More recently, smart phones and tablets are becoming mainstream platforms for EMS.

Engagement can refer to automated or manual responses to collected and analysed energy data. Building control systems can respond as readily to energy fluctuation as a heating system can respond to temperature variation. Demand spikes can trigger equipment power-down processes, with or without human intervention. Another objective of Engagement is to connect occupants' daily choices with building energy consumption. By displaying real-time consumption information, occupants see the immediate impact of their actions. The software can be used to promote energy conservation initiatives, offer advice to the occupants, or provide a forum for feedback on sustainability initiatives.

People-driven energy conservation programs, such as those sponsored by Energy Education, can be highly effective in reducing energy use and cost. Letting occupants know their real-time consumption alone can be responsible for a 7% reduction in energy consumption.

5. CONCLUSION

It is the demand of the day that techniques are to be applied to minimize pollution and create a climate friendly building structure pattern with minimization of energy required. Sensors made for specific purpose of application are the best options for lighting control systems and other energy requirements as in a progressive world today Energy control in a climate friendly mode is the backbone of development for a country.

6. FUTURE PROSPECTS

Further analysis can be made for customized demand for the sensors application in given buildings using software's like Energy plus, safaira, E-Quest GBS etc. for minimizing the energy consumption meeting all requirement of occupant comfort levels and at the same time maintaining the LEED instructions to be climate friendly.

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