IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 11, Nov 2022

A Review Study on Lighting Control Technologies in Commercial Buildings

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ABSTRACT: Lighting accounts for a large part of a building's energy usage. Automatic lighting control systems save energy by reducing lamp running times depending on variables such as occupancy, time of day, and daylight availability. Lighting control may be accomplished using a variety of methods. At the moment, one of the major areas of electrical engineering research is energy efficiency. The increasing need to preserve diminishing global resources, as well as growing worries about the environmental effect of traditional energy sources, has prompted greater research and attention to find more efficient and smarter methods to utilize electrical energy. Reduced energy use implies lower energy bills, less strain on the grid, and less environmental effect. These technologies vary in terms of input parameters, control technique, control algorithm, installation cost, commissioning difficulty, and so on. Each control system has its own set of variables that influence its success in terms of energy savings and user acceptability. The purpose of this article is to look at the many kinds of control systems, the development of their associated technologies, the savings claimed from their use, and the variables that influence their performance.

KEYWORDS: Building, Control, Energy, Lightening, Technology.

1. INTRODUCTION

The most frequent and presumably the most consistent kind of burden is lighting. It accounts for a substantial percentage of overall energy usage across all building types, with commercial buildings accounting for the majority of it. Lighting, for example, accounts for 14 percent of energy use in commercial buildings, according to the US Department of Energy. Other studies have shown that in certain instances, the average illumination demand may be considerably greater. According to a European research, interior lighting consumes approximately 40% of total energy in medium and big buildings [1]–[8]. When it comes to energy usage, commercial buildings are very important. Commercial buildings, for example, use nearly one-third of the total primary energy demand in the United States. If office buildings are examined individually, lighting energy demand may account for 25–35 percent of total energy usage. As a result, reducing the lighting load in commercial buildings may have a substantial beneficial effect on lowering power consumption, which in turn helps decrease carbon footprint, which is now a major priority for energy engineers. Various countries, worldwide and regional organizations advocate particular energy saving standards for lighting systems, taking into account the energy effect of lighting systems. As a result, experts have been working hard to improve lighting efficiency, which involves maintaining optimal lighting conditions while using as little energy as possible [9]–[11].

Various kinds of lighting control systems have been shown to save money in studies. The majority of manual lighting controls are based on occupant behavior, occupancy patterns, and general energy conservation awareness. Different kinds of switching systems may be used to control lighting installations at the user level. Simple on/off choices are provided by traditional switching systems. Users may lower the intensity of the lights using dimming regulators, however the lamps

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must be controlled by dimmable ballasts in that case. Electronic switches that are more sophisticated may be designed to work in a variety of ways, such as toggling or increasing strength in stages. Advanced building automation systems, which include the capacity to install computer-controlled lighting systems, give greater flexibility in terms of user control. Users may adjust the brightness level and other settings directly from their computer displays in such situations. Furthermore, devices are now on the market that enable internet connectivity to be regulated through smartphone applications. These technologies provide users new and more flexible methods to manage lighting situations. However, there are many distinct technologies that operate beyond the user end when it comes to automating the light switching or dimming procedure. These methods differ in terms of the parameters they use to regulate the lights. The purpose of this article is to talk about these technologies.

The technology and complexity of automatic systems varies greatly. The automated controls may be used to turn on or off the lights at a basic level, and they can also adjust the amount of lighting depending on the need. It's important to keep in mind that any control system may not be appropriate for every. Varied workplaces have different illumination needs and occupant behavior that varies greatly. To guarantee occupant happiness and productivity, the selection of lights, luminaries, and control systems must be guided by those criteria. The tenant behavior of every kind of space or structure, depending on their type of activity, must be surveyed in order to effectively choose the appropriate lighting technology. This occupancy pattern will subsequently give information on how the room's occupants utilize energy in various areas.

There are many additional variables that influence the operation of control systems, including tenant use patterns, and these factors may be specific to a particular kind of control system. For occupancy sensors, for example, choosing between switching and dimming or between open and closed loop algorithms can be crucial in the success of the implementation; for daylight-linked systems, choosing between switching and dimming or between open and closed loop algorithms can be decisive in the success of the implementation. The influencing variables of these technologies vary since each of the control systems utilizes distinct parameters to regulate the illumination. Failure to correctly grasp these influencing factors may result in incorrect lighting control system commissioning, resulting in inefficient energy savings and low user satisfaction. As a result, the purpose of this literature review is to examine the influencing variables for each of these control methods and to analyze existing research to assess the effect of altering these factors on the lighting control systems' energy saving performance. The article also covers current and emerging trends in lighting control, as well as potential future work in this area.

1.1. Occupancy-based control systems classification:

The scheme may be one of two kinds, depending on the type of activities done by the controllers:

1. *Motion-based switching:*

This system turns on or off the lights depending on movement sensed by the occupancy sensor. The lights are turned off when the area covered by the sensor is empty for a certain time period. As soon as the sensors detect occupancy, they turn on. Obviously, the lower the delay setting, the more money you can save. However, in certain instances, especially in rooms with irregular occupant influx and egress, lower wait periods may create discontent among users, since they are often greeted with totally dark workplaces. Longer delay times, on the other hand, decrease the control system's energy-saving potential. As a result, it is self-evident that before installing the control system, the room or area's occupancy behavior pattern must be thoroughly investigated in order to achieve the best balance of energy savings and user happiness. For single workplaces, this kind of design is preferred.

2. Motion-based dimming:

This system can dim the lights when no one is there for a certain amount of time. It is possible to pre-set the brightness level to which the lights will be lowered in the event of no occupancy. This is more helpful in workplaces when users don't want to return to work to find the room totally dark, and the lights switch on as soon as they walk in. Although this method uses less energy than the previous one, it may be more pleasing to consumers since the transition from non-occupied to occupied state of lights is considerably smoother than an abrupt on-off switch. Because electronic dimmable ballasts are required to regulate the light output of the lights, this system has a greater installation cost than switching. In landscape offices, this kind of lighting control may be very helpful. If the room is split into several occupancy regulated zones, a general illuminance level may be maintained across the office floor when the workstations are vacant while still providing sufficient lighting for the current inhabitants. Instead of totally brilliant and dark areas, which may induce visual and psychological discomfort, this creates a smoother contrast between occupied and empty regions.

1.2. Techniques for detecting occupants:

There are many kinds of sensing systems that are based on the occupancy detection method. Ultrasonic and passive infrared (PIR) sensors are commonly utilized detecting technologies. New technologies such as Radio Frequency Identification (RFID) and digital imaging are also being developed and are gaining popularity. The next sub-sections will go through these technologies.

1.2.1. Passive Infrared (PIR) sensors:

The observation of a change in the temperature pattern in the sensor's detection zone is the basis of passive infrared (PIR) detection systems. In this instance, a Pyroelectric detector is used for detection. In this instance, the sensor is referred to as a "passive" sensor since it does not produce any energy. The sensitivity of these sensors is proportional to the distance between the subject and the sensor. The sensor's detecting accuracy decreases when the subject of heated body moves farther away. A frequent criticism about this kind of sensor is that it is prone to ‘False-off' problems, which means that the lights are turned off despite the presence of people. This is possible owing to the PIR sensors' detecting mechanism. The detecting zone of PIR sensors has gaps, which may be very large as you go farther away from the sensor. The sensors may not be able to detect movement inside these spaces.

1.2.2. Ultrasonic sensors:

The Ultrasonic occupancy sensor is the second most used occupancy detecting technology, and it has been in research and use for a long time. The Doppler Effect is used to operate these gadgets. They use ultrasonic sound waves to generate and compare reflected signals. When an ultrasonic sound wave is produced and reflected off a stationary object, the reflected signal has the same

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wavelength as the original. When the object is moving, however, the reflected signal will have a changing wave length. The fundamental concept of motion detection using ultrasonic occupancy sensors is the Doppler Effect. Because ultrasonic waves are reflected by room surfaces, unlike PIR sensors, ultrasonic occupancy sensors do not need a field of view. As a result, ultrasonic sensors are considerably better at detecting occupant motion, which is especially helpful in enclosed areas.

Research has shown the accuracy of ultrasonic sensors in detecting presence across great distances. In this kind of sensor, the increased sensitivity also creates issues. The sensor may be triggered by movements in the room that are not caused by human movement. As a result, 'False-on' mistakes in ultrasonic occupancy detection are frequent. It may catch up on movements of leaves outside the window and even air turbulence from workplace air conditioners in certain instances. Another drawback, similar to PIR sensors, is that when individuals move farther away from the sensors, the detection accuracy decreases owing to the progressive weakening of the reflected ultrasonic waves.

1.2.3. Radio Frequency Identification (RFID):

In lighting research, the use of Radio Frequency Identification (RFID) as a means of sensing occupancy is gaining traction. In workplaces, RFID tags are frequently used for employee identification. Tags are used inside ID cards to monitor the entry and leave times of office workers, students, and others because to their tiny size and low cost. Research indicates that current occupancy detection techniques may be improved using this existing technology. RFID may be used as a supplement to an existing occupancy monitoring system, according to some academics. The limitations of the current system may be reduced with the help of the additional information from the RFID system. They also suggested reducing the Time Delay (TD) setting of the lighting control system to save even more electricity. Because passive RFID tags rely on RFID readers for power, the researchers created an RFID 'gateway' in this instance.

The occupancy density and pattern are recorded by the gateway using flag statuses, which change when users enter and leave the control zone. Because the RFID tags are unique to each individual, the RFID detection system can offer not just occupant density, but also occupant profile, or knowing which inhabitants are utilizing the zone at any particular time. The control scheme may then regulate the lights relevant to the occupant entering or leaving the room after the information about each user's assigned workplace is programmed into the system. Due to the unreliability of passive RFID signals, this basic gateway method may sometimes fail to detect a tag, causing the zone to be considered empty even though it is occupied or vice versa.

1.3. Time Delay's Impact (TD):

The time delay settings are a significant element that influences the energy savings obtained by occupancy sensors. When the occupancy sensors indicate that an area is empty, the control system waits a certain period of time before turning off the lights. The occupancy sensor's Time Delay Setting is what it's called. This is done to reduce the number of times lights are switched on and off when people leave their area for a brief time. Frequent switching in these situations may be extremely upsetting for the occupants, and has been linked to control system complaints. The greater the energy savings potential by decreasing light use duration, the shorter the time delay setting. On the other hand, frequent switching of lights may shorten the life of the lamps and irritate the users of the space, leading to the decommissioning of the control system entirely. As a result, it is obvious that a balance between energy savings, product dependability, and user pleasure must be established.

1.4. Lighting control based on timers:

Scheduling-based lighting control systems work on a fairly basic concept of setting a light fixture's operational time. The lights regulated by the control system turn on and off according to a predetermined timetable. Because scheduling systems are dependent on time, they are most effective in regions where the occupancy pattern is well-known. Scheduling systems are ideal for use in rooms or places where activities take place over long periods of time. For example, a classroom could have a set pattern of holding lessons from 9:00 AM to 1:00 PM, then taking a one-hour break before starting again from 2:00 PM to 5:00 PM. In such a classroom, a simple time switch might be utilized to turn on the lighting system during class time and turn it off during lunch break and after class time.

Each of these systems has its own features, as demonstrated in the preceding discussion of the many lighting control methods presently in use. A specific control system may perform better in one circumstance than other schemes, but it may not perform similarly in other scenarios. Due to the inherent flaws in each technology, these technologies often fail to provide accepting results. Researchers have experimented with combining several kinds of control schemes in one system to overcome these drawbacks and guarantee optimum savings without sacrificing user pleasure. It has been shown that combining technologies improves performance significantly in terms of accuracy and energy savings.

2. DISCUSSION

Current lighting control research is pushing the boundaries of energy savings and user comfort even farther. The present state of affairs in this area may be viewed in two ways. Combined control systems save money. Individual lighting control technology development and development of integrated control ecosystems are two viewpoints. In terms of technological advancement, new techniques are becoming more prominent in study. Researchers are concentrating on enhancing detection utilizing image systems and RFID, as described in the preceding section, rather than depending on previously known techniques of detecting occupancy such as PIR and ultrasound.

Hybridization of control systems seems to be a promising area, with more and more researchers combining different control techniques. Apart from the preceding section's discussion of the integration of common control systems, there are many works that offer novel hybrid control systems. A combination system that uses automatic window blinds to regulate both the interior illumination intensity and the amount of daylight penetration is one such method.

An algorithm may be created by integrating the current published studies discussed in this article with further experimental analyses and simulations. This algorithm will consider different characteristics of a given area, such as room type, number of people, floor space, window area, and orientation, and will offer valuable information for selecting the optimal control approach. The algorithm may provide many choices utilizing a single or multiple control systems, and rank them

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according to their energy-saving potential. Users may make an educated choice based on the recommendations based on their energy savings goal and project cost. The development of such an algorithm may aid in decreasing the frequency of inadvertent control system application and tuning, thereby improving commissioning effectiveness and resulting in higher user satisfaction.

3. CONCLUSION

As can be seen from the analysis, lighting control systems may save a considerable amount of energy and reduce power bills. Reduced carbon footprint from lower energy consumption also has a beneficial environmental effect. However, each of the control technologies has its own set of characteristics that influence its performance. As discussed in this article, human behavior patterns, geometric characteristics of the space or structure, daylight entry, kind of work done, and other factors have a significant impact on lighting management systems. Only by thoroughly researching these variables can correct commissioning be carried out, resulting in significant energy savings and occupant satisfaction.

REFERENCES:

[1] Y. Zhang, X. Bai, F. P. Mills, and J. C. V. Pezzey, "Rethinking the role of occupant behavior in building energy performance: A review," *Energy and Buildings*. 2018, doi: 10.1016/j.enbuild.2018.05.017.

[2] L. Schwartz *et al.*, "Electricity end uses , energy efficiency , and distributed energy resources baseline," *Energy Anal. Environ. Impacts Div. Lawrence Berkeley Natl. Lab.*, 2017.

[3] M. Krarti, *Energy Audit Of Building Systems An Engineering Approach*. 2012.

[4] F. Motazedian and M. Mahdavinejad, "Light Shelves' Typology and their Characteristics," *Arman. Archit. Urban Dev.*, 2015.

[5] C. F. Reinhart and S. E. Selkowitz, "Guest editorial: Daylighting--light, form, and people," *Energy Build.*, 2006.

[6] T. Lawrence and K. W. Roth, *Commercial Building Toplighting: Energy Saving Potential and Potential Paths Forward*. 2008.

[7] T. Long, "Effectiveness of a Transitional Program for Youth with Emotional and Behavioral Difficulties," 2014.

[8] Ö. Göçer *et al.*, "A Ship in a Box.," *Appl. Mech. Mater.*, 2014.

[9] M. A. U. Haq *et al.*, "A review on lighting control technologies in commercial buildings, their performance and affecting factors," *Renewable and Sustainable Energy Reviews*. 2014, doi: 10.1016/j.rser.2014.01.090.

[10] R. Baetens, B. P. Jelle, and A. Gustavsen, "Properties, requirements and possibilities of smart windows for dynamic daylight and solar energy control in buildings: A state-of-the-art review," *Solar Energy Materials and Solar Cells*. 2010, doi: 10.1016/j.solmat.2009.08.021.

[11] S. E. Diaz-Mendez, A. A. Torres-Rodríguez, M. Abatal, M. A. E. Soberanis, A. Bassam, and G. K. Pedraza-Basulto, "Economic, environmental and health co-benefits of the use of advanced control strategies for lighting in buildings of Mexico," *Energy Policy*, 2018, doi: 10.1016/j.enpol.2017.11.028.