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IOT-based Energy Efficient Lighting as Emerging Technology

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Abstract: *Smart lighting control systems have emerged as a sophisticated means of reducing energy consumption.Advanced technology enables smart lighting control systems to afford greater user control by manually, remotely, and autonomously adjusting the brightness of lights, color, and timing. The review provides an overview of energy-efficient lighting technologies: LEDs, CFLs, and advanced controls in lighting. It describes the salient features and relative merits of each technology in saving energy and benefiting the environment. The review further discusses various benefits of energy- efficient lighting technologies, such as reduced energy use, lower operation and maintenance costs, and increased quality on account of better lighting. The discussion also involves ways these technologies help in energy conservation and sustainability, improving theoverall experience of the lighting for its users [2]*

Keywords: Energy-Efficient, Lighting, LEDs, CFLs,Halogen.

I. INTRODUCTION

The increasing demand for energy-efficient and sustainable indoor environments has led to the development of various smart lighting and energy consumption management systems. This is primarily because the energy use in office buildings is substantially influenced by electric lighting equipment.

Previous studies have shown that smart lighting can reduce energy consumption by up to 50% in indoor environments. Smart lighting enables the use of big data to enhance the efficiency of energy consumptionfor light usage[1].

For example, weather data have been utilized for further analysis to understand household behavioral energy consumption, and weather condition data, particularly daylight data, have been used to enhance smart lighting management systems for energy efficiency. The predominant method for handling large amounts of data involves the use of Internet ofThings (IoT) sensing devices, such as light, motion, relay, LCD, lux meter, occupancy sensor, and photocell sensors. These sensors are carefully integrated into either an Arduino or NodeMcu board. Sensors are then employed to regulate the luminous flux of light sources in indoor environments by implementing dimming control schemes [3].

This comprehensive approach aims to optimize energy savings based on real-time data, determine the best scenario, provide user recommendations, and ultimately contribute to the development of moreenergy-efficient and user-friendly smart lighting systems.

Significance:

1. Environmental impact: With decrease in energy consumption decreases the demand for power plants,leading to lower carbon emissions.
2. Enhanced Comfort and Ambiance: By automatically adjusting to the room's natural light and temperature, smart lighting systems create acomfortable and visually appealing environment.
3. Extended Lifespan of Lighting: Since lights are dimmed or switched off when not needed, this reduces the overall strain on bulbs, extending their life and reducing the frequency of replacements.
4. Reallocation of Conserved Energy: The energy saved by smart lighting can be redirected for use in other essential sectors like:

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5. Cost Savings: Using less energy, smart lighting helps reduce electricity bills in homes, offices, and public spaces.

Objectives:

- To minimize operational costs.
- To enhance the reusing and recycling of energy.
- To minimize the energy costs in the lightingsystem.
- To improve the use of energy-efficient lights.

II. MECHANISM

The structure of a smart lighting system that incorporates brightness control strategies typically involves three main components: the input, process,and output. The input component consists of a data collection method that collects data from various sources. Weather (daylight) data were retrieved by two open application programming interfaces (APIs) covering sunrise and sunset data, cloud cover percentages, and other related weather data. The useof sensor devices to detect the presence of people (occupants) and light intensity in an indoor environment. In addition, user interaction through the application prototype can be used to store user preferences. These preferences consist of changing the light source state (switching OFF/ON or changing the light source color) [2]. The process component is the process of processing all of the data, including the strategy used to determine the color change in the light source, which is then used to calculate energy consumption. The output component is the output of all input data, which has a direct effect on the light source of the lamp used and the real-time monitoring of energy consumption.

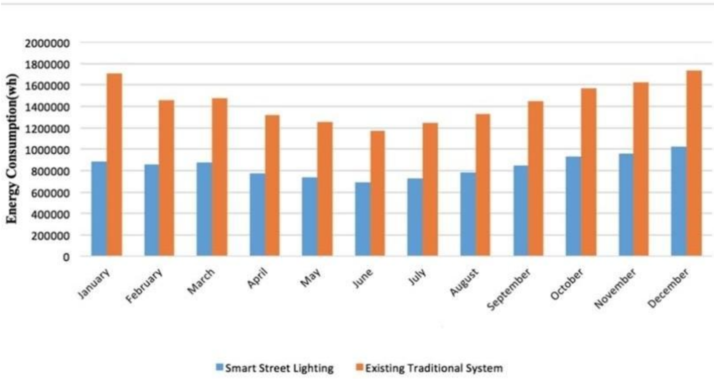

Figure 1: energy consumption of smart lighting and traditional lighting system [Source: ResearchGate]

Materials / Equipment:

Obviously, the type of bulb you pick can have quite an effect on energy savings and consumption. This isthe explanation for various kinds of bulbs and how much energy they can save:

Incandescent Light Bulb:

- Energy Use: These lightbulbs are the lowest in terms of energy efficiency. Only 10% of the energy is converted by them into light, whereas the energy remaining gets lost as heat.
- Compared to Others Life Expectancy: 1,000 hours isa relatively short life expectancy.
- Energy Efficiency: Limited; the real savings are made by moving from incandescent to more energy-efficient bulbs.
- Halogen Bulbs: Energy Use: Not as energy- efficient as more recent technology, but still marginally better than incandescent bulbs.
- Life Expectancy: Between two and four thousand hours.
- Energy Saving: Not as good as with incandescent bulbs, but still rather good.

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CFLs –

- Energy Consumption: These lights are much more efficient than incandescent bulbs, they use 70%-80% less energy for the same amount of light
- Life expectancy: About 8,000 to 10,000 hours.
- Save Energy: CFLs use up to 80% less energy in comparison to normal incandescent light bulbs.

Light Emitting Diodes (LEDs):

- Energy Use: Very efficient; utilizes about 75-80% less energy than incandescent bulbs and roughly 50% less energy than CFLs.
- Life Span: They have a very long life expectancy ofup to 25,000 hours or even longer.
- Energy Saving: Tremendous—equivalent to the highest savings in both energy and replacement costs.

IOT-based energy efficient lighting systems incorporate variety of different sensors to optimize maximum efficiency. Here are some of the sensors:

- Occupancy Sensor
- Daylight Sensor (Photocell)
- Motion Sensor
- Light Level Sensor
- Ambient Light Sensor
- Infrared Sensor
- Smart Light Controller
- Networked Sensor

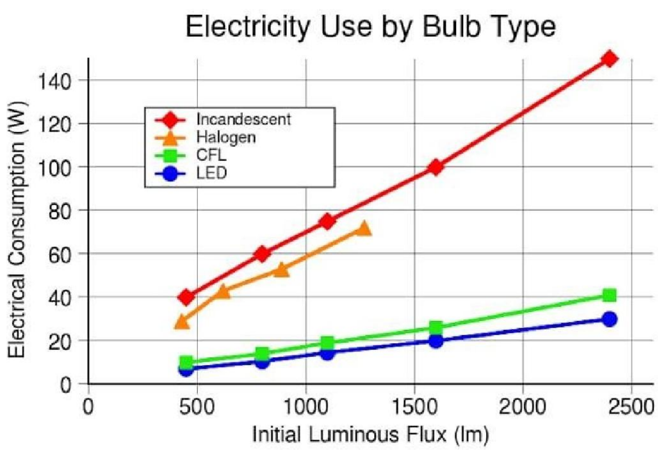

Fig no. 2: Types of bulbs and their energy usage [Source: Wikimedia Commons]

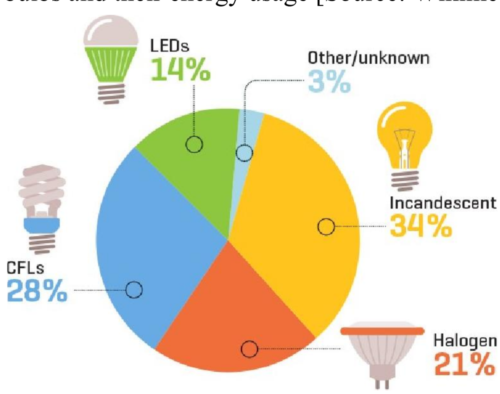

Fig no. 3: Types of bulbs used in household [Source: branz.co.nz]

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Relatable existing technology:

Several models have been developed, such as Bluetooth-based and IoT-based systems.

Smart Lighting Systems

- Philips Hue: A well-known smart lighting system that allows users to control their lighting via mobile apps, voice commands, or automated schedules. It integrates with sensors to adjust brightness based onthe time of day and occupancy.

IoT-Based Smart Lighting

- Internet of Things (IoT): IoT-enabled lightingsystems connect to the internet and allow centralizedcontrol over all lights in a building. These systems can use sensors, weather data, and user preferences to optimize energy use.

Bluetooth and Wi-Fi Controlled Systems

- Bluetooth-Based Systems: Such as the one developed by Wipro, where LED lights can be controlled via a smartphone app through Bluetooth, ensuring easy control and energy efficiency.

Fig no. 4: Smart lighting system [Source: wiprolighting.com]

- Wi-Fi Controlled Systems: These systems allow users to remotely control lighting via mobile apps, enabling energy savings even when users are not physically present.

Energy Management Systems (EMS)

- Building Management Systems (BMS): These systems integrate smart lighting with HVAC and other building controls to optimize energy usageacross an entire building. The smart lighting aspect of these systems helps in reducing energy consumption based on occupancy, daylight, and userpreferences.
- Efficient use of the energy being saved:

Rural Electrification

- Village Schools: The saved energy can be used to power schools in rural or remote areas. With reliable electricity, these schools can run computers, lighting, and other educational tools, improving the quality of education.
- Healthcare Facilities: Rural healthcare centres can benefit from the conserved energy to power essentialmedical equipment, lighting, and refrigeration for vaccines and medicines, providing better healthcare services.

Public Infrastructure and transport

- Street Lighting: Excess energy from smart lighting systems can be redirected to power streetlights, especially in underdeveloped rural areas. This improves public safety, facilitates night-timeactivities, and reduces crime rates in poorly lit areas.

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- Public Transportation Lighting: It can also be used topower efficient lighting systems at bus stops, train stations, or along transit routes, enhancing safety andvisibility.

Disaster Relief and Emergency Services

- Emergency Shelters: During natural disasters or power outages, the saved energy can be used to power emergency lighting, heating, andcommunications in shelters, improving disasterresponse capabilities.
- Critical Medical Equipment: Hospitals or emergencycentres could utilize saved energy to power life- saving medical equipment and ensure continuity of care during power shortages.

Versatility and adaptability:

Energy-efficient lighting systems are versatile and adaptable, suitable for commercial, industrial, residential, and outdoor use. They come in various styles, can be integrated with existing fixtures and control systems, and offer features like colour temperature and dimming. Smart technology integration allows for energy savings by adjusting lighting based on occupancy, time of day, or ambientlight levels. These systems can be scaled to fit different room sizes and perform well in various climatic conditions [3].

III. FUTURE SCOPE FOR DEVELOPMENT

The future of energy-efficient lighting systems holdspromising potential for further advancements and innovations. Here are some key areas of developmentto watch:

- Enhanced LED Technology: LEDs will continue to evolve with brightness, color accuracy, and energy efficiency improvements. Advances may include better light quality and the ability to mimic natural daylight more closely, benefiting both health and productivity.
- Smart Lighting Systems: Integration with smart technology will become more prevalent. Smart lighting systems can be controlled remotely, adjusted automatically based on occupancy or natural light levels, and be integrated with home automation systems for greater convenience and efficiency.
- Adaptive Lighting Solutions: Future lighting systems may feature adaptive technology that adjustslight output based on real-time conditions such as ambient light levels, user preferences, or activity. This could further optimize energy use and enhance user experience.
- Improved Photovoltaic Integration: Combining energy-efficient lighting with solar power sources could enhance the sustainability of lighting systems. Future developments may include more efficient solar panels and better integration with LED systemsto create off-grid or low-energy lighting solutions.
- Data-Driven Insights: The use of data and analytics to optimize lighting performance will become more common. Data collected from smart lighting systemscan provide insights into usage patterns, enabling more precise energy management and maintenance.
- Human-centric lighting (HCL): It is one of the latest additions to the innovative lighting solutions domain. It works in harmony with the earth’s natural lighting cycle to provide the right light intensity. It can be programmed to emulate daylight in workspaces to provide employees with the right level of alertness at all times.

Fig no. 5: how HCL changes the ambiance of a room [Source: RadiantVision Systems]

IV. CONCLUSION

This study successfully implemented The integration of accurate sensors and continuously updated daylight data to provide a strong foundation for intelligent decision-making in managing light sources. A rule-based heuristic algorithm approach relies on predefined rules or heuristics to make decisions, enabling decision-making based on a set of logical rules that correlate with the brightness value, daylight, and sensor data. These rules were developed by considering relevant factors such as natural light intensity, human presence, and weatherconditions.

The results of this study provide a strong foundation for the further development of smart lighting systems. The use of advanced daylight and sensor data, together with a rule-based heuristic algorithm, shows great potential for improving energy efficiency and reducing unnecessary consumption. In addition, this research also makes a significant contribution to the collection of data, which is essential for the development of a more efficient smart lighting system. Continuously updated daylight, sensor, and user data provide valuable insights into optimizing energy usage, particularly inindoor environments.

REFERENCES

[1]. https://www.mdpi.com/2079-9268/14/1/6 (13 November 2023)
[2]. https://www.mdpi.com/1996- 1073/13/21/5821 (5 August 2020)
[3]. https://www.aceee.org/files/proceedings/2004/data/papers/SS04_Panel3_Paper09.pdf