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# IOT POWERED - ENERGY EFFICIENT LIGHTING FOR SMART INDUSTRIES

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ABSTRACT:

The implementation of an IOT based energy efficient lighting system in industries enhances energy savings and improves industrial settings through intelligent lighting solutions. Node MCU, LDR sensor (Light Dependent Resistor), DS18B20 temperature sensor. The framework dynamically adjusts the brightness and colour temperatures based on habitation and nature light levels. Real-time sensor information and IOT network empower ideal lighting conditions, diminishing energy efficiency utilization essentially. During periods of high natural light or elevated temperatures, the system intelligently dims artificial lighting to conserve energy without compromising visibility or safety. Conversely, in low light or cooler conditions, brightness levels are increased to maintain optimal illumination. Certain lighting systems, particularly energy-efficient lighting systems that use low-wattage LED bulbs, which consume less energy than conventional lighting systems, can have a significant variation in power supply and voltage. As for voltage, it regularly depends on the electrical architecture of the industry and the lighting system's design. The IOT integration provides the lighting architecture to the administrator, alarms such as issues, downtime of potential utilisation and warning buzzer are designed to send an information to the administrator, if there any problems or support needs like defective bulbs or low battery bulbs. This equipments can be used to fix essential operations immediately. It moreover improves operational effectiveness by giving genuine time data to the administrator. This adaptive control mechanism not only reduces operational costs but also contributes to environmental sustainability by minimizing energy consumption and associated carbon emissions. The IoT architecture allows for remote monitoring, control, and maintenance, empowering facility managers to optimize lighting performance efficiently. This development of innovation not only priortize energy efficiency of effectiveness but leads to reduce energy consumption, lower electricity bills, and fosters environmental sustainability by promoting greener practices and too conveys are more wonderful and feasible lighting encounter.

KEYWORDS: Node-MCU, LDR sensor, Temperature sensor, Power supply and Voltage, Alert system and Buzzers.

## INTRODUCTION

The fourth industrial revolution is predicted to be fuelled by a wide range of contemporary technologies, including Internet of Things (IoT), intelligent robotics, and communication systems (like 5G) [1]. Because it enables seamless communication between them, IoT connects a multitude of devices, people, data, and processes. Because of this, IoT can assist in making many processes more quantifiable and measurable through the collection and processing of vast amounts of data [2]. Realtime decision-making that is more automated and tools that make it easier to optimize decisions like these make this possible.

When an intelligent energy efficiency system gathers a large quantity of data and compares it with correct data that is taken into consideration by industries to boost energy in smart industries, it can compromise control units and sensor networks [3]. The data is then evaluated using a platform. However, the cost of installing the various sensors needed for smart industry deployments and the difficulty of installing industrial energy management systems can often be a hindrance [4]. Even yet, IoT-IEELMS can lower the cost and labour of energy management system installation in smart industries [5].

Industrial lighting systems are traditionally based on fixed schedules or manual adjustments, which often lead to inefficient energy use and suboptimal lighting conditions. However, the emergence of IoT technology offers a paradigm shift in managing these systems [6]. The ability to dynamically adjust lighting levels based on real-time environmental conditions is provided to industrial facilities by equipping lighting fixtures with Internet of Things-enabled sensors, such as LDRs. This adaptive control mechanism not only optimizes energy consumption, but also ensures consistent light levels adapted to specific usage requirements [7].

Internet-of-things (IoT) systems can be used in the processing and manufacturing of agricultural goods; they can also be used to secure systems and monitor data in real time. Prior to now, industries were Internet manually supervised; however, with the development of intelligent processing methods, items can now be processed in an automated manner [8]. Considerable work has been done to address the energy issue and energy conservation. One of the primary challenges in the smart industry is enhancing energy in the industrial sector, for which we need more strategies and standardization policies. WSN and energy management systems are major factors that have an impact in the smart industry [9].

The industry can control factors like temperature, humidity, energy consumption, and equipment heating by reading data from sensors installed on common equipment [10]. Enhancing energy efficiency in industry 4.0 requires a high standard of management through effective analysis and real-time data in the energy supply [11]. The Internet of Things is currently being used by major industries, with smart objects and energy saving being its main uses. This investigation has produced a system that can automatically display values to users, monitor industrial projects using IoT hypotheses, and assist users in making decisions [12]. With the aid of hardware communication equipment and intelligent systems, the Internet of Things has allowed us to access physical, well-planned industrial networks.

***FEATURES***

- Intelligent algorithms correlate temperature readings with optimal brightness levels.
- Diminishes light intensity in response to high temperatures to conserve energy.
- Increases brightness during cooler conditions or night-time operations for safety and productivity.
- Integrates sensors to measure power supply and voltage parameters of lighting fixtures.
- Facilitates predictive maintenance and optimization
- of lighting infrastructure through trend analysis.
- Alerts operators about critical events or abnormalities in the lighting system.
- Delivers alerts through various communication channels like mobile devices, email, or control consoles.
- Provides access to lighting system data and controls from anywhere with an internet connection. (Remote monitoring & controls)

## B. LITERATURE REVIEW

As a result of its capacity to significantly enhance sustainability, reduce operational expenses, and enhance energy efficiency, the integration of industrial lighting systems with the Internet of Things (IoT) has garnered considerable interest. This paper examines recent developments, challenges, and potential in IoT-enabled energy-efficient lighting for industrial use.

***Improvements in Lighting Systems Powered by IoT:***

The latest advancements in IoT technology have sparked a transformative change in industrial lighting systems, providing the capability for live monitoring, management, and enhancement of lighting operations. Through seamless integration of IoT-enabled sensors, actuators, and communication networks with lighting fixtures, intelligent control can now be implemented based on occupancy patterns, ambient conditions, and energy consumption. This has revolutionized industrial lighting systems by allowing for efficient optimization and precise adjustments. Computers and communication technologies, including automation and cell phones, were introduced during the third revolution. The fourth generation, or Industry 4.0, uses big data, artificial intelligence, IoT, 5G, smart robotics, and big data collection and processing to enhance industrial operations. Research conducted in 2020 by Li et al. and in 2021 by Zhang et al. has shown how effective Internet of Things (IoT)-based lighting solutions can be in reducing energy consumption and enhancing illumination quality in industrial environments.

***Maximizing Energy Efficiency:***

Ensuring optimal energy economy while maintaining sufficient illumination levels is a key goal of lighting systems driven by the Internet of Things. Real-time usage patterns and environmental elements may be taken into account by IoT-enabled lighting systems to dynamically modify illumination levels through the deployment of sophisticated sensors for occupancy detection, daylight harvesting, and adaptive dimming. Furthermore, the research focused on regulating the lighting system in the environment to achieve energy efficiency by utilizing an Android application. IoT-based algorithms have the ability to optimize energy and reduce carbon emissions and power usage significantly, as demonstrated by research by Chen et al. (2020) and Kumar et al. (2019).

***Integration Difficulties and Solutions:***

Despite all of the advantages, there are a number of obstacles to overcome when incorporating IoT technology into the current lighting infrastructure. These include concerns about cybersecurity, interoperability, and implementation difficulties. Nevertheless, a variety of approaches have been put up by academics and business leaders to address these issues. As an example, protocols for encryption and secure communication frameworks provide data integrity and secrecy, while standards like MQTT, Bluetooth Low Energy (BLE), and Zigbee promote interoperability amongst IoT devices. Furthermore, advances in edge computing and cloud computing technologies provide robust and scalable frameworks for data analytics and decision-making in lighting systems powered by the Internet of Things (Al-Fuqaha et al., 2015).

**Future Directions and Expectations:**

With current research focused on cutting-edge approaches like machine learning algorithms, predictive maintenance, and integration with renewable energy sources, the future of IoTdriven energy-efficient lighting in industrial environments seems bright. Furthermore, new prospects for the synergistic integration of lighting systems and larger energy management methods are presented by the introduction of demand-response mechanisms and smart grid technology. Through the full use of IoT technology, enterprises may achieve major cost savings as well as noteworthy progress toward environmental sustainability goals in the context of Industry 4.0.

The relevant research addresses alternative approaches to energy efficiency with intelligent management systems that employ various techniques and applications. The potential for improving energy efficiency, productivity, and sustainability in industrial environments is enormous as IoT and lighting technologies come together. Unlocking the full potential of Internet of Things-driven energy-efficient lighting systems requires persistent innovation and collaboration among researchers, industry partners, and policymakers—even in the face of ongoing hurdles. Industries can show the way to a more sustainable and productive future by embracing these game-changing technologies.

## C. SYSTEM MODEL

***EXISTING SYSTEM*:**

As of right now, no industry research project is using Node-RED data for an energy efficiency management system that tracks, estimates, and reports energy use to industrial operators simultaneously taking equipment control and electrical failure risks into account. One technology that bears promise in this area is machine-to-machine (IoT) connectivity. Many sensors, including temperature and humidity sensors, are used to collect data depending on variables like frequency and power consumption. Following transmission, the collected data is compared with actual values by the microcontroller (Node MCUESP8266). Through efficient electricity consumption management and environmental monitoring, this approach seeks to improve the energy efficiency of a variety of intelligent field equipment.

Industrial lighting systems often operate on fixed schedules with manual adjustments based on observations or time intervals, leading to limited flexibility in adapting to changing environmental conditions. This results in wasted energy during periods of high natural light or low usage, and suboptimal light levels during periods of low natural light or increased activity. Manual control of light sources through regular checks can be timeconsuming and error-prone, with difficulty in obtaining real-time information on parameters such as current and voltage. Communication gaps between infrastructure and operators can impede decision-making and problemsolving processes.

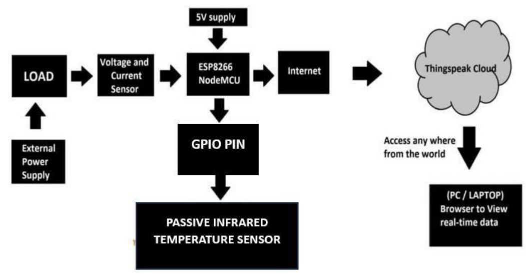
***PROPOSED SYSTEM:***

Improved energy management across a variety of industry equipment is anticipated with the proposed IoT system. The data gathered within the system will be evaluated and presented to industry operators through the use of the Node-RED analytical visualization platform. **Dallas temperature sensors** are strategically placed throughout the industrial facility uses temperature sensors to monitor ambient temperature changes. Data is fed to an IoT lighting system which adjusts brightness levels based on temperature readings. Lights dim when temperature rises, saving energy, and increase in colder conditions or at night for safety and productivity. The IoT lighting system integrates sensors **to measure power source and voltage**, allowing for real-time monitoring of electrical performance. It analyzes parameters to detect anomalies and alerts the maintenance department in case of malfunction. Historical data is collected for trend analysis and predictive maintenance, optimizing the lighting infrastructure. An IoT lighting system includes a **notification mechanism** such as alarms, buzzers, or notification messages to notify users of critical events or anomalies. These notifications may include warnings about equipment outages, power outages, maintenance reminders, or system-detected safety hazards. Operators receive notifications through dedicated communication channels such as mobile devices, email or centralized control consoles.

***IoT- EEL USES***

A use case diagram is used by the IoT to show how its operational interactions work in a variety of scenarios, such as sensor data collection, data notification, operator decisionmaking, data processing, recordkeeping, and data display.

- **Sensors:** To enable data gathering in smart businesses, IoT sensors are used to record certain factors like temperature and humidity.
- **Data Collection:** By using Internet of Things concepts, the IoT sensors collect data about physical items.
- **Data Notification:** Publication is the method used to distribute data, and MQTT subscription makes this possible. Any changes observed by the sensors are instantly alerted through a dashboard created using IoT
- **Data Visualization:** Data is shown using the Node-RED interface using the MQTT framework, assisting users in making decisions based on the numbers provided.
- Information Analysis and
- Documentation: Through the control panel, operators may examine and retrieve important information. For smart companies to improve energy efficiency, this feature is essential for viewing, changing, and making datadriven choices.
- **Operator Decisions**: In intelligent industry environments, operators make decisions and take appropriate action on a variety of devices by using data visualization.




## SYSTEM TESTING

An IOT-based energy-efficient lighting system for industries must be tested in a variety of scenarios in order to confirm its functionality, dependability, and effectiveness.

***COMPONENT LEVEL TESTING***:

To make sure the device is operating properly, test each individual module or component separately. This comprises microcontroller logic, communication modules, sensors for voltage and temperature, and emergency response systems.

***INTERACTION TESTING:***

Test the integration of several modules to ensure that they all operate without error. Check for compatibility with the mobile app, information that moves between parts, and communication guidelines.

***FEATURE TESTING***:

Make sure the lighting levels and schedules are adjusted by the control module in accordance with user instructions and sensor inputs.

***PERFORMANCE SCALING EVALUATION:***

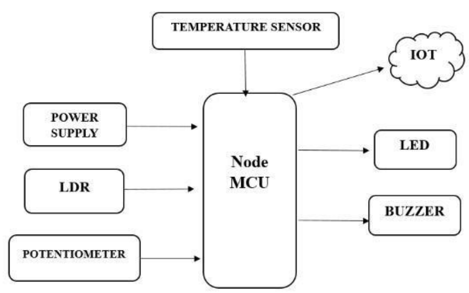
Determine whether the system can manage a growing number of users, sensors, and connected lighting fixtures. Observe performance metrics like response time and resource utilization to gauge the system's scalability as you progressively add more devices.

***FAULT TESTING:***

Examine the system's capacity to recognize and respond to errors, such as software bugs, network outages, or sensor malfunctions. Make sure the system can gracefully recover from errors without causing data loss or system outages, and that error messages are presented to users in an appropriate manner.

The interpretation of user actions through data visualization takes into account various factors such as energy consumption, noise levels, ambient temperature, and elevated temperatures in production zones or machinery. These features are generally applicable to all tasks, such as detecting anomalous frequencies, fluctuations, or high energy consumption in particular machinery. These parameters are routinely shown on the panel to help users with maintenance tasks, equipment replacement, and machinery adjustments.

- System setup.
- Parameter identification.
- Facts collection and transport.
- Field operators acquire information rec ording, analysis, visualization, and notification.
- Commercial entrepreneur's selectionmaking system.




## D. MODULE DESCRIPTION

IoT-based energy-efficient lighting for a description of some of the key modules:

**SENSOR MODULE**: This module's sensors are placed throughout the industrial facility to gather data on illumination, use patterns, environmental factors (such ambient light level), and energy use. Light emitting diodes, often known as light sensors, are devices that detect light intensity. Other types of sensors include temperature sensors, which keep an eye on the environment, power/voltage sensors, which measure energy.

**CONTROL MODULE**: The components in the control module regulate lighting fixtures by using sensor data and user interaction. (4)It comprises microcontrollers or programmable logic controllers (PLCs) that have been configured to carry out lighting control algorithms, including regulating brightness, turning on and off lights, and putting schedules in place. Actuators or relay modules may also be incorporated into this module to interface with lighting fixtures and control their operation.

**COMMUNICATION MODULE**: Data interchange between the sensor and control modules, as well as with external systems like the cloud-based platform and IoT gateway, is made possible by the communication module. It consists of hardware interfaces and communication protocols for sending sensor data to the control module and receiving updates from outside sources or alarm messages for the operator.

**IOT GATEWAY MODULE**: This module serves as a central point for gathering sensor data, controlling cloud-based service communication, and establishing internet access. Typically, it consists of hardware elements like microcomputers (such Node MCUs) or specialized gateways with networking capabilities and data processing and transmission software. The sensor data is securely sent to the cloud-based platform for additional analysis and visualization thanks to the gateway module.

**USER INTERFACE MODULE:** This part offers user interfaces for interacting with and keeping track of the energyefficient lighting system. It includes desktop software programs, smartphone apps, and web-based dashboards that may manage lighting settings, show data in real time, and provide reports. Notification systems are also a possible feature of user interface modules, which are designed to notify users of important events or system abnormalities.

**USER AUTHENTICATION**: This process uses security controls to manage user access to the device and its information by authenticating users. It could have features like biometric identification and PIN/password protection.

## E. IMPLEMENTATION PROCESS

**INPUT DESIGN**

**POWER FIXTURE:** Compared to typical incandescent lighting, they are safer and more energy-efficient since they operate on 12 or 24 volts. Power is delivered to the control board, which then distributes it to the other circuits.

**TEMPERATURE SENSOR:** A temperature-sensing element known as a "band-gap sensor" - a stainless steel tube with a 6 mm diameter—is included in the

DS18B20. The electrical properties of this sensor change with temperature. The electrical characteristics of the sensor also fluctuate with temperature. It communicates via a single digital pin and employs the 1-Wire interface. These sensors take the room's (or area's) temperature and relay the information to the computer for processing.

**DISPLAYS:** These user interfaces let users see system data, such as local lighting voltage and temperature.

**SINGLE-WIRE TRANSMISSION:** One-wire digital communication protocol is used by the DS18B20 to communicate. Through this protocol, the sensor's digital temperature value may be obtained by the microcontroller, which can then request temperature measurements from it.

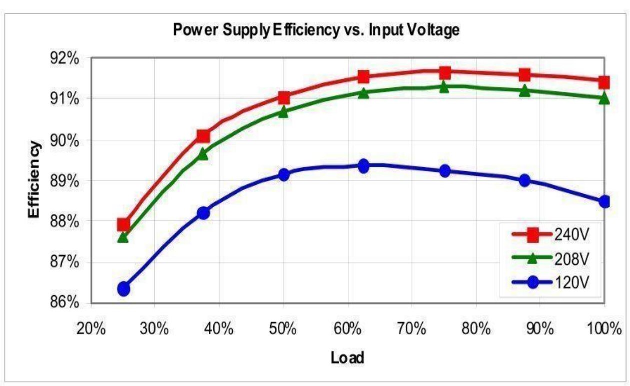
**UNIQUE PUBLIC ADDRESS:** A distinct 9–12-bit configurable resolution address is built into the memory of every DS18B20 sensor during the manufacturing process. On a single-wire bus, this address is utilized to distinguish between different sensors.

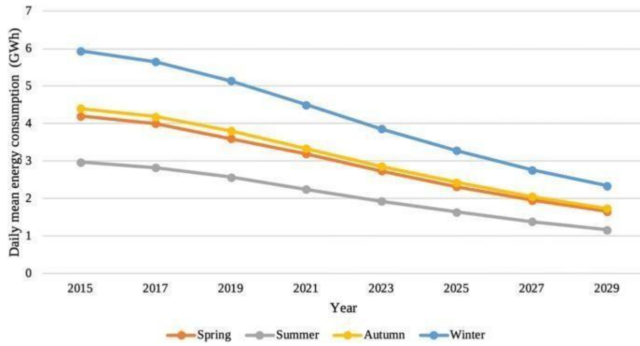
**MANAGEMENT INTERFACE:** By utilizing the (SET, +, -) keys, users may set and modify the control board's temperature, giving them control over the temperature of the room or region.

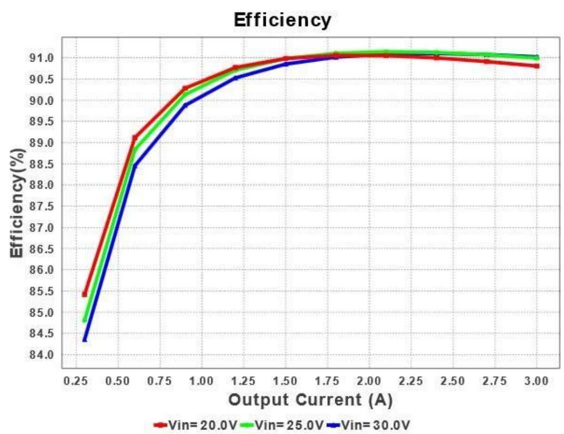
**TESTING THE TEMPERATURE:**

By utilizing the one-wire protocol, the microcontroller obtains the digital temperature value from the sensor. After processing, an intelligible temperature measurement is obtained from this digital value.

This measurement can be used by the microcontroller for a number of purposes, including logging the temperature, showing it on a display, and initiating actions depending on temperature thresholds.






## OUTPUT DESIGN

Designing the output interfaces that give users feedback and information is part of the output design for energy-efficient lighting in industries using NTC thermistors (-ve temperature), PTC thermistors (+ve temperature), Integrated Circuit (IC) temperature sensors, Voltage Divider Circuits, and Shunt Resistor Sensors (ohm's law V = I * R).

***GATEWAY FOR IoT*:**

The local network of IoT devices and the internet are connected via the IoT gateway, which acts as a bridge. It makes communication between the cloud-based IoT platform and the energy-efficient lighting system easier. Describe how the Internet of Things gateway gathers sensor data, connects to the internet securely, and sends data to the cloud for additional processing and analysis.

***LDR GUIDELINES:***

These indicators display the system's status and the indication when the relay is operating.

***NOTIFICATIONS AND ALARMS:***

When the system identifies an issue, such as an LDR that appears on the display when the Passive Infrared Resistor (PIR) temperature sensor is disconnected from the interface, these outputs notify the user.

***DISPLAYS:***

Temperature, voltage, and error indicators are only a few of the system information shown by these interfaces.

***5. RELAY POWER FOR***

**LIGHTS:** When the module detects temperature, these outputs supply 12 volts of power from the relay to the lights. If the temperature is lower than the level, the relay supplies the light with the highest color brightness; if it is higher than the level, the relay supplies the light with a mild color brightness.

*6. POWER SUPPLY RELAY TO VOLTAGE SENSOR:*

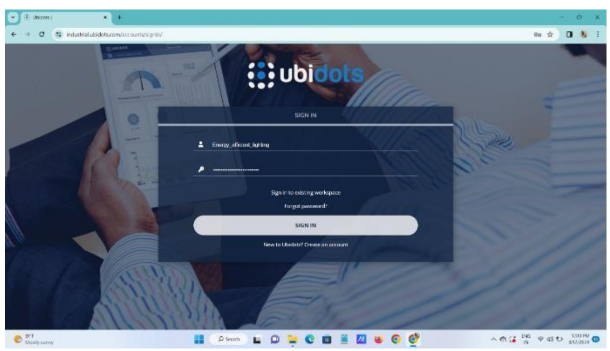
The relay contacts change state when the microcontroller sends a signal to energize the relay coil in response to specific situations, such as voltage current levels exceeding a predefined threshold.

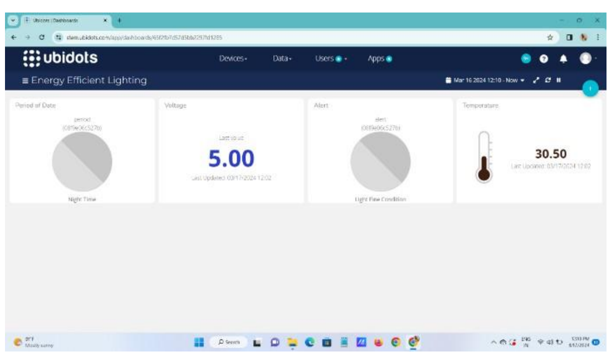
## F. PROJECT-TO-INTERNET CONNECTIVITY

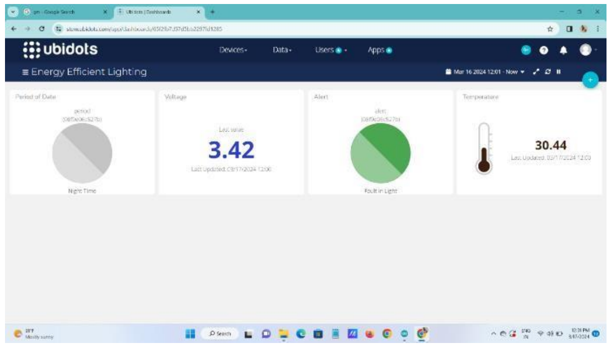
This project uses an IoT device to measure the temperature and voltage sensors. Node MCU, an IoT enabled board, connects our projects to the internet via Wi-Fi. Configuring a Things talk account to receive sensor data. To sign up for Things speak, enter your email address and complete all required fields. Your channel is now prepared, but in order to receive three sensor data, you must make the following adjustments. Select Channel Settings and give your channel a new name or rename. Programming code for Arduino microcontrollers would be done via the Arduino IDE. Developers may use it to program microcontrollers to carry out particular functions including interacting with other IoT devices, reading sensor data, and controlling actuators.

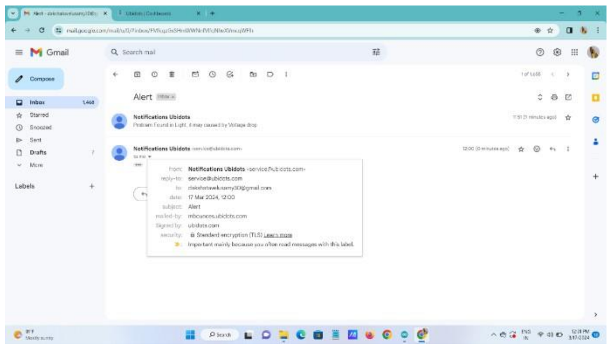
## G. RESULTS ANALYSIS AND SIMULATION

In the field of energy-efficient lighting, analysis and simulation of the outcomes are vital. To evaluate the effectiveness and performance of the lighting setup, this involves looking at the data gathered from numerous sensors and systems. Predictive modeling and testing of various scenarios are made possible by simulation, which helps to maximize energy efficiency and lighting quality. The overall energy efficiency and efficacy of the lighting system can be improved by making wellinformed decisions about modifications or enhancements based on the analysis of the outcomes from these processes.






## H. CONCLUSION

With the thoughtful integration of Internet of Things (IoT) technology, Light Dependent Resistors (LDR) sensors, and sophisticated control algorithms, the suggested approach offers a comprehensive framework for improving energy efficiency and operational effectiveness in industrial lighting systems. The suggested approach optimizes energy consumption while preserving constant illumination levels by utilizing IoT connection and real-time data collection to enable dynamic lighting level adaption based on environmental variables. In addition, the integration of remote monitoring and control functionalities, in conjunction with alerting systems and predictive maintenance approaches, endows operators with the capacity to anticipate and anticipate lighting system malfunctions, minimize downtime, and optimize system dependability. The suggested technique ensures that industrial lighting systems adapt to the changing demands and difficulties of contemporary industrial contexts by means of ongoing observation, analysis, and iterative development. In the end, using the suggested approach should improve workplace security, productivity, and sustainability overall in addition to lowering operating expenses and environmental effect.

As this project's findings demonstrate, putting the suggested system into practice can help achieve Industry 4.0 goals, particularly improving energy efficiency in industrial settings. Incorporating different parameters like power consumption, lighting conditions, and noise levels are among the things to be considered in the future. Plans also entail the integration of alerts and a graphical user interface for real-time notification. Actuators are also being considered as a direct control method for industrial appliances, and an advanced algorithm may be used to improve operator decision accuracy by utilizing realtime sensor data.

In the future, this project is anticipated to focus on the following areas: broadening the project's scope to include other industries and improving sensing parameters; automating controls, monitoring, and operation of machinery, equipment, and other industrial appliances; and implementing a test-bed application of the suggested system model in an industrial environment.

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