DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING,
SHARDA SCHOOL OF ENGINEERING AND TECHNOLOGY,
SHARDA UNIVERSITY, GREATER NOIDA

Energy Conservation with Modern Technology using IoT

A project submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Technology in Computer Science and Engineering

by

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May, 2023

CERTIFICATE

This is to certify that the report entitled "**Energy Conservation with Modern Technology using IoT**" submitted by **Ms. Nikita Sinha(2019610336)**,**Ms. Pallavi(2019003306)** to Sharda University, towards the fulfillment of requirements of the degree of Bachelor of Technology is record of bonafide final year Project work carried out by him/her in the Department of Computer Science and Engineering, School of Engineering and Technology, Sharda University. The results/findings contained in this Project have not been submitted in part or full to any other University/Institute for award of any other Degree/Diploma.

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ACKNOWLEDGEMENT

A major project is a golden opportunity for learning and self-development. We consider our self very lucky and honored to have so many wonderful people lead us through in completion of this project.

First and foremost we would like to thank Dr. Nitin Rakesh, HOD, CSE who gave us an opportunity to undertake this project.

My grateful thanks to **Dr. Subrata Sahana (Associate Professor)** for his guidance in my project work. MS. Kanika Singla(Assistant Professor), who in spite of being extraordinarily busy with academics, took time out to hear, guide and keep us on the correct path. We do not know where we would have been without his help.

CSE department monitored our progress and arranged all facilities to make life easier. We choose this moment to acknowledge their contribution gratefully.

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ABSTRACT

The Internet of Things (IoT) has enabled the development of smart homes and buildings that can be monitored and controlled remotely using IoT devices. These devices have the potential to optimize energy consumption and reduce energy waste, which is crucial for sustainability and cost savings.The proposed framework uses IoT devices to monitor visitor count and energy consumption, enabling real-time monitoring and control. The framework includes two microcontrollers, an Arduino Nano, and an IR sensor, which detects visitor presence and activates the light bulb using a relay module. The energy consumption of the connected appliance is monitored using an energy meter, which is connected to the Arduino Nano. The energy count is displayed on an LCD screen and sent to ThingSpeak.com for real-time monitoring and analysis. The black painted energy meter ensures accurate energy readings by preventing any external light interference. This report highlights the potential of IoT devices in energy conservation and the challenges associated with their implementation. It provides a comprehensive overview of the existing technologies and strategies used for energy management, including energy-efficient lighting systems, smart thermostats, and renewable energy sources. The report emphasizes the importance of energy conservation for environmental sustainability and cost savings. The proposed framework demonstrates the potential of IoT devices in enhancing energy efficiency and visitor experience. It provides a flexible and scalable platform for energy monitoring and control, enabling users to optimize their energy consumption and reduce energy waste. It also highlights the importance of energy conservation for environmental sustainability and cost savings and provides a comprehensive overview of the existing technologies and strategies used for energy management.

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CHAPTER 1
INTRODUCTION

Energy conservation has become an increasingly critical issue in recent years due to the rising global demand for energy and the finite resources available to meet this demand. Energy conservation refers to the practice of reducing energy consumption by utilizing energy-efficient technologies and implementing behavioral changes that reduce energy waste. Energy conservation is not only critical for the sustainability of the planet but also helps to reduce costs for businesses and households. The increasing demand for energy is driven by several factors, including population growth, urbanization, and industrialization.[2] In addition, the use of fossil fuels such as coal, oil, and gas to meet energy demands has resulted in environmental concerns, including air pollution and climate change. It is therefore imperative to reduce energy consumption and to transition towards renewable energy sources to ensure a sustainable future. Energy conservation is a pressing concern worldwide, with increasing energy consumption and limited resources to meet this demand. The use of energy-efficient appliances can also help to reduce greenhouse gas emissions and mitigate the effects of climate change. Another important aspect of energy conservation is the implementation of energy management systems that allow for real-time monitoring and control of energy consumption. Energy management systems use sensors and smart meters to track energy usage and provide insights into energy consumption patterns. By analyzing energy consumption data, energy management systems can identify areas of energy waste and optimize energy usage to reduce costs and improve energy efficiency. In addition to the use of energy-efficient technologies and energy management systems, energy conservation also requires changes in behavior and lifestyle. Renewable energy sources can help to reduce dependence on fossil fuels and mitigate the environmental impacts of energy production. Energy conservation is a critical component of sustainable development and is essential for the protection of the environment and the economy. The benefits of energy conservation are numerous and include cost savings, reduced greenhouse gas emissions, improved energy security, and increased energy efficiency. The adoption of energy-efficient technologies, energy management systems, and renewable energy sources can help to achieve energy conservation goals and ensure a sustainable future.

The Internet of Things (IoT) has emerged as a promising solution to address energy conservation issues.[9] IoT is a system of interconnected devices, sensors, and software that enables seamless communication and data sharing. IoT has the potential to revolutionize the way we consume and manage energy by providing real-time insights into energy consumption patterns and enabling automated control of energy usage.IoT technology has opened up new opportunities for energy conservation by providing tools to track and optimize energy consumption in real-time.[15] With IoT-enabled sensors, energy consumers can monitor energy consumption in real-time and identify areas where energy is being wasted. This enables energy consumers to make informed decisions on reducing energy consumption, such as turning off appliances when not in use or adjusting heating and cooling systems. In addition to real-time energy monitoring, IoT can also enable the automation of energy consumption through smart devices. Smart thermostats, for instance, can automatically adjust heating and cooling systems based on occupancy and temperature, resulting in significant energy savings. Smart lighting systems can also be used to reduce energy consumption by turning off lights in unoccupied areas automatically. IoT technology can also be used to optimize energy production by integrating renewable energy sources such as solar and wind power into the grid. IoT-enabled sensors can monitor the output of renewable energy sources in real-time, providing insights into the amount of energy produced and the potential for energy storage. This can help energy producers to optimize energy production, reduce waste, and improve the reliability of renewable energy sources.Moreover, IoT technology can enable demand response programs, where energy consumers are incentivized to reduce energy consumption during peak demand periods. IoT-enabled devices can be used to automatically adjust energy consumption based on demand response signals, resulting in a more stable energy grid and reduced energy costs for consumers. [3]IoT can help to reduce energy consumption, increase energy efficiency, and optimize energy production, resulting in significant cost savings and environmental benefits. However, there are also challenges to the adoption of IoT, such as security concerns and data privacy issues. These challenges must be addressed to ensure the widespread adoption of IoT in the energy sector.

1.1 Problem Statement

Energy conservation is an essential aspect of sustainable development, particularly in today's world where the demand for energy is constantly increasing. The depletion of non-renewable energy sources, such as coal, oil, and gas, has created a need for alternative sources of energy that are environmentally friendly and sustainable. One way of reducing the demand for energy is by conserving it through various measures. Energy conservation has become an increasingly critical issue in recent years due to the rising global demand for energy and the finite resources available to meet this demand. To effectively conserve energy, it is crucial to monitor energy consumption and identify areas where energy is being wasted.The globe is now facing major problems, the most severe of which is an energy crisis that has persisted for many days. The most effective remedy for this is not an increase in energy production but rather the efficient use of the energy. By keeping accurate records of energy use and avoiding unnecessary energy waste, the severity of the current energy crisis may be mitigated to some extent.In addition, the lack of energy conservation measures can lead to inefficient use of resources, including energy, water, and materials. This can result in increased waste generation and environmental pollution, contributing to the degradation of natural resources and habitats. The inefficient use of energy can also lead to a higher carbon footprint, contributing to the acceleration of climate change.

Yet, the fundamental difficulty is that energy monitoring cannot be done successfully since shoppers are not sensitive to their capacity use. This makes it hard to monitor energy effectively.The consumer does not have any knowledge about their energy used. This strategy has to be repeated several times in order to successfully regulate the amount of energy that is used in a month. Monitoring the energy usage on their mobile phone or Laptop rather than examining their energy meter, it will be an amazing leap forward in the field of energy administration. It would be beneficial for everyone to know their power use online from any location in the world.

1.2 Objectives

1. Energy Efficient Service Providing: By implementing energy-efficient service providing practices, businesses can reduce their energy consumption and associated costs, while also decreasing their carbon footprint. This can involve adopting renewable energy sources, optimizing energy usage through automation, and implementing energy-efficient technologies and processes.
2. Energy Efficient Resource Utilization: Energy-efficient resource utilization involves optimizing the use of available resources such as electricity, water, and fuel, to minimize waste and maximize efficiency. This can involve adopting energy-efficient appliances, equipment, and processes, as well as reducing unnecessary consumption and waste.
3. Energy Effective Networking: Energy-effective networking refers to the use of advanced communication and networking technologies to improve energy efficiency. This can involve utilizing cloud computing, the Internet of Things (IoT), and other digital technologies to optimize energy usage, monitor energy consumption in real-time, and reduce energy waste.
4. SMART devices and tools: SMART devices and tools are those that incorporate advanced sensors, automation, and networking capabilities, enabling them to collect and analyze data, communicate with other devices, and optimize their performance based on real-time conditions. These devices and tools can be utilized in various settings, including homes, businesses, and cities, to improve energy efficiency, reduce waste, and enhance sustainability.

1.3 Existing System

The existing system for energy conservation using IoT involves the use of Building Management Systems (BMS) and Smart Grid technologies. BMS is a centralized system that manages and controls various building systems such as heating, ventilation, air conditioning, lighting, and security. On the other hand, Smart Grid technology enables two-way communication between the utility company and the end-user, allowing for the efficient management of energy consumption and distribution.

1.3.1 Building Management System

BMS technology is a critical component of IoT-based energy conservation systems.[10] It enables building managers to remotely monitor and control building systems in real-time, allowing for the efficient use of energy. BMS can also provide alerts for potential issues and maintenance requirements, reducing the risk of energy waste due to system malfunction.

1.3.1.1 Architecture of BMS

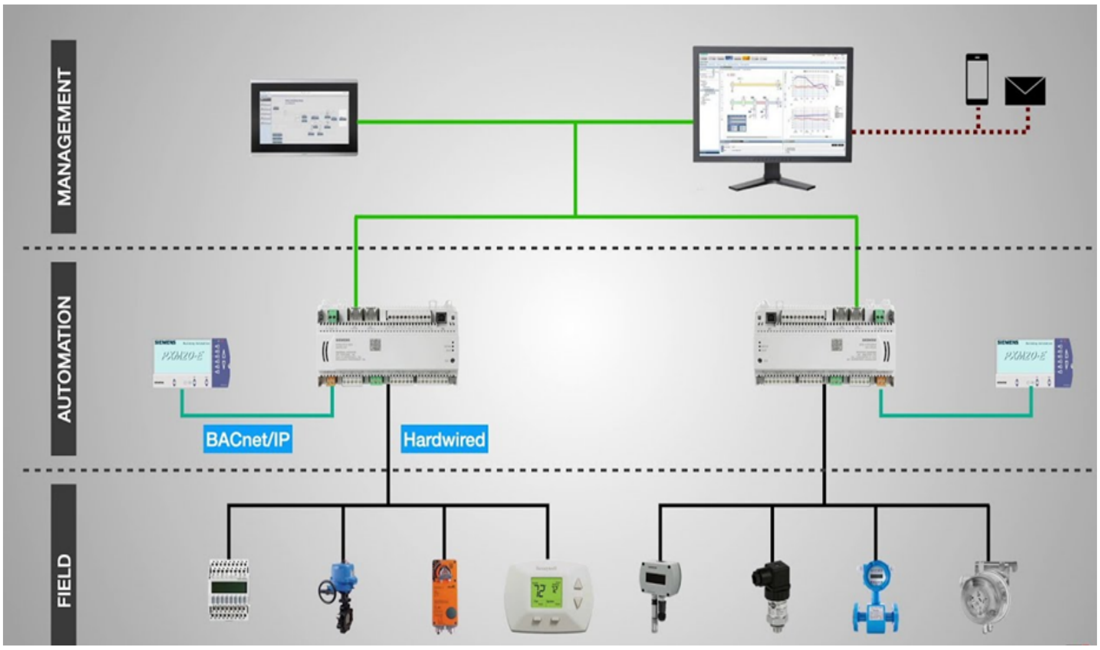

Figure. 1.1 Architecture of Building Management System

[5]Figure 1.1 describes the architecture of the building management system.

The architecture of a BMS typically includes three main components:

Field devices: These are the sensors and actuators that are installed in various parts of the building to monitor and control different systems such as temperature, humidity, lighting, and occupancy.

Automation: These are the devices that receive data from the field devices and process it to make decisions about how to control the various building systems. These controllers can be either local or remote, depending on the specific needs of the building.

Management: This is the central control unit that manages and monitors the controllers and the overall building systems. The supervisory system typically includes software and hardware components that are used to collect data from the controllers and field devices and analyze it to make decisions about how to control the building systems.

The BMS architecture can be further broken down into two main types:

Decentralized architecture: In this type of architecture, the controllers are distributed throughout the building, and each controller is responsible for a specific set of systems or equipment. These controllers communicate with the supervisory system to provide real-time data on the status of the systems they are controlling.

Centralized architecture: In this type of architecture, all of the controllers are located in a central location, typically in a control room. This allows for more centralized control of the building systems, but can also result in higher costs due to the need for more complex communication and control systems.

1.3.1.2 Advantages of BMS

1. Increased Energy Efficiency: A BMScan help optimize energy usage by controlling HVAC systems, lighting, and other building systems based on occupancy, temperature, and other factors. This can lead to significant energy savings and reduced utility bills.
2. Improved Comfort and Productivity: BMS can provide a comfortable indoor environment for occupants by maintaining appropriate temperature, lighting, and air quality levels. A comfortable environment can increase productivity and satisfaction among employees, customers, and residents.
3. Enhanced Security: BMS can integrate security systems such as access control, video surveillance, and intrusion detection to provide a comprehensive security solution for a building. This can help protect against unauthorized access, theft, and vandalism.
4. Centralized Management: BMS allows for centralized monitoring and control of all building systems, which can simplify facility management and reduce the need for on-site staff. This can also enable remote monitoring and control, which can save time and resources.
5. Real-time Data and Analytics: BMS can collect real-time data on building systems and occupancy, which can be used to identify areas for improvement and optimize building performance. This can also provide insights into energy usage and help identify opportunities for further energy savings.

1.3.1.3 Disadvantages of BMS

1. High Initial Cost: Building Management Systems can be expensive to install and configure, especially for large buildings or complex systems. This can make it difficult for some building owners to justify the cost of installation.
2. Complexity: Building Management Systems can be complex to operate and maintain, requiring specialized skills and knowledge. This can increase the cost of maintenance and make it difficult to find qualified technicians.
3. Compatibility Issues: Building Management Systems can be incompatible with existing building systems or devices, which can make it difficult to integrate them into the building infrastructure. This can require additional retrofitting or upgrades, which can increase costs.
4. Cybersecurity Risks: Building Management Systems can be vulnerable to cyber attacks, which can compromise the security and safety of the building occupants. This can lead to theft, vandalism, or even physical harm to occupants.
5. Dependence on Technology: Building Management Systems are highly dependent on technology, which can make them susceptible to hardware and software failures. This can lead to system downtime and disruption of building operations.

Overall, the architecture of a BMS is designed to provide centralized control and management of a building's various systems, allowing for more efficient operation and energy conservation. The specific design of the BMS architecture will depend on the size and complexity of the building and the specific needs of the building occupants.

1.3.2 Smart Grid

A Smart Grid is an electrical grid that uses advanced communication and monitoring technology to optimize the generation, transmission, and distribution of energy.[12] The primary goal of a Smart Grid is to improve energy efficiency, reduce energy waste, and enhance the reliability and security of the electrical grid.

1.3.2.1 Architecture of smart Grid

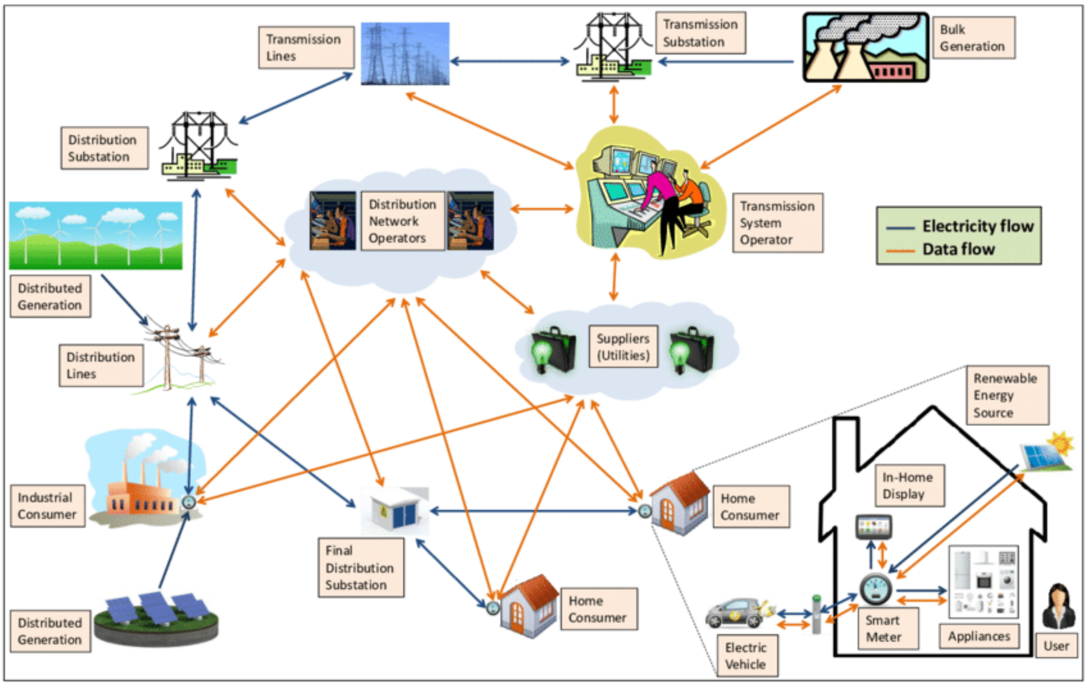

Figure. 1.2 Architecture of Smart Grid

The Figure 1.2 shows the smart grid architecture[11] consists of various components that work together to enable the intelligent and automated management of electricity generation, distribution, and consumption.

Generation: The first component of the smart grid architecture is electricity generation. It includes a wide range of power generation sources such as coal, gas, nuclear, wind, solar, and hydroelectric. Smart grid technologies enable the integration and management of renewable energy sources with the traditional power generation sources to ensure a stable and efficient power supply.

Transmission: The transmission system comprises high-voltage power lines that transport electricity from power plants to local substations. The smart grid architecture uses advanced sensors and communication systems to monitor the performance of the transmission system and detect any faults or outages in real-time.

Distribution: The distribution system includes local transformers, distribution lines, and power substations that deliver electricity to homes and businesses. The smart grid architecture uses smart meters and sensors to monitor and manage the distribution system, enabling utilities to detect and fix power outages quickly.

Advanced Metering Infrastructure (AMI): The AMI is a critical component of the smart grid architecture that enables two-way communication between utilities and customers. Smart meters are installed in homes and businesses to measure and report energy consumption in real-time. This data is transmitted back to the utility company, enabling them to optimize the distribution of power and offer customers more flexible pricing options.

Energy Storage: Energy storage is a critical component of the smart grid architecture that allows excess energy to be stored and used during peak demand periods. Energy storage technologies include batteries, pumped hydro storage, and thermal energy storage.

Control Systems: Control systems are used to manage and control the flow of electricity within the smart grid architecture. They include advanced software and communication systems that enable utilities to manage power generation and distribution in real-time, reducing waste and increasing efficiency.

Cybersecurity: Cybersecurity is an essential component of the smart grid architecture that ensures the security and reliability of the electricity distribution system. Smart grid technologies use advanced cybersecurity protocols and techniques to protect against cyber attacks and other security threats.

1.3.2.2 Advantages of Smart Grid

1. Enhanced Energy Efficiency: Smart Grid technology allows for real-time monitoring and control of energy distribution, enabling utilities to optimize energy usage, reduce waste, and improve overall energy efficiency. This can result in reduced greenhouse gas emissions and lower energy costs for consumers.
2. Improved Reliability and Resilience: Smart Grid incorporates advanced sensors and automation, allowing for quicker detection and response to power outages, faults, and other grid disturbances. This can help minimize downtime, reduce the duration and frequency of outages, and enhance the reliability and resilience of the power grid.
3. Integration of Renewable Energy: Smart Grid enables the seamless integration of renewable energy sources, such as solar and wind, into the power grid. This can facilitate the adoption of clean energy and promote sustainability by efficiently managing the variable and distributed nature of renewable energy generation.
4. Empowered Consumers: Smart Grid empowers consumers with real-time energy usage data, allowing them to monitor and manage their energy consumption more effectively. This can enable consumers to make informed decisions about their energy usage, conserve energy, and potentially save on their energy bills.
5. Advanced Grid Management: Smart Grid enables advanced grid management techniques, such as demand response, load balancing, and grid optimization, which can help utilities efficiently manage energy supply and demand, reduce peak demand, and avoid grid congestion.

1.3.2.3 Disadvantages of Smart Grid

1. High Implementation Costs: The implementation of Smart Grid technology can be expensive, requiring significant investments in infrastructure, equipment, and software. These costs can be a barrier to entry for smaller utilities or developing regions.
2. Cybersecurity Risks: Smart Grid relies heavily on communication networks and digital technology, which can make it vulnerable to cyber attacks. A cybersecurity breach can result in data theft, grid disruptions, and potential safety risks, highlighting the need for robust security measures.
3. Data Privacy Concerns: Smart Grid generates a vast amount of data on energy usage, which raises privacy concerns. Collection, storage, and usage of this data may raise privacy and security risks, and necessitate careful handling to protect consumers' personal information.
4. Interoperability Challenges: Smart Grid involves complex and interconnected systems, which can pose challenges in terms of interoperability and standardization. Different technologies, protocols, and communication interfaces may not always be compatible, requiring additional efforts for integration.
5. Potential Workforce Disruption: The implementation of Smart Grid technology may require changes in the skill sets and roles of utility workers, potentially resulting in workforce disruptions or job displacements. Adequate training and planning are needed to mitigate potential impacts on the workforce.

Overall, the smart grid architecture is a complex and interconnected system that relies on advanced technologies and communication systems to ensure the efficient and reliable distribution of electricity. The integration of renewable energy sources, energy storage, and advanced control systems enables utilities to optimize power generation and distribution, reduce waste, and improve the sustainability of the electrical grid.

1.4 Motivation

Motivation for a project aimed at achieving the above objectives can be multifaceted. By adopting energy-efficient practices and technologies, organizations can significantly reduce their energy consumption and associated costs, resulting in significant cost savings over time. This can free up resources that can be redirected towards other business initiatives, such as innovation and expansion, driving growth and competitiveness. Energy efficiency and sustainability have become increasingly important considerations for businesses and consumers alike, with a growing emphasis on corporate social responsibility and environmental stewardship. By implementing energy-efficient practices and technologies, organizations can demonstrate their commitment to sustainability and enhance their brand image, attracting environmentally conscious customers and stakeholders.Energy-efficient practices can help mitigate the impacts of climate change by reducing greenhouse gas emissions, thereby promoting environmental sustainability and contributing to global efforts to combat climate change.

CHAPTER 2
LITERATURE SURVEY

This research paper describes the benefits of energy monitoring. To properly accomplish their objectives of energy monitoring in, new businesses and a variety of industries that need more energy. An effective result can be found by integrating Cloud and IoT technologies. The results of numerous research work and use case studies were used to demonstrate that the energy monitoring system leads to greater energy consumption reduction. Real-time data helps the consumer to monitor the energy and helps in consumption of energy successfully. [1]

This paper acknowledges a method for lowering the consumption of power and identifying the shortest path for the transmission of data in a wireless sensor network. A spatially dispersed device with minimal battery life and processing power makes up a wireless sensor network. A shortest route-finding method that combines the BTC (Broadcast Tree Construction) algorithm with a data aggregation method is suggested to reduce network overhead during communication [2].

This Paper offered a safe and effective smart home automation system. Bluetooth Low Energy is used in a dynamic multi-hop communication system to accomplish this. The MATLAB-12b experiments that were run. The output value in relation to throughput, workload, battery level, and sleep time was calculated using nine fuzzy rules. In order to increase the longevity of IoT devices and the link stability of nodes in smart home automation, an approach based on fuzzy reasoning is created here.[3]

In this paper, the author's major objective was to give users the best services available in a lasting method to achieve energy conservation through smart home or building design. The solution makes commonplace equipment intelligent, establishes a solid system, and most importantly lowers power usage and consequently energy cost. This paper focuses on the applications and increasing demand for various energy management systems. In this IoT-based Energy Management System (EMS) that combines smart meters and smart boards is built and put into practice in a residential building. In a residential or commercial structure, EMS is used for energy monitoring, management and consumption. To ensure effective and consistent operations and the provisions of electrical energy, this system connected the customer and the utility provider.[4]

The use of Building Management System (BMS) technology in buildings, which account for the majority of energy production users, is highlighted in this study. BMS helps future generations conserve natural resources and increase the usage of renewable energies like wind and solar power. It also saves both money and energy. BMS technology allows for effective cost savings in buildings.[5]

By considering the loads in a classroom of a learning establishment, Considering the energy used by the present loads, advising energy-efficient equipment, and using a powerful yet straightforward sensor-based model to reduce energy usage, the paper emphasizes on the importance of energy conservation. The outcomes are then contrasted. There were a number of straightforward energy-saving tips for the home mentioned, including setting the refrigerator to the ideal temperature, unplugging the plugs when the appliances are not in use, putting the computer in sleep mode when inactive for a while, setting the air conditioner to the ideal temperature, and using renewable energy sources that are naturally available as much as possible.[6]

The Internet of Things (IoT) is experiencing explosive growth and has the potential to bring about a transformation in many different sectors, including the management of energy resources. The Internet of Things is not complete without the smart energy meter, which is a vital component since it enables the measurement and monitoring of energy use in real time. This literature review is on Arduino-based smart energy meters that are based on the Internet of Things in order to save energy.

A smart energy metering system that is based on the Internet of Things and uses Arduino and GSM connection is proposed in the paper[9]. The technology gathers information on energy use and transmits it to a remote server so that it may be monitored and analyzed in real time. The system that has been presented offers a way that is both dependable and effective for conserving energy.

A smart energy metering system that was developed in this paper[10] makes use of Arduino and Zigbee for its communication. The suggested system is able to assess the amount of energy used and give users with statistics on their energy consumption in real time. The design of the system is one that will not break the bank and is simple to put into action in order to save energy.

A smart energy meter that is based on the Internet of Things and employs Arduino and Wi-Fi connectivity is proposed in [11]. The technology keeps track of the amount of energy used and transmits the data to a server in the cloud so that it may be monitored and analyzed. The suggested system is not only simple to use, but it also offers an effective way for the preservation of energy.

In a smart energy metering and monitoring system that makes use of Arduino and Internet of Things connectivity is proposed in the study [12]. The system that has been suggested takes readings of the amount of energy used and transmits them to an off-site server, where they are monitored and analyzed in real time. The design of the system is not only cost-effective but also offers an effective way for energy saving.

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Table 2.1 Pre-existing applications

S.No	Year	Methodology	Limitation	Advantages
[1]	2020	BLE(Bluetooth-Low-Energy)	Device Discovery Delay, Limited energy level nodes, Operation is battery based	Lower power consumption, Lower cost of modules and chipsets, exist in most smartphone
[2]	2017	Smart Sensors, Smart grid, Smart Power Meter, PMU(phasor measurement unit)	High Investment Difficult to visualize volumize Data Expensive communication network required communication delay All modes are not captured	To improve the accuracy of modeling system conditions To predict and detect stress and instability on the grid To provide information for event analysis after a disturbance has occurred To identify inefficiencies To predict and manage line congestion
[3]	2022	Wireless Sensors, Wireless Devices, Simulator- NS2, Language C++, BTC algorithm	Cost	Shortest data transmission channel in a wireless sensor network is determined, reduce data redundancy
[4]	2022	Smart Meters, Smart Boards, Smart Mobile Apps, Database Server	Initial Cost is problem for the system integration and adaption for the consumer	Mobile app was created for monitor the load scheduling , notification alert, recharge and loan option were there
[5]	2011	BMS Technology, Fire alarm, Smoke Detector, HVAC equipment	Do not control smaller equipment Data is already close to optimized hence do not give significant results and rarely require changes.	Significant reduction in energy bills. Improve comfort of staffs More effective operation of building services plant Better ability to monitor and collect building performance data for analysis It calculates the preset requirement of the building and controls the connected plant to meet those needs.
[6]	2020	Lighting Energy Saving, Emission Reduction Technology, Air conditioning system, Water supply system	Cost, Home decoration pollution	Better Interior look, Use of renewable source of energy like solar energy
[7]	2019	Direct Sensing, ILD sensors, RFID, Infrared sensors, Indirect sensing, Magnetic sensor, Acoustic sensors, Light and piezoelectric sensors, online spaces and offline spaces	Limited Storage Unit	Real time monitoring yields a high percentage of energy consumption reduction. It eliminates the waste in resources. Reduces redundancy in energy usage, and improves existing approaches and procedures in power generation
[8]	2015	Energy Efficient Appliances, Sensor based switching model	Costly Appliances need to purchase	Less Energy is used, Carbon Dioxide emission is reduced, Systems make Environment Friendly

[9]	2017	Mathematical model unit	Only works at certain parameters	Clarify the mapping relationship between the components. Provide technical support for the energy-saving service
[10]	2021	Smart Grid, Energy Transition	Cost , Security	Flexibility , Upgrades and automats energy infrastructure
[11]	2022	IE3 motors, VFDs , payback	Infrastructure Cost	Energy consumed, It is reduced 4.33 from 4.99. The positive environmental impact attained in CO_2, SO_2, and NO_x emission reduction
[12]	2022	Arduino, IoT, Voltage Sensor	Real Data is not stored in the cloud. Cannot measure the reading of the appliances having less than 100 W	Users can monitor this data using their mobile devices. Testing of the sensors reveals an accuracy of 77% for the voltage sensor and 86% for the current sensor.
[13]	2013	IoT, Machine learning, Smart Grid	The collection, storage, and processing of energy usage data could raise privacy concerns and require robust security measures to protect against unauthorized access or data breaches.	Stage 1 achieving an energy theft accuracy of 56.39%. By adding Stage 2, the accuracy increases to 99.89%, and with all 3 stages combined, the energy detection algorithm achieves an accuracy of 99.96%
[14]	2022	IoT, Energy Monitoring system	The system relies on internet connectivity for data transmission to the server, any disruptions in internet connectivity may impact the system's performance and reliability.	The use of low-cost components makes the system affordable and accessible for implementation in various applications, especially in resource-constrained environments. The system's potential applications in various domains, such as electricity billing, smart grid energy management, and home automation, make it versatile and adaptable to different use cases and scenarios.
[15]	2017	IoT, Home Monitoring System, Current Sensor SCT-013-030	The current implementation only assumes a fixed voltage of 230v Rms, which may not accurately reflect the actual voltage levels in different environments or locations.	The paper utilizes low-cost components, such as the PZEM-004T, CT sensors, and ESP8266 microcontroller, making the energy meter cost-effective and accessible for potential widespread use in various applications.
[16]	2017	IoT, Cloud Computing, Demand Side Management	The collection, storage, and processing of energy usage data could raise privacy concerns and require robust security measures to protect against unauthorized access or data breaches.	The research paper demonstrates that the developed system is capable of accurately measuring current, power consumption, and calculating the cost incurred by a customer. This indicates the reliability and effectiveness of the system in monitoring energy usage.
[17]	2023	Cyber-Physical System, IoT, Energy Monitoring, Control System,	low Wi-Fi bandwidth, outdated networking technologies, power outages, and limited Wi-Fi network range	The system collects and analyzes data on energy consumption in real-time, allowing for trend analysis, identification of peak energy usage periods, and understanding of energy usage patterns, which can support energy conservation efforts.

CHAPTER 3
SYSTEM ANALYSIS AND REQUIREMENTS

System analysis is[14] the process of examining a system to identify its components and their relationships, and to understand how the system functions. The objective of system analysis is to determine the requirements for a new or improved system.

3.1 Drawbacks of Existing System

There are several other models that are commonly used to manage energy consumption in households and offices. One such model is the timer-based system, which uses a timer to turn off lights and appliances after a set period of time. However, this model has several disadvantages. Firstly, the timer may not accurately reflect the actual time that someone is in the room, leading to lights turning off unnecessarily. [18]Secondly, the timer-based system is not adaptable to changes in the environment, such as changes in the number of occupants in a room. Thirdly, this model does not provide real-time data on energy consumption, making it difficult to monitor and manage energy usage effectively.[19]Another model is the occupancy-based system, which uses motion sensors to detect the presence of people in a room and turn on/off lights and appliances accordingly. However, this model also has several disadvantages.[17] Firstly, the sensors may not accurately detect the presence of people, leading to lights turning off unnecessarily. Secondly, the sensors may not work in certain environments, such as in areas with a lot of noise or movement. Thirdly, this model may not provide real-time data on energy consumption, making it difficult to monitor and manage energy usage effectively.The model consisting of Arduino Nano, electric meter, LCD, WiFi ESP8266, and IR sensors is an effective and efficient solution to manage electricity consumption and improve energy efficiency.[21] The system provides real-time data on energy consumption, allowing users to identify areas of high power consumption and manage their energy usage effectively. The IR sensors help in reducing energy consumption by automatically turning off lights when there is no motion detected in the room. This helps in saving electricity bills and conserving energy.

3.2 Hardware and Software Requirements

3.2.1 Hardware Requirements

Identifying the hardware components and specifications is essential for software operations and productivity . Required Hardware are as follows:

(i) Arduino Nano

Figure. 3.1 Arduino Nano

Figure.3.1 shows design of the Arduino Nano and Figure.3.2 shows the layout of the is a small, compact board designed for electronic projects that require a small form factor, low power consumption, and easy programmability. It is based on the Atmega328P microcontroller and comes with a built-in USB interface, making it easy to program and upload code.[20] The board measures just 18mm x 45mm and can be powered using a mini-USB cable or an external power supply. It features 14 digital input/output pins, 8 analog pins, and 6 PWM pins, allowing it to interface with a wide range of electronic components and sensors. The Arduino Nano is popular among hobbyists and professionals alike due to its versatility and ease of use. It can be used in a wide range of applications, including robotics, automation, sensing, and IoT.

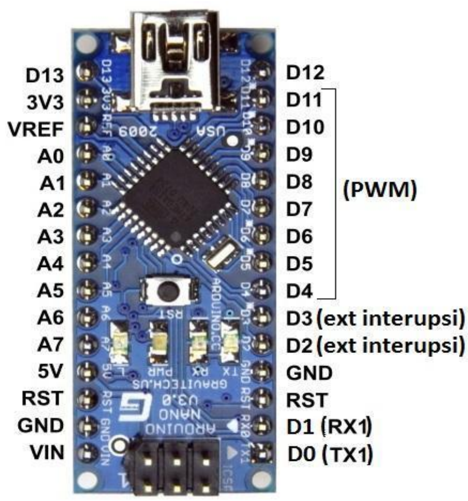

Figure. 3.2 Layout of Arduino Nano Board

[12]Table 3.1 given contains the description of each pin present in the Arduino Nano Board .

Table. 3.1 Arduino Nano Pin description

Sr.No	Pin No.	Name	Type	Description
1.	1-2, 5-16	D0-D13	I/O	Digital input/output port 0 to 13
2.	3, 28	RESET	Input	Reset (active low)
3.	4, 29	GND	PWR	Supply ground
4.	17	3V3	Output	+3.3V output (from FTDI)
5.	18	AREF	Input	ADC reference
6.	19-26	A7-A0	Input	Analog input channel 0 to 7
7.	27	+5V	Output or Input	+5V output (from on-board regulator) or +5V (input from external power supply)
8.	30	VIN	PWR	Supply voltage

[20]Programming the Arduino Nano is easy thanks to the Arduino IDE, which provides a simple and intuitive interface for writing and uploading code. The IDE is compatible with Windows, Linux, and MacOS, and supports a wide range of programming languages, including C and C++. In summary, the Arduino Nano is a versatile and compact board that is well-suited for a wide range of electronic projects. Its small form factor, low power consumption, and easy programmability make it a popular choice among hobbyists and professionals alike.

(ii) ESP8266 Wi-Fi Module

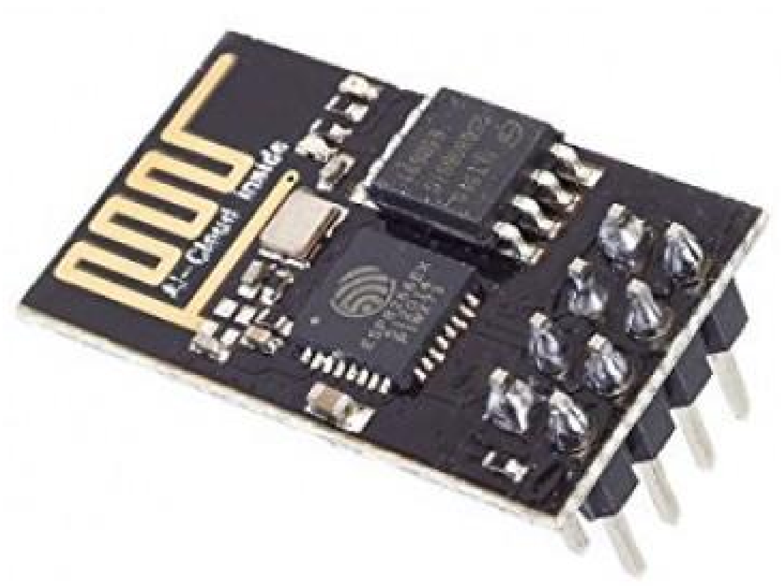

Figure. 3.3 Wi-Fi ESP8266 Module

Figure 3.3 is The ESP8266 is a WiFi module that has gained popularity due to its low cost, ease of use, and compatibility with the Arduino platform. It is a complete WiFi networking solution, providing both TCP/IP protocol stack and a powerful microcontroller on a single chip. It supports both 2.4 GHz Wi-Fi networks and WPA/WPA2 authentication, allowing it to connect to most wireless networks. It can be programmed using a variety of programming languages, including C, Lua, and Python. The module is also highly configurable, with support for a wide range of network protocols, such as HTTP, MQTT, and CoAP. This makes it an ideal choice for IoT (Internet of Things) projects, where it can be used to communicate with sensors and other devices over a wireless network.[22] One of the most attractive features of the ESP8266 is its low power consumption. The module can operate on as little as 3.3V and has a sleep mode that can be used to conserve power when not in use. This makes it ideal for battery-powered devices that need to operate for long periods of time. Overall, the ESP8266 is a versatile and powerful WiFi module that has revolutionized the world of IoT. Its low cost, ease of use, and compatibility with Arduino have made it a popular choice among hobbyists and professionals alike. Its ability to connect to wireless networks, support a wide range of protocols, and operate on low power make it an ideal choice for a variety of projects.

(iii) Liquid Crystal Display(LCD)

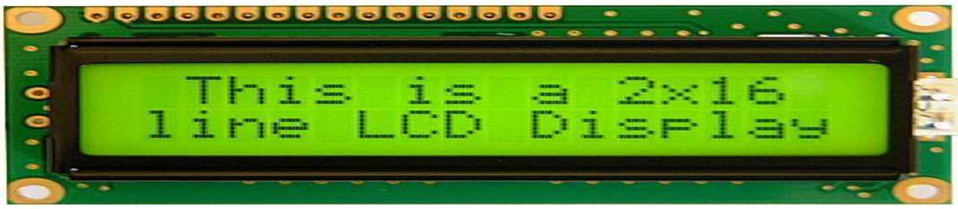

Figure. 3.4 LCD 16X2

The LCD 16x2 which is shown in Figure 3.4 is a popular display module used in various electronic devices, including Arduino boards, Raspberry Pi, and other microcontroller-based projects. It has a resolution of 16 characters per line and 2 lines,which is shown in the Figure.3.5.

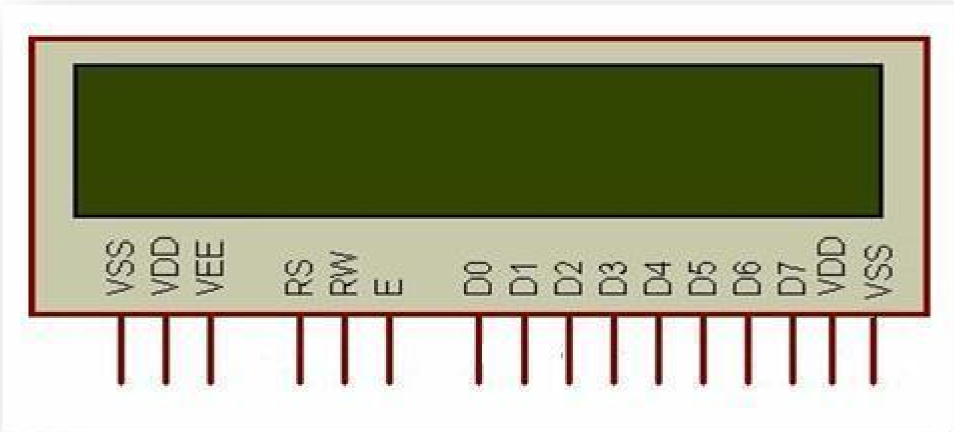

Figure. 3.5 Layout of LCD 16X2

[12]In Table 3.2 descriptions of all the pin present in LCD 16X2is given

Table. 3.2 Pin Layout of LCD 16X2

Sr. No	Pin No.	Pin Description
1	Pin 1 (GND)	This is a ground pin to apply a ground to the LCD.
2	Pin 2 (VCC)	This pin is connected to ground and provides the reference voltage for the LCD.

3	Pin 3 (VEE)	This pin is connected to the power supply, and the recommended voltage is 5V.
4	Pin 4 (RS)	RS stands for Register Select. This pin is used to select the data register or the instruction register of the LCD. A high signal on this pin selects the data register, while a low signal selects the instruction register
5	Pin 5 (R/W)	R/W stands for Read/Write. This pin is used to control the read/write operation of the LCD. A high signal on this pin enables the read operation, while a low signal enables the write operation.
6	Pin 6 (EN)	En stand for Enable signal. This pin is used to enable the data transfer to the LCD. A high signal on this pin enables the transfer of data to the LCD, while a low signal disables it.
7	Pin 7-14 (DB0-DB7)	This 8 pin is used as a Data pin of LCD.
8	Pin 15 (LED+)	This pin is used with pin 16(LED-) to setting up the illumination of back light of LCD. This pin is connected with VCC.
9	Pin 16 (LEC-)	This pin is used with pin 15(LED+) to setting up the illumination of back light of LCD. This pin is connected with GND.

To use the LCD 16x2 with a microcontroller, the connections need to be made between the microcontroller and the LCD module, and the software needs to be programmed to control the display. The pin layout and the associated functions should be carefully understood before interfacing the LCD with any microcontroller

(iv) Jumper wire

a. Male wires

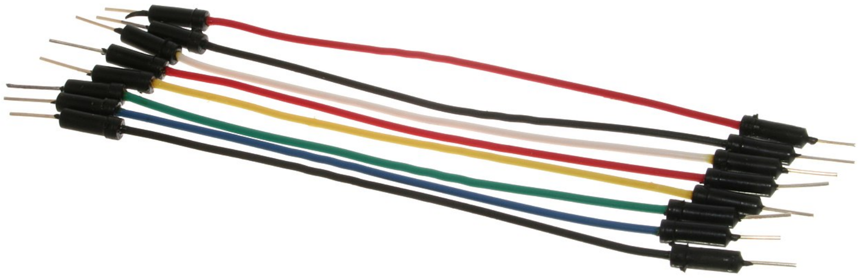

Figure. 3.6 Male to Male Jumper Wires

Male to male jumper wires are electronic connectors that have male headers at both ends as shown in Figure 3.6. They are also known as Plug. [20] They are commonly used in electronics and IoT projects to connect different electronic components together. The wires themselves are typically thin and flexible, with insulation around them to protect them from damage and prevent electrical shorts. The male headers at each end are typically made of metal and have small pins that can be inserted into the female headers on other components to create a secure electrical connection. Male to male jumper wires are extremely versatile and can be used to connect a wide variety of electronic components. They are especially useful for prototyping and testing new ideas in electronics, as they allow for quick and easy connections between components without the need for soldering or other more permanent connections.[23] In IoT projects, male to male jumper wires are often used to connect sensors to microcontrollers or other devices, allowing data to be collected and processed in real-time. They can also be used to connect actuators such as motors or lights to a microcontroller, allowing the microcontroller to control these components based on sensor data or other inputs.

b. Female Wires

Figure. 3.7 Female to Female Jumper Wires

Female to female jumper wires are electronic connectors that have square heads at both ends. It is also known as Jack. They are commonly used in electronics and IoT projects to connect different electronic components together. The wires themselves are typically thin and flexible, with insulation around them to protect them from damage and prevent electrical shorts. The female headers at each end are typically made of plastic and have small sockets that can be inserted onto the male headers on other components to create a secure electrical connection. [23]Female to female jumper wires are also extremely versatile and can be used to connect a wide variety of electronic components. They are especially useful for prototyping and testing new ideas in electronics, as they allow for quick and easy connections between components without the need for soldering or other more permanent connections.

c. Male -Female wires

Figure.3.8 shows the Male to Female jumper wires which are electronic connectors that have a male header at one end and a female header at the other. They are commonly used in electronics and IoT projects to connect different electronic components together.

Figure. 3.8 Male to Female Jumper Wires

The wires themselves are typically thin and flexible, with insulation around them to protect them from damage and prevent electrical shorts. The male header at one end is typically made of metal and has small pins that can be inserted into the female headers on other components to create a secure electrical connection. The female header at the other end is typically made of plastic and has small sockets that can receive the pins from other male headers to create a secure electrical connection. Male to female jumper wires are also extremely versatile and can be used to connect a wide variety of electronic components. They are especially useful for prototyping and testing new ideas in electronics, as they allow for quick and easy connections between components without the need for soldering or other more permanent connections.

(v) Infrared (IR) Sensors

As Shown Figure.3.9, IR sensors, or infrared sensors, are electronic devices that detect infrared radiation emitted by objects in their surrounding environment. IR sensors are used in a wide variety of applications, including remote controls, motion sensors, and temperature sensors.

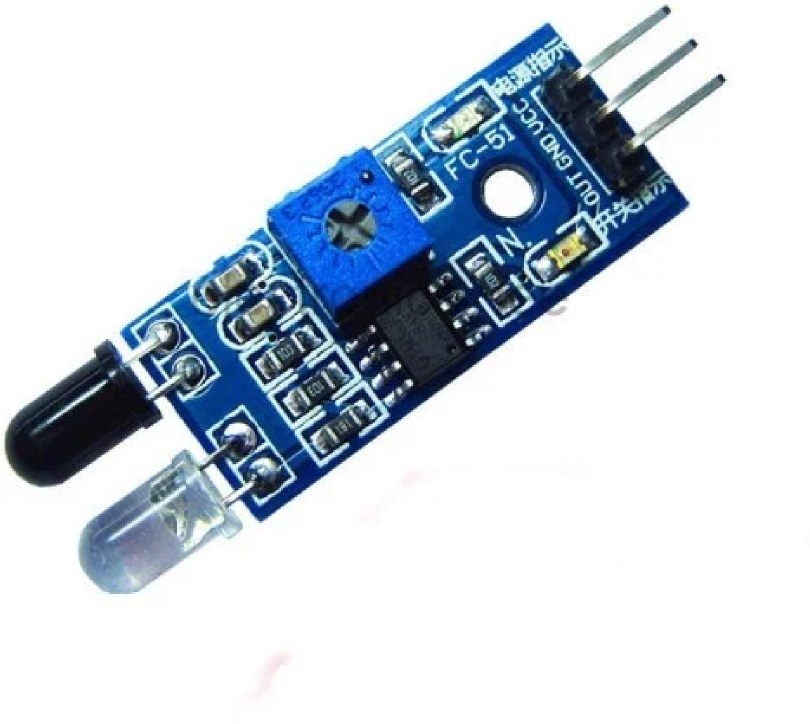

Figure. 3.9 IR Sensors

IR sensors work by detecting changes in infrared radiation, which are caused by changes in temperature. When an object moves within the range of the sensor, it detects changes in the infrared radiation emitted by the object, and triggers an alarm or activates a switch.[24] One of the advantages of IR sensors is that they are non-contact sensors, meaning they do not require physical contact with the object being measured. This makes them ideal for use in applications where contact is not desired, such as in remote control devices or in industrial applications where contact may be hazardous. IR sensors are also highly sensitive and can detect small changes in temperature, making them useful in applications where accuracy is important. They are also relatively inexpensive and can be used in a wide range of applications, from consumer electronics to industrial automation.

(vi) Relay Module

A relay module as shown in Figure.3.10 is an electronic device that allows low voltage signals to control high voltage circuits. In IoT, relay modules are used to control various devices such as lights, motors, and heaters.

Figure. 3.10 Relay Module

Relay modules consist of a coil, which when energized, generates a magnetic field that pulls a movable armature towards the coil. This armature is connected to one or more electrical contacts, which in turn are connected to the high voltage circuit. When the armature moves, it closes or opens the contacts, thus allowing or blocking the flow of current to the high voltage circuit. It can control high voltage devices using low voltage signals. This allows for more precise and efficient control of devices and reduces the risk of electrical hazards.

3.2.2 Software Requirement

Identification of the Software for the better result of the project. The required Software are as :

(i) Arduino IDE

The Arduino Integrated Development Environment (IDE) is a software application that is used to write and upload code to Arduino microcontroller boards.[25] The IDE provides an easy-to-use interface for creating and uploading code, as well as a range of useful tools and features to help users develop their projects.The Arduino IDE is based on the Processing programming language, and provides a simplified programming environment for beginners and experienced users alike. The IDE includes a code editor with syntax highlighting, as well as a library of pre-written code examples and functions that can be used to quickly build and test projects.One of the key features of the Arduino IDE is its ability to upload code to Arduino boards via a USB connection. This allows users to quickly and easily test their code on real hardware, without the need for complex programming tools or equipment.[27]In addition to its programming and uploading features, the Arduino IDE also provides a range of tools for troubleshooting and debugging code, including a serial monitor that allows users to view and manipulate data sent from their Arduino board.

CHAPTER 4
SYSTEM DESIGN

4.1 Project Perspective

The project utilizes an Arduino Nano microcontroller, which serves as the brain of the system, to interface with various components and collect data. The LCD display is used to showcase the electricity consumption in units and also used to display the count of visitors. The WiFi module is integrated into the system, enabling data to be uploaded to ThingSpeak, an IoT platform, for further analysis and visualization. One of the key features of the project is the use of IR sensors to count visitor entries. When a visitor enters the room, the IR sensor detects the movement and increments the count. Similarly, when the visitor leaves, the count is decremented. This information is used to optimize lighting usage. When there is at least one visitor present in the room, the lights are turned on, and when there are no visitors, the lights are turned off automatically, reducing unnecessary energy consumption.The data collected from the energy meter is uploaded to ThingSpeak, where it is displayed in graphical format. This allows users to visualize their energy usage patterns over time, identify trends, and make informed decisions on how to optimize their energy consumption. Additionally, the data is also logged into an Excel sheet for further analysis and record-keeping. The project has several potential benefits. First, it promotes energy conservation by providing real-time monitoring and display of electricity usage, helping users to be more conscious of their energy consumption habits and make informed decisions to reduce their carbon footprint. Second, the visitor counting system helps optimize lighting usage, ensuring that lights are only turned on when needed, which can lead to significant energy savings. Third, the integration of IoT technology through the WiFi module and ThingSpeak allows for remote monitoring and data analysis, providing a more comprehensive and convenient approach to managing energy usage.

4.2 Project Design

The model consisting of Arduino Nano, electric meter, LCD, Wifi ESP8266, and IR sensors is an innovative solution to manage electricity consumption and improve energy efficiency, as shown in Figure.4.1. The Arduino Nano is the brain of the system that controls the sensors and displays real-time data on the LCD. The electric meter is used to measure the power consumption of the household or office. The WiFi ESP8266 module enables the device to connect to the internet and send data to a server for monitoring and analysis. The IR sensors detect motion and switch on/off the lights to save electricity.

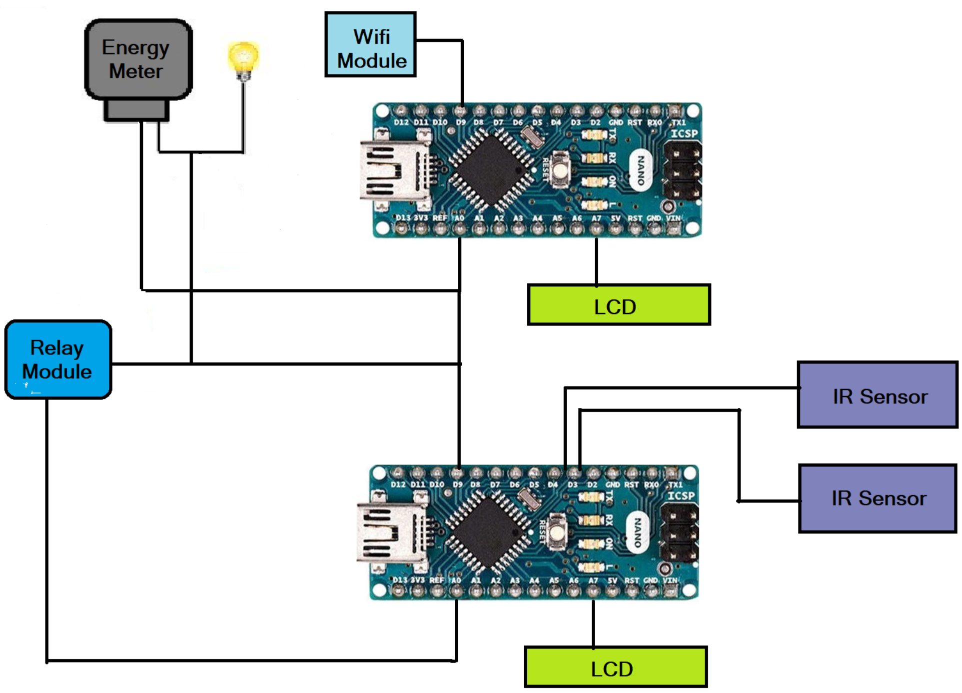

Figure. 4.1 Design of the project

The advantages of this model are numerous. Firstly, the device helps in reducing energy consumption by automatically turning off lights when there is no motion detected in the room. This helps in saving electricity bills and conserving energy. Secondly, the device provides real-time data on electricity consumption, which can help in identifying areas of high power consumption and managing energy usage. Thirdly, the system is user-friendly, with the LCD displaying the real-time energy count, making it easy for users to monitor their energy consumption. Fourthly, the device is scalable and can be easily integrated into existing electrical systems.

The model consisting of Arduino Nano, electric meter, LCD, WiFi ESP8266, and IR sensors is an effective and efficient solution to manage electricity consumption and improve energy efficiency. The system provides real-time data on energy consumption, allowing users to identify areas of high power consumption and manage their energy usage effectively. The IR sensors help in reducing energy consumption by automatically turning off lights when there is no motion detected in the room. This helps in saving electricity bills and conserving energy. Overall, this model is a scalable, user-friendly, and innovative solution to manage energy consumption in households and offices.

4.3 Module Integration

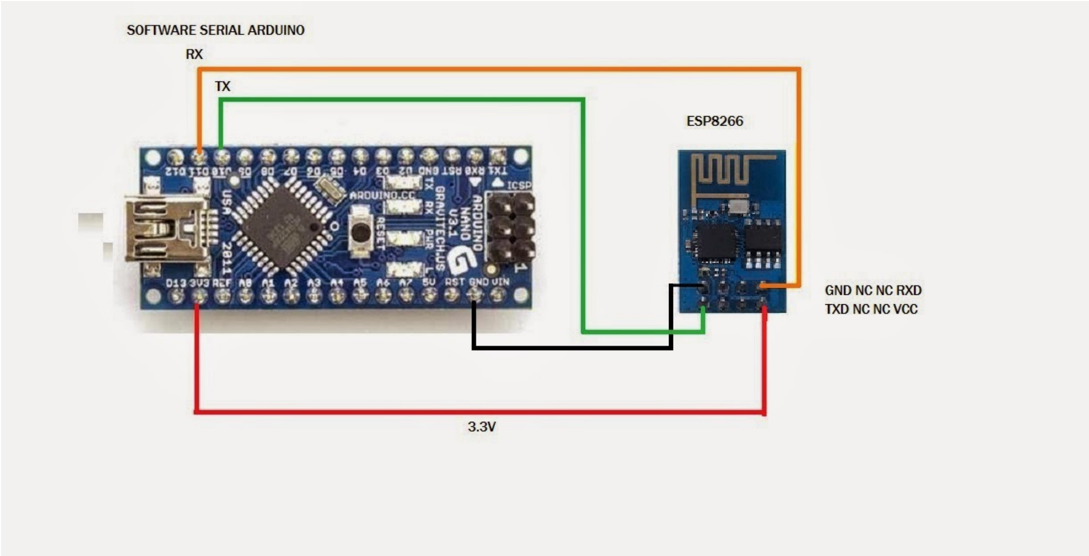

Figure. 4.2 Arduino ESP8266 Circuit

The integration of Arduino Nano and ESP8266 WiFi module is typically done through serial communication, as shown in Figure.4.2. The ESP8266 module communicates with Arduino Nano using UART (Universal Asynchronous Receiver-Transmitter) protocol, which allows for the exchange of data between the two devices. The Arduino Nano acts as the master device, sending commands and data to the ESP8266 module, which acts as a slave device and handles the WiFi communication. To establish the connection, the ESP8266 module is connected to the Arduino Nano using the serial pins (RX and TX) on both devices. The RX pin of the Arduino Nano is connected to the TX pin of the ESP8266 module, and the TX pin of the Arduino Nano is connected to the RX pin of the ESP8266 module. Additionally, the Arduino Nano is powered by a separate power supply, while the ESP8266 module is powered through the 3.3V pin of the Arduino Nano or an external power source.

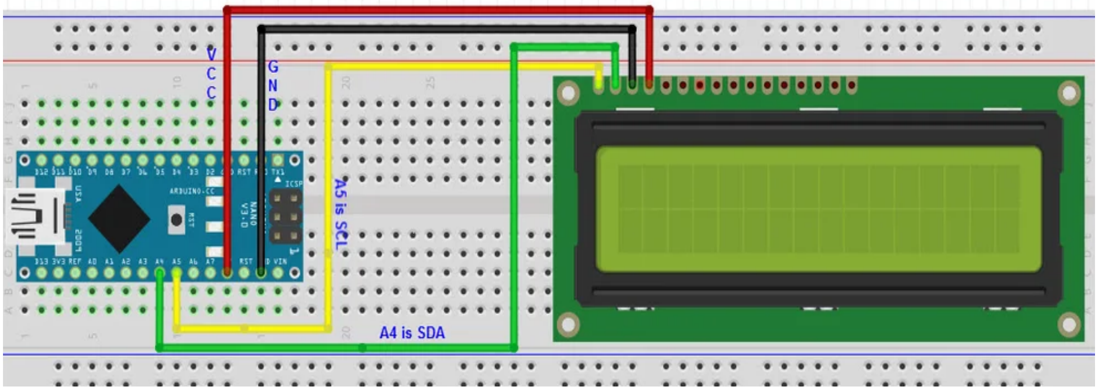

Figure. 4.3 Arduino LCD Circuit

Arduino Nano, a compact microcontroller board, can be easily integrated with a 16x2 LCD module to display information and interact with users in various projects,as shown in the Figure.4.3. The 16x2 LCD module is a commonly used display module that can display up to 16 characters per line with 2 lines of text. To integrate Arduino Nano with the 16x2 LCD module, a parallel connection is typically used. The 16x2 LCD module requires 6 digital pins on Arduino Nano for communication, which are used to control the register select (RS), enable (EN), and data pins (D4, D5, D6, D7) on the LCD module.

The connections between Arduino Nano and the 16x2 LCD module are as follows:

- RS (Register Select) pin on the LCD module is connected to a digital pin on Arduino Nano (e.g., D2).
- EN (Enable) pin on the LCD module is connected to another digital pin on Arduino Nano (e.g., D3).
- Data pins (D4, D5, D6, D7) on the LCD module are connected to four other digital pins on Arduino Nano .

Additionally, the LCD module requires a VSS (ground) connection and a VDD (5V) connection for power, which can be connected to the appropriate pins on Arduino Nano or an external power source. Once the hardware connections are made, a software library such as the "LiquidCrystal" library in the Arduino IDE can be used to program the Arduino Nano to communicate with the LCD module. The "LiquidCrystal" library provides pre-defined functions to initialize the LCD module, write text to the display, control the cursor position, and perform other operations. With the Arduino Nano and the 16x2 LCD module integrated, a wide range of applications can be developed. For example, it can be used to display sensor readings, system status, messages, menu options, and other information in various projects such as weather stations, data loggers, alarm systems, and more. The LCD module provides a simple and effective way to visually communicate information to users, making projects more interactive and user-friendly.

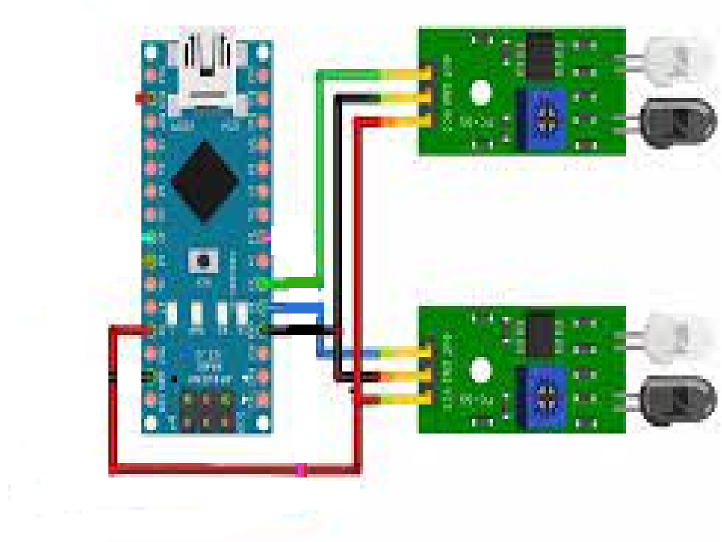

Figure. 4.4 Arduino with IR Sensors

Integrating Arduino Nano with IR sensors as shown in Figure.4.4, typically involves connecting the output pin of the IR sensor to a digital or analog pin on the Arduino Nano, depending on the type of IR sensor used. IR sensors can have different output types, such as digital (binary) or analog (continuous), and may require different connection methods. For digital output IR sensors, such as those with a binary output of HIGH or LOW, the output pin of the IR sensor is connected to a digital pin on Arduino Nano. The sensor typically generates a HIGH signal when an object is detected within its sensing range and a LOW signal when no object is detected. Arduino Nano can then read the digital signal using the "digitalRead()" function in the Arduino IDE to detect the presence of an object. For analog output IR sensors, such as those that provide a continuous voltage or current output proportional to the detected distance or intensity, the output pin of the IR sensor is connected to an analog pin on Arduino Nano. The sensor typically generates an analog signal that varies based on the distance or intensity of the detected object. Arduino Nano can then read the analog signal using the "analogRead()" function in the Arduino IDE to obtain the precise value of the detected object.

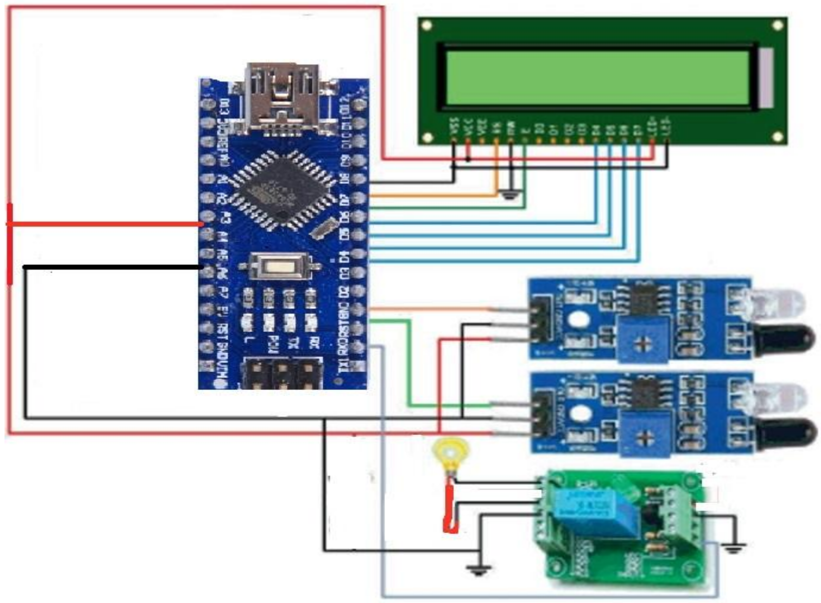

Figure. 4.5 Arduino with IR Sensors,Relay Module and LCD

The integration of Arduino Nano with IR sensors, relay module, and LCD as shown in Figure.4.5 allows for a visitor count display on the LCD screen, and control of a bulb based on the visitor count. The IR sensors can be used to detect the presence of visitors, while the relay module can control the bulb, and the LCD can display the visitor count in real-time. The IR sensors can be connected to digital or analog pins on the Arduino Nano, depending on the type of IR sensor used. When a visitor is detected by the IR sensor, the Arduino Nano can increment the visitor count variable in the code. This count can then be displayed on the LCD screen using appropriate LCD libraries and functions. The relay acts as a switch, allowing the Arduino Nano to control the bulb by triggering the relay to turn it on or off. The relay module is typically used to control high-voltage devices, such as the bulb, that require more current or voltage than what the Arduino Nano can provide directly. After integrating with the sensor, the bulb is on when the visitor count is greater than 0 and bulb is off when visitor count is equal to 0.

CHAPTER 5
SYSTEM ARCHITECTURE

5.1 Block Diagram

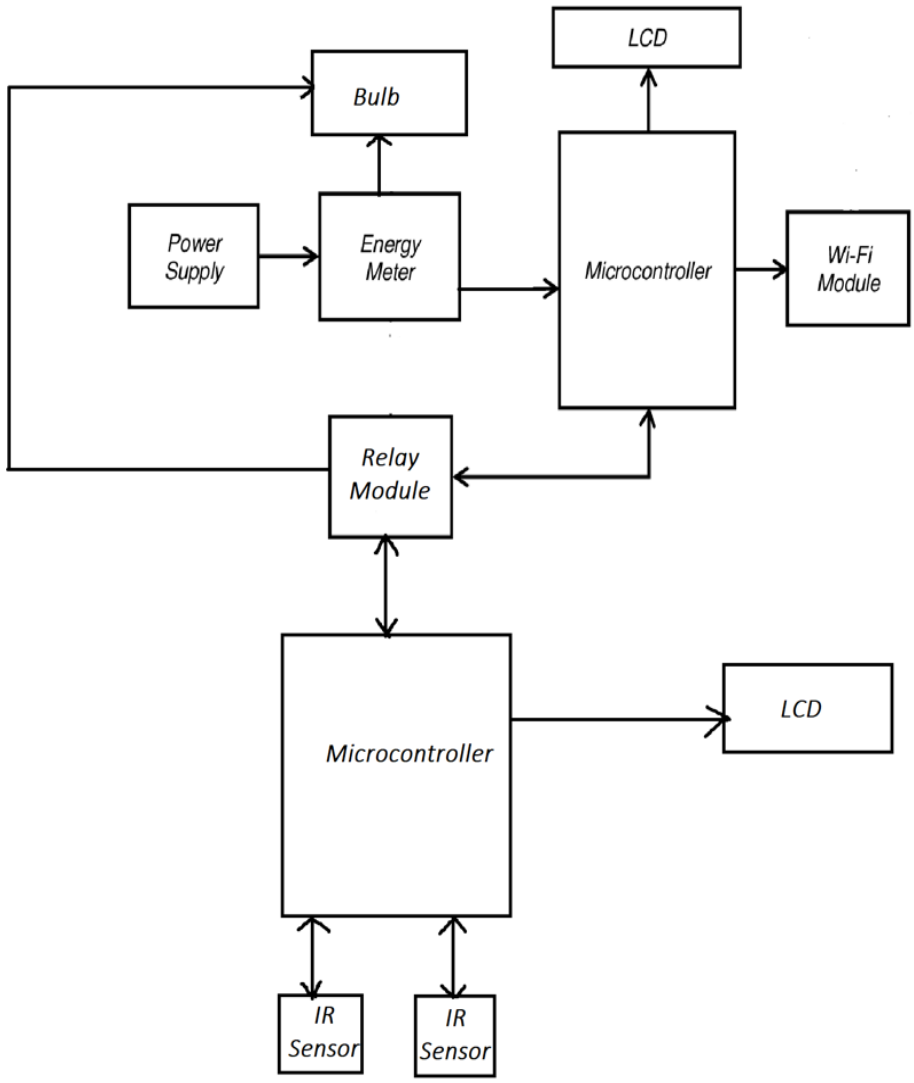

Figure. 5.1 Block diagram of Module

The Figure.5.1 shows the various components of the system and their interconnections.
speak.com, and controlling the light based on the visitor count. The system provides real-time monitoring of unit count data, visitor count, and light control, making it suitable for applicaLCD Display: The LCD display is used to monitor the unit count and display relevant information in a user-friendly format. It provides a clear and easy-to-read interface for viewing the real-time data. The LCD display is connected

to the Arduino Nano and displays the unit count, time, date, and other relevant details.
ESP8266 WiFi Module: The ESP8266 WiFi module is responsible for sending the unit count data to the cloud-based platform Thingspeak.com. It connects to the internet through WiFi and uses the ThingSpeak API to send the data to the cloud. This allows for remote monitoring and access to the unit count data from anywhere with an internet connection.
Arduino Nano: The Arduino Nano acts as the main controller of the system. It interfaces with the LCD display, ESP8266 WiFi module, energy meter, and IR sensors to collect and process the data. The Arduino Nano runs the necessary code to control the overall functionality of the system, including reading data from the energy meter, updating the LCD display, sending data to Thingspeak.com, and processing data from the IR sensors.
Energy Meter: The energy meter is used to measure the unit count data.[29] It is connected to the Arduino Nano and provides the necessary input for monitoring the unit count. The energy meter can be configured to work with different types of energy sources, such as electricity, gas, or water, depending on the application requirements.
IR Sensors: The IR sensors are used to count the number of visitors in the area. They are strategically placed at the entrance/exit points and detect the presence of visitors using infrared technology. The IR sensors are connected to the Arduino Nano and provide input for counting the visitors.
Additional LCD Display: Another LCD display is used to display the visitor count in real-time. It shows the number of visitors detected by the IR sensors and provides a visual indication of the current visitor count. This LCD display is connected to the Arduino Nano and updates in real-time as the visitors are detected or leave the area.
Light Control: A light is controlled based on the visitor count. When there is at least one visitor detected by the IR sensors, the light is turned on. If there are no visitors, the light is turned off. This is achieved through the control logic implemented in the Arduino Nano, which reads the visitor count from the IR sensors and controls the light accordingly.
The block diagram illustrates the interconnected components of the Real-Time Monitoring System, including the LCD displays, ESP8266 WiFi module, Arduino Nano, energy meter, IR sensors, and light control. The Arduino Nano acts as the main controller, collecting data from the energy meter and IR sensors, updating the LCD displays, sending data to Thingtions such as energy management systems, visitor counting systems, and automation applications.

5.2 Circuit Diagram

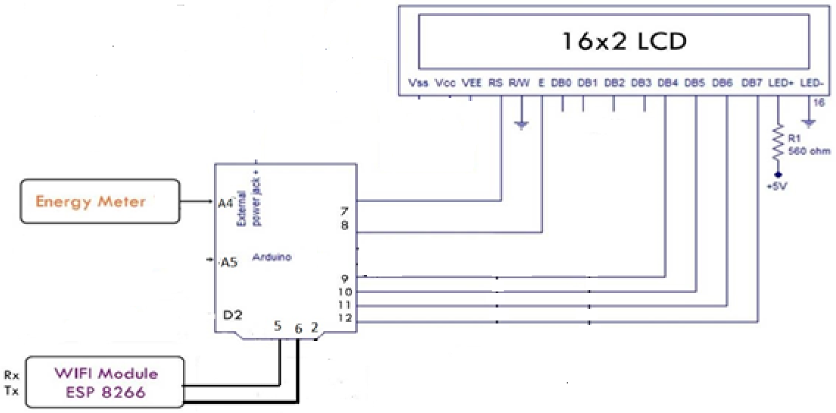

Figure. 5.2 Energy Meter Circuit Diagram

The circuit diagram as shown in the Figure.5.2 is a sophisticated and innovative design that aims to monitor and conserve energy usage in a space through the use of an energy meter, an LCD display, a Wi-Fi module (specifically the ESP8266), and an Arduino Nano microcontroller. This cutting-edge circuit offers real-time monitoring of energy consumption, providing valuable insights for efficient energy management. At the heart of the circuit is the energy meter, which is connected to the bulb or load that is being monitored. The energy meter is a high-precision device that measures the energy consumption in terms of units or kilowatt-hours (kWh). It accurately records the amount of energy consumed by the load, providing precise data for analysis and monitoring. The LCD display is a crucial component of the circuit as it provides a clear and concise readout of the energy consumption in real-time. The display is connected to the Arduino Nano, which receives data from the energy meter and processes it to calculate the energy consumption in units or kWh. The Arduino Nano then sends this data to the LCD display for display purposes. The LCD display can be programmed to show the energy consumption data in various formats, such as units or kWh, making it easy for users to understand and monitor their energy usage. One of the key features of this circuit is the use of the Wi-Fi module (ESP8266), which enables the circuit to send the energy consumption data to an online platform called ThingSpeak.com. ThingSpeak.com is a popular Internet of Things (IoT) platform that allows users to store, analyze, and visualize data in real-time. The ESP8266 module connects to the Arduino Nano and establishes a Wi-Fi connection to the internet, enabling the circuit to send the energy consumption data to ThingSpeak.com.The real-time data sent to ThingSpeak.com can be accessed from anywhere in the world through a web browser or a mobile app, making it convenient for users to monitor their energy consumption remotely. The data is displayed in a user-friendly graphical format, such as charts or graphs, which allows for easy visualization and analysis of energy usage patterns. This data can be used to identify energy-intensive periods, detect abnormal energy usage, and make informed decisions for efficient energy management.The Arduino Nano serves as the brain of the circuit, controlling the flow of data between the energy meter, the LCD display, and the Wi-Fi module. It receives data from the energy meter, calculates the energy consumption, and sends the data to the LCD display for local display.[28] Simultaneously, it sends the data to the ThingSpeak.com platform using the Wi-Fi module for online monitoring. The Arduino Nano is known for its reliability, stability, and versatility, making it an ideal choice for this application.

One of the key advantages of this circuit is its potential for energy conservation. By providing real-time monitoring of energy consumption, users can gain insights into their energy usage patterns and take proactive measures to reduce energy waste. For example, users can identify energy-intensive periods and take steps to optimize energy usage during those times. They can also detect abnormal energy usage, such as unexpected spikes in consumption, and investigate and rectify the issue promptly. This data-driven approach to energy management can lead to significant energy savings, reducing costs and environmental impact.

The circuit is also user-friendly and easy to install. The components, such as the energy meter, LCD display, Wi-Fi module, and Arduino Nano, are readily available in the market and can be easily connected using standard wiring techniques. The Arduino Nano can be programmed using user-friendly software tools, making it accessible to users with varying levels of technical expertise.[26] The ThingSpeak.com platform provides a simple and intuitive interface for monitoring and analyzing energy consumption data, making it user-friendly and convenient.

Moreover, the circuit is highly scalable and can be customized to suit different energy monitoring requirements. For instance, additional features can be added to the circuit, such as integrating multiple energy meters for monitoring multiple loads or incorporating sensors for measuring other parameters like temperature, humidity, or occupancy. The Arduino Nano can be programmed to accommodate these additional features and send the data to ThingSpeak.com for comprehensive monitoring and analysis.

Another potential benefit of this circuit is its potential for integration with smart home systems. With the increasing adoption of smart home technology, this energy monitoring circuit can be integrated into a larger smart home ecosystem to provide seamless energy management. For example, the energy consumption data can be used to trigger automation events, such as turning off lights or appliances when there is no occupancy, or adjusting thermostat settings based on energy usage patterns. This can result in more efficient energy management and greater energy savings.

In terms of applications, this circuit can be utilized in various settings where energy management is critical, such as homes, offices, commercial buildings, or industrial facilities. It can be particularly useful in places where energy costs are high, or where there is a need for strict energy monitoring and conservation measures. This circuit can also be used in educational or research settings to study energy usage patterns, analyze energy consumption data, and develop energy-saving strategies.Additionally, this circuit can be a valuable educational tool for learning about energy management, data analysis, and Internet of Things (IoT) concepts. It can be used in educational institutions, workshops, or DIY projects to teach students or enthusiasts about energy conservation, sensor integration, microcontroller programming, and cloud-based data analysis. The circuit provides a hands-on learning experience that combines theory with practical application, fostering a deeper understanding of energy management principles and technologies.

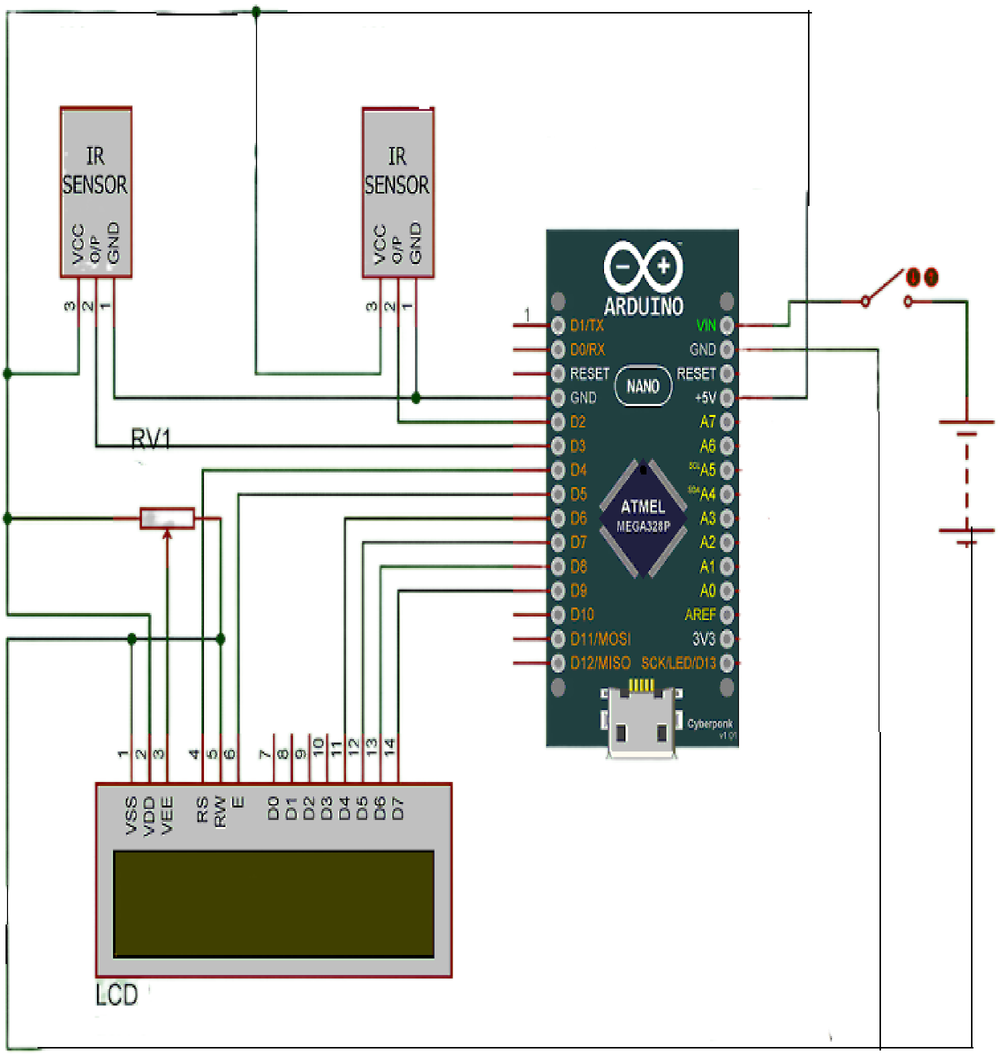

Figure. 5.3 Circuit diagram of IR sensors Connection

The circuit diagram as shown in Figure.5.3 is an efficient system designed to accurately track and display visitor counts using two infrared (IR) sensors, an LCD, and an Arduino Nano. The purpose of this circuit is to provide a seamless and automated solution for managing visitors in a space, such as a room or a building, by turning on and off a light based on the presence of visitors. At the heart of the system is the Arduino Nano, a compact and powerful microcontroller that acts as the brain of the circuit. The Arduino Nano is programmed to receive inputs from the two IR sensors, process the data, and control the LCD display and the light output accordingly. The Arduino Nano is known for its versatility and ease of programming, making it a perfect choice for this application.The IR sensors used in this circuit are carefully chosen for their accuracy and reliability. These sensors emit infrared radiation and measure the intensity of the reflected radiation to detect the presence of an object in their field of view. When a person enters the sensing range of the IR sensors, they reflect the emitted radiation back towards the sensors, triggering them to send signals to the Arduino Nano. The LCD display is a crucial component of the circuit, as it provides real-time feedback on the visitor count. The LCD is connected to the Arduino Nano and displays the visitor count in a clear and easily readable format. The display can show the visitor count in numerical form, along with relevant labels or messages, making it user-friendly and informative. The circuit is designed to have a simple and intuitive operation. When a visitor enters the sensing range of the IR sensors, the Arduino Nano receives signals from the sensors and increments the visitor count on the LCD display. Simultaneously, the Arduino Nano sends a command to turn on the light, providing illumination in space. The light can be connected to the Arduino Nano through a relay or a transistor, which allows for easy control of the light output. The light serves as a visual indicator to signify the presence of a visitor, making it convenient for monitoring and managing visitor flow in a space.On the other hand, when there is no visitor detected by the IR sensors, the Arduino Nano updates the LCD display accordingly by decrementing the visitor count. The Arduino Nano also sends a command to turn off the light, conserving energy and ensuring that the light is only active when needed. This smart and automated system not only provides an efficient way to manage visitor counts but also promotes energy-saving practices, making it environmentally friendly. The circuit is designed with accuracy and reliability in mind. The IR sensors are carefully calibrated to minimize false triggers and provide precise detection of visitors. The Arduino Nano is programmed with robust algorithms to filter out noise and ensure accurate counting of visitors. The LCD display is designed to be clear and readable, even in varying lighting conditions. The light output is controlled with precision to ensure it turns on and off promptly, providing a seamless and efficient operation. The circuit is also versatile and can be customized to suit different applications. The sensitivity of the IR sensors can be adjusted to accommodate different sensing ranges and environments. The LCD display can be configured to show additional information, such as time, date, or other relevant data. The light output can be customized to match the requirements of the space, such as brightness level, color temperature, or duration of operation. The Arduino Nano can also be programmed to perform additional tasks, such as sending notifications or integrating with other systems, making it a flexible solution for various scenarios. The relay module used for controlling the lights is designed to handle high voltages, ensuring safe and reliable operation. The Arduino Nano is also equipped with built-in safety features, such as short circuit protection and voltage regulation, to protect the circuit from damage and ensure safe operation.

CHAPTER 6
RESULTS AND OUTPUT

6.1 Proposed Model

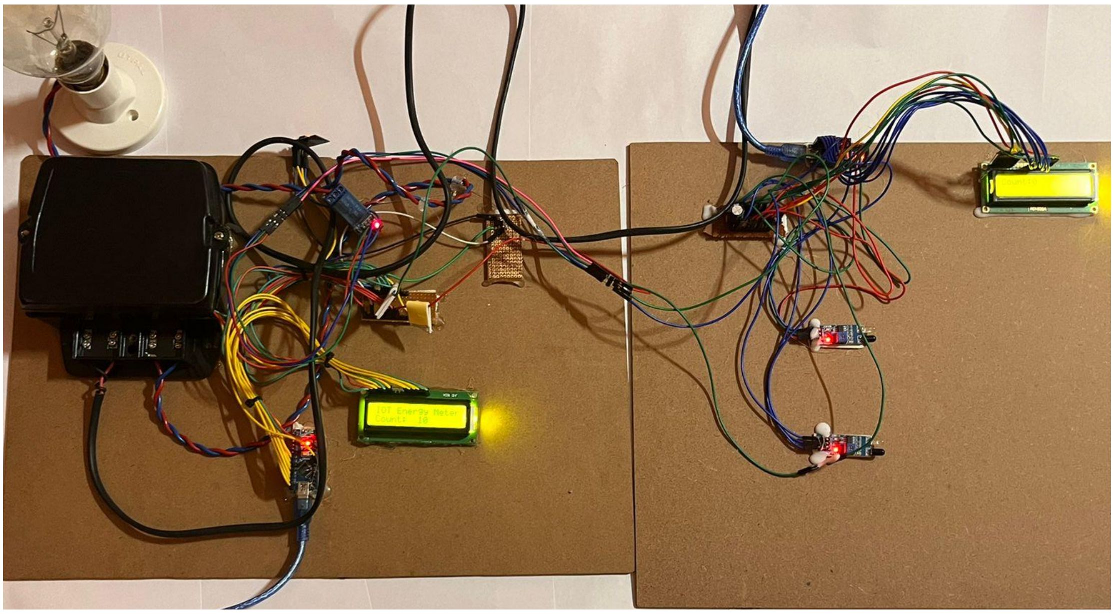

Figure. 6.1 Prototype of model

The Figure 6.1 shows a model , we have integrated multiple components to achieve two main objectives: energy monitoring and visitor counting.

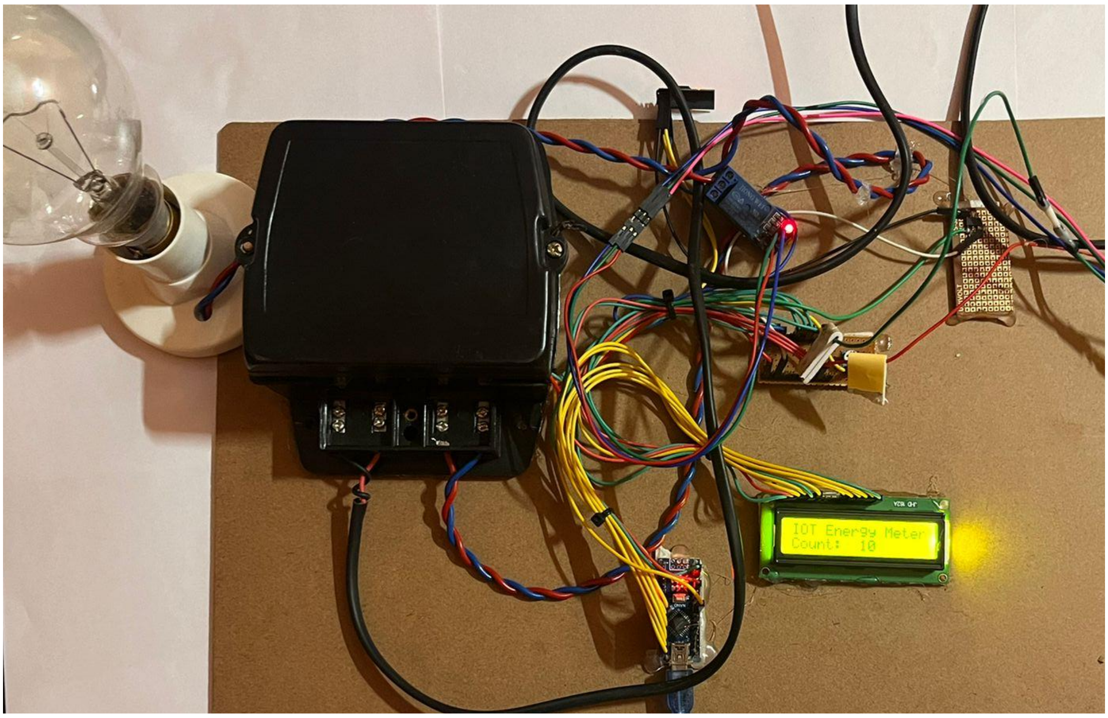

Figure. 6.2 Model for Monitoring Unit count

In Figure.6.2, an Arduino Nano microcontroller is connected to an energy meter and an LCD display. The energy meter records the energy consumption of the connected appliance, and the LCD displays the energy count in real-time. This information is sent to ThingSpeak.com through a Wi-Fi ESP 8266 module, enabling remote monitoring and control.To ensure accurate energy readings, the energy meter is painted black to prevent any interference from external light sources. Additionally, the model includes a bulb that is connected to a relay module, acting as a switch to turn the bulb on and off.

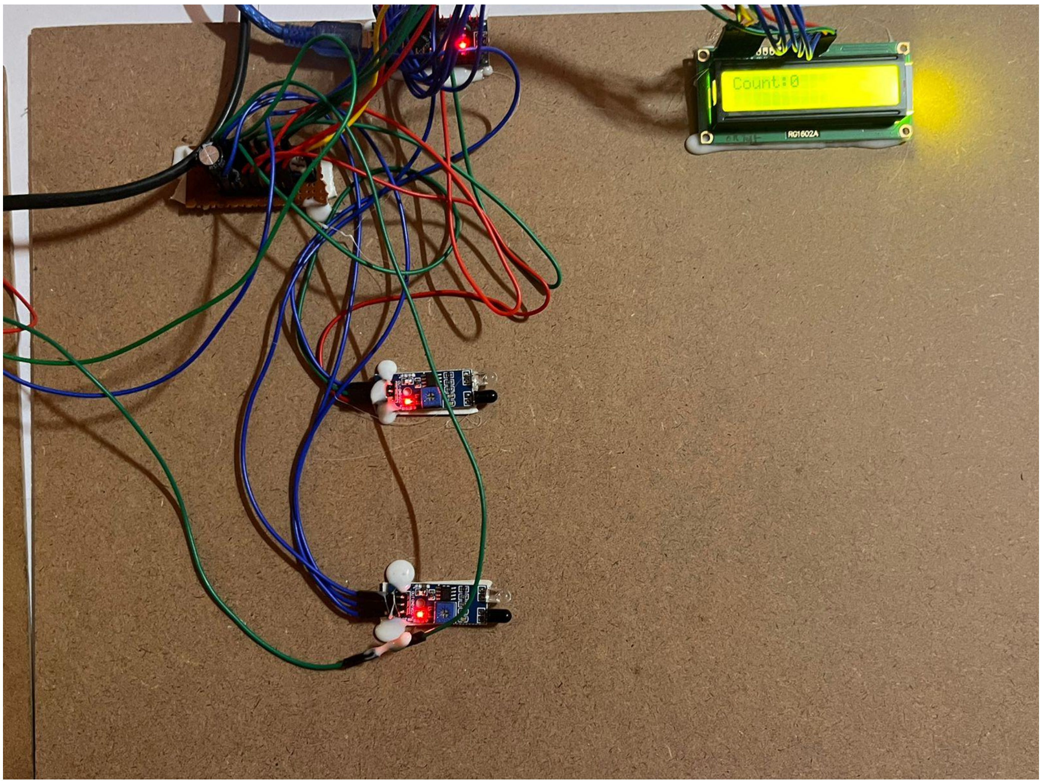

Figure. 6.3 Model for Visitor Count

We have used another microcontroller as shown in Figure.6.3 that is connected to an IR sensor. The IR sensor monitors visitor count by detecting their presence in the room. When the visitor count is one, the microcontroller activates the relay module to turn on the bulb, and when there is no visitor, it turns off the bulb. This feature is useful in energy conservation, as it ensures that the bulb is only on when needed.
Both microcontrollers are connected to the same relay module to complete the circuit. The proposed model is designed to be flexible and scalable, allowing for integration with other IoT devices and sensors to further enhance its functionality.

6.2 Results

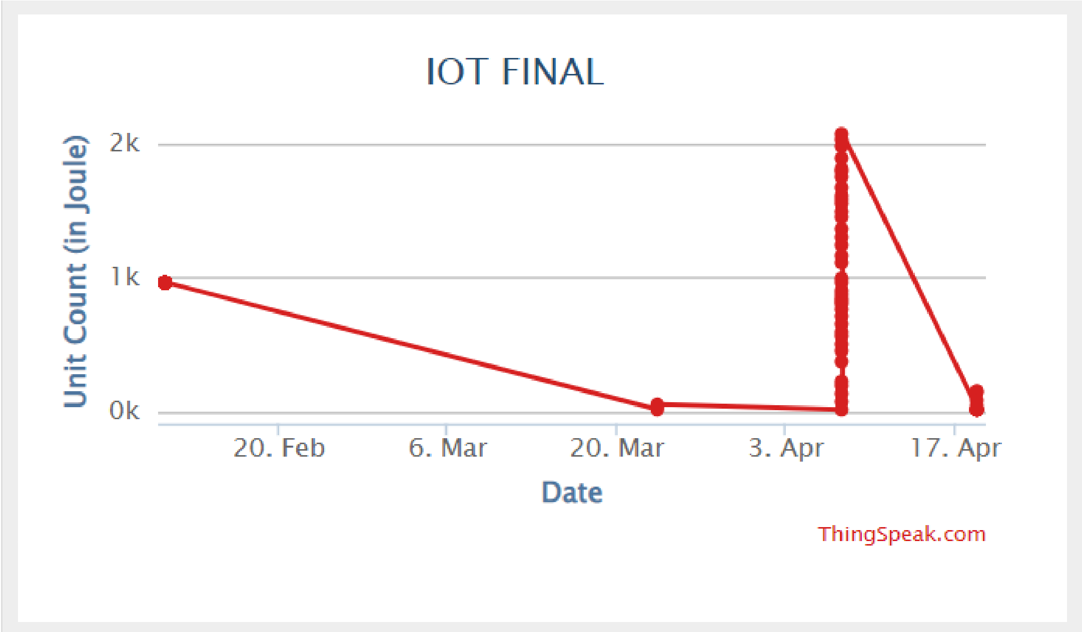

Figure. 6.4 Monthly Monitored Data of the Energy

The graph shown in Figure.6.4 displays the monthly data of energy consumption, which is recorded by an energy meter connected to an Arduino Nano microcontroller through an API key. The energy meter measures the amount of energy consumed by the appliance, and this data is sent to ThingSpeak.com through the API key. ThingSpeak.com is an IoT analytics platform that collects, analyzes, and visualizes data from IoT devices. The graph displays the monthly energy consumption of the connected appliance over a period of time. The data is presented in a line chart format, with the X-axis representing time and the Y-axis representing energy consumption. The line chart shows the trend of energy consumption, indicating whether energy usage is increasing or decreasing over time.

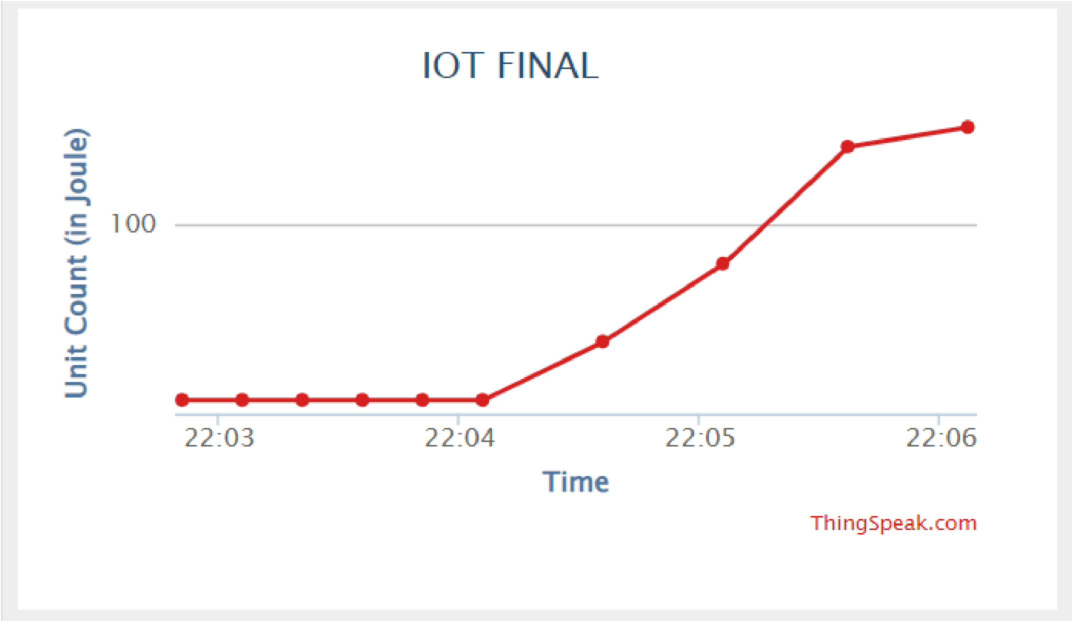

Figure. 6.5 Real-Time Monitored data

The graph shown in Figure.6.5 displays the energy count over time, allowing users to monitor their energy consumption and identify any anomalies or inefficiencies. The real-time nature of the data allows for immediate feedback and control, enabling users to adjust their energy usage patterns accordingly. The graph also enables users to set goals for energy reduction, track their progress, and make informed decisions about energy usage.From Thingsspeak.com we can get data as per as the user demand , daily, monthly or yearly basis. ThingSpeak.com is a cloud-based platform that provides data storage, analysis, and visualization for IoT applications. It enables users to monitor and analyze their data in real-time, as well as view historical data on a daily, monthly, or yearly basis.The platform provides various tools for data analysis and visualization, such as graphs, charts, and maps, which can be customized to suit the user's needs. Users can also set up alerts and notifications to inform them of any anomalies or events of interest, enabling them to take timely action. ThingSpeak.com provides an open API, which enables users to integrate their IoT devices and applications with the platform. This allows for greater flexibility and scalability, as users can easily add or remove devices as their needs change.

CHAPTER 7
CONCLUSION

7.1 Conclusion

The project utilizes an Arduino Nano microcontroller, which serves as the brain of the system, to interface with various components and collect data. The LCD display is used to showcase the electricity consumption in units, allowing users to monitor their usage and make informed decisions about their energy consumption habits. The WiFi module is integrated into the system, enabling data to be uploaded to ThingSpeak, an IoT platform, for further analysis and visualization.

One of the key features of the project is the use of IR sensors to count visitor entries. When a visitor enters the room, the IR sensor detects the movement and increments the count. Similarly, when the visitor leaves, the count is decremented. This information is used to optimize lighting usage. When there is at least one visitor present in the room, the lights are turned on, and when there are no visitors, the lights are turned off automatically, reducing unnecessary energy consumption.

The data collected from the energy meter and visitor counting system is uploaded to ThingSpeak, where it is displayed in graphical format. This allows users to visualize their energy usage patterns over time, identify trends, and make informed decisions on how to optimize their energy consumption. Additionally, the data is also logged into an Excel sheet for further analysis and record-keeping.

The project has several potential benefits. First, it promotes energy conservation by providing real-time monitoring and display of electricity usage, helping users to be more conscious of their energy consumption habits and make informed decisions to reduce their carbon footprint. Second, the visitor counting system helps optimize lighting usage, ensuring that lights are only turned on when needed, which can lead to significant energy savings. Third, the integration of IoT technology through the WiFi module and ThingSpeak allows for remote monitoring and data analysis, providing a more comprehensive and convenient approach to managing energy usage.

7.2 Future Scope

The project also has potential for further enhancements. For instance, additional sensors, such as temperature and humidity sensors, could be integrated to provide more comprehensive data on the energy usage patterns and environmental conditions in the room. This could enable users to optimize their energy usage based on factors such as weather conditions or room occupancy. Moreover, the project could be expanded to include home automation features, such as controlling other appliances or devices based on energy usage or visitor counts, to further enhance energy conservation efforts.

Expansion to industrial and commercial applications: The system can be expanded to commercial and industrial applications where effective energy management and use are essential for the large scale operations. To meet the unique needs of commercial and industrial contexts, this would necessitate customization and scalability of the systems.

Integration with renewable energy sources: To track and maximize the use of renewable energy, the system can be connected with sources like solar cells or wind turbines. This would allow customers to use renewable energy as much as possible while reducing their reliance on grid electricity.

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ANNEXURE I

Source Code

```
#include<LiquidCrystal.h>
LiquidCrystal lcd(7,8,9,10,11,12);
#include <SoftwareSerial.h>
long  t2=0;
long  t1=0;
SoftwareSerial ser(5, 6); // RX, TX
String stri;
char buf1[16];
// MY channel's thingspeak API key
String apiKey = "IHB5AUKVFV0FIJJX";
int sem1=0;
int count3=0;
int i=0;
int sem=0;
int count =0;
int count1 =0;s
int count2 =0;
long measurementStartTime = 0;
void setup(){
  Serial.begin(9600);
  lcd.begin(16,2);  lcd.setCursor(0,0);
      lcd.print("IOT Energy Meter");
       lcd.setCursor(0,1);
      lcd.print("Count:");
         analogReference(DEFAULT);
    // enable software serial
  ser.begin(115200);
// reset ESP8266
  ser.println("AT+RST");
   delay(500);
  ser.println("AT+CWMODE=3");
   delay(500);
  ser.println("AT+CWJAP=\"project\",\"12345678\"");
  delay(500);
}
void loop(){
//Serial.println(analogRead(A4));
  if((analogRead(A4) < 850) && (sem == 0))
{
  sem = 1;
  count++;
  //Serial.println(count1);
}
count1=count*10;
lcd.setCursor(8,1);
```

```
      lcd.print(count1);
      lcd.print("    ");
if((analogRead(A4) >= 850) && (sem == 1))
{sem = 0;}
stri = dtostrf(count1, 4, 1, buf1);
    Serial.print(stri);
    Serial.println(" ");
 delay(100);
      if(millis() - t2>15000)
  {
    t2=millis();
    // TCP connection
  String cmd1 = "AT+CIPSTART=\"TCP\",\"";
  cmd1 += "184.106.153.149"; // api.thingspeak.com
  cmd1 += "\",80";
  ser.println(cmd1);
  if(ser.find("Error")){
    return;
  }
  String getStr1 = "GET /update?api_key=";
  getStr1 += apiKey;
  getStr1 +="&field1=";
  getStr1 += String(stri);
  getStr1 += "\r\n\r\n";
  cmd1 = "AT+CIPSEND=";
  cmd1 += String(getStr1.length());
  ser.println(cmd1);
   if(ser.find(">")){
    ser.print(getStr1);
  }
   else{
    ser.println("AT+CIPCLOSE");
       Serial.println("AT+CIPCLOSE");
  }}}
```

For IR Sensors

```
#include<LiquidCrystal.h>
LiquidCrystal lcd(7,8,9,10,11,12);
#define in 4
#define out 5
int count=0;
void IN()
{
delay(100);
while(digitalRead(out)==1);
  if(digitalRead(out)==0)
  {
    count++;
```

```
  }
      lcd.setCursor(0,0);
    lcd.print("Count:");
    lcd.print(count);
      lcd.print(" ");
    delay(1200);
}
void OUT()
{
delay(100);
while(digitalRead(in)==1);
  if(digitalRead(in)==0 && count>0)
  {
    count--;
  }
      lcd.setCursor(0,0);
    lcd.print("Count:");
    lcd.print(count);
      lcd.print(" ");
    delay(1200);
}
void setup() {
Serial.begin(9600);
analogReference(DEFAULT);
  Serial.println("Counter");
   lcd.begin(16,2);
  lcd.print("Visitor Counter");
  delay(2000);
  pinMode(in, INPUT); // in sensor
  pinMode(out, INPUT); // out sensor
   lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Count:");
    pinMode(6, OUTPUT); //r
     digitalWrite(6, HIGH);
      lcd.print(count);
}
void loop() {
while(digitalRead(in)==0)
  IN();
  while(digitalRead(out)==0)
  OUT();
  if(count>0)
 {digitalWrite(6, LOW);}
 else
 {
  digitalWrite(6, HIGH);
  }
```

ANNEXURE II

1. Nikita Sinha, Pallavi, Subrata Sahana, Sanjoy Das, "Real-time IoT Based Energy Efficient Framework for Home Appliances", 2023 IEEE IAS Global Conference on Emerging Technologies (**GlobConET SCOPUS Index**)
   Accepted and Registered

2. Nikita Sinha, Pallavi,Subrata Sahana, "Adaptive Energy Harvesting for Efficient Power Generation in IoT Applications", 2023 International Conference on Advanced Intelligence System (**ICAIS**)
   Communicated