Design and Development of IOT Based Solar Powered Building Energy Management System (BEMS).

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ABSTRACT

This paper presents the IoT-Based Solar Powered Building Energy Management System (BEMS), addressing typical building issues like high energy consumption during peak hours and elevated electricity costs. It revolutionizes energy management by integrating solar power and IoT technology to optimize consumption and enhance efficiency. The system targets sustainable energy solutions for residential and commercial buildings by integrating solar energy and optimizing the load curve, especially during peak hours, through load scheduling and shifting. It minimizes thermal discomfort while optimizing load consumption, considering factors like temperature, humidity, and occupancy, with manual control via an app. An ESP32 microcontroller, charge controller, battery, solar panel, water tank motor, ultrasonic sensor, I2C module, voltage and current sensor, buck converter, and temperature and humidity sensor (DHT11) are some of the essential parts. The elements gather data in real time that is saved on Firebase. By alternating between solar and WAPDA power and controlling large load demands during peak hours, the system automates load management. To ensure optimal energy utilization, fan speeds and lighting are adjusted based on the number of people in the room. The energy efficiency of the system was found to have significantly improved, and users benefited from complete control and insights obtained from constant monitoring using an LCD display and a mobile app. The conclusion emphasizes how BEMS is a crucial development in sustainable building management systems because of its creative approach, which improves energy efficiency and gives users access to energy consumption and data monitoring.

Keywords: BEMS, BMS, IOT, ESP32, Automation, Microcontroller.

Introduction

In this era, where energy management is the concern of everyone, the buildings are being constructed in a manner to provide maximum comfort and ease to the people with minimum energy utilization. The whole thing is only possible with the help of controlling devices that are to be installed in a building during construction. The controlling can be of any type, from simple switching to water motor control and many more. Therefore, main idea of designing this system is to automate these operations of the buildings in more resourceful manner.

1.Problem Statement

In typical buildings energy management system following are the issues that need to be rectified or improved that are higher energy consumption in peak hours, higher demand and cost of electricity. These issues lead to overall aggregated increase in load.

1.1 Aims & Objectives

The main objective of this project is to design an IoT-based Solar Powered Building Energy Management System (BEMS) which include:

- Integrate solar energy.
- Optimization of load curve especially during peak hours through load schedule and shifting.
- To minimize the thermal discomfort while optimizing load consumption that depends upon (Temperature, Humidity and number of occupants.)
- Manual control of building loads through App.

2. Literature Review

This chapter will go into great detail regarding the literature review. During this workshop, we will familiarize ourselves with previously published building energy management system (BEMS) publications. The paper discusses the importance of demand response (DR) in smart grids and the need for effective pricing strategies. It highlights the focus on residential load scheduling and the development of a model that considers both cost efficiency and consumer preferences. The proposed model aims to optimize electricity usage by scheduling appliances based on real-time pricing, ultimately improving energy efficiency and reducing costs for consumers. The working of BMS is totally based on the input in a form of information by the devices such as sensors, once the information is collected it can be processed with the help of controller that will further instruct the system to perform a specific task, in this BMS, switching on and off of the plant can be controlled in the same manner, plant can be set to a respective temperature in order to provide heating and cooling with respect to the temperature outside the building. Microcontroller has been used, as it has the mail role in this system in order to control the devices connected, beside controller transistor has also been used in order to control switching the connection between the two has been made by connecting the base of a transistor to the controller's output pin, this makes the switching easy. Controller usually needs 5V dc in order to operate therefore for that a regulate IC 7805 has also been installed in order to provide fix 5v dc output. LED's and LCD has been kept in this system in order to perform their respective tasks, such as LED's are used to show illumination of each room together with its controlling from main supply. Whereas for Security processing and Passwords LCD has been used.

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3. Methodology:

The project consists of hardware (Prototype with mechanical and electrical components). The first and initial step is to build a structure to apply the building Energy management system. The working of BMS is totally based on the input in a form of information by the devices such as Temperature and humidity sensors, once the information is collected it can be

processed with the help of ESP32 microcontroller that will further instruct the system to perform a specific task, in this BEMS, manual switching on and off of the loads can be controlled from the android app, prototype can be set to a respective temperature in order to provide heating and cooling with respect to the temperature according to ISO standard.

A block diagram of the hardware is shown in Figure 1.

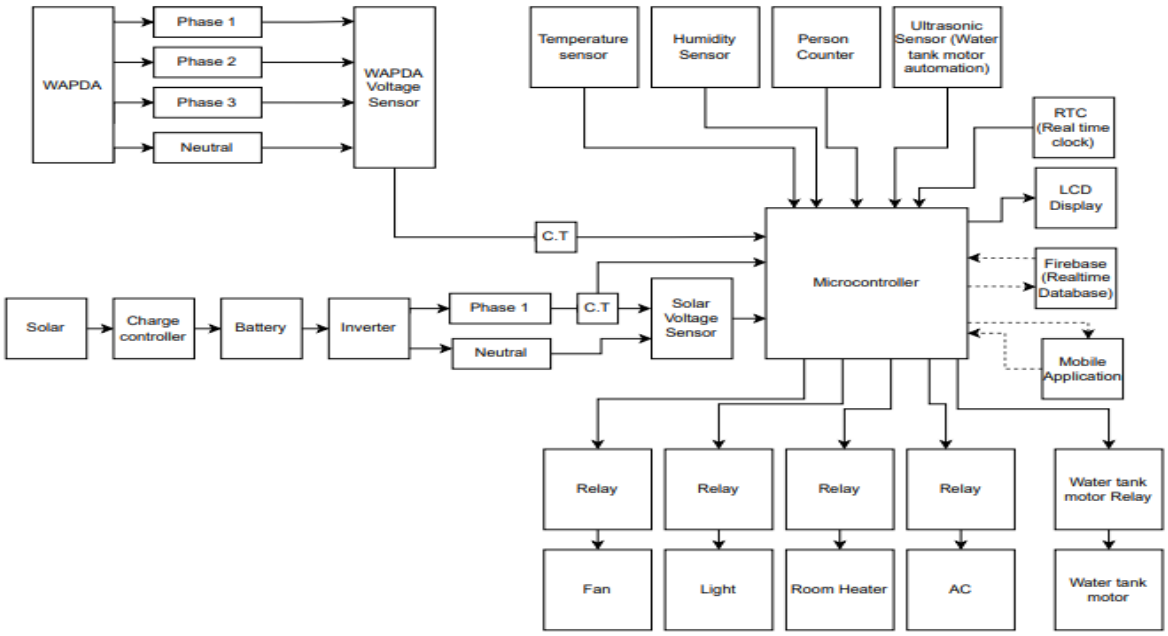

Figure 1. Block Diagram of BEMS

4. Results

This chapter describes main concluded facts about installed and works out Building Energy Management System (BEMS). After the analysis of the collected data, we will assess the system performance and its correspondence with the design's goals as well as we define the measures intended to eliminate any obstacles. The BEMS effectively reduced energy consumption by analyzing sensor data to optimize heating, ventilation, lighting, and renewable energy integration. Real-time data analysis enabled load shedding during peak hours, minimizing grid reliance. The user-friendly mobile app and LCD display provided real-time energy consumption monitoring and control, allowing users to manage settings remotely and access essential system information.

Figures: Simulation Diagram of BEMS is shown in Figure 2.

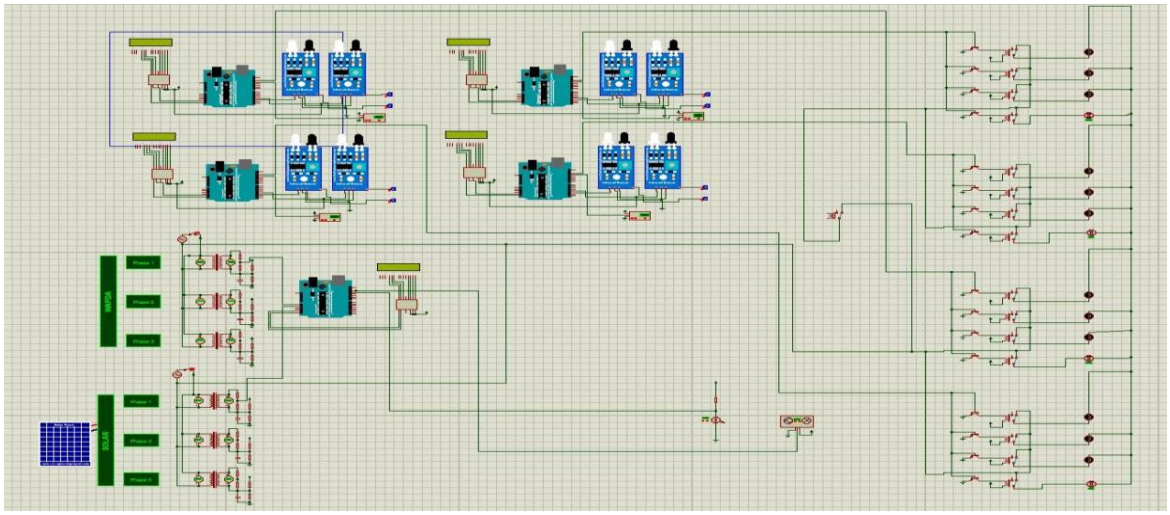

Figure 2. Simulation Diagram of BEMS

The hardware components of the suggested system are discussed below.

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The thesis project employs a range of components to create an efficient and sustainable Building Energy Management System (BEMS). A lithium polymer battery stores solar energy, reducing reliance on non-renewable sources. The ESP32 microcontroller manages data processing, communication, and sensor interaction. Voltage and current sensors monitor electrical parameters, while an IR sensor detects objects and proximity. An LCD screen displays system information, and a DHT11 sensor measures temperature and humidity. Resistors control current flow, and an ultrasonic sensor measures distance. An RTC module provides accurate timekeeping. A water pump, integrated with an SR04 sensor, efficiently manages water usage. A solar module and inverter harness solar energy, while a charge controller regulates battery charging. A buck converter efficiently converts voltage for system components.

Prototype of BEMS is shown in Figure 3.

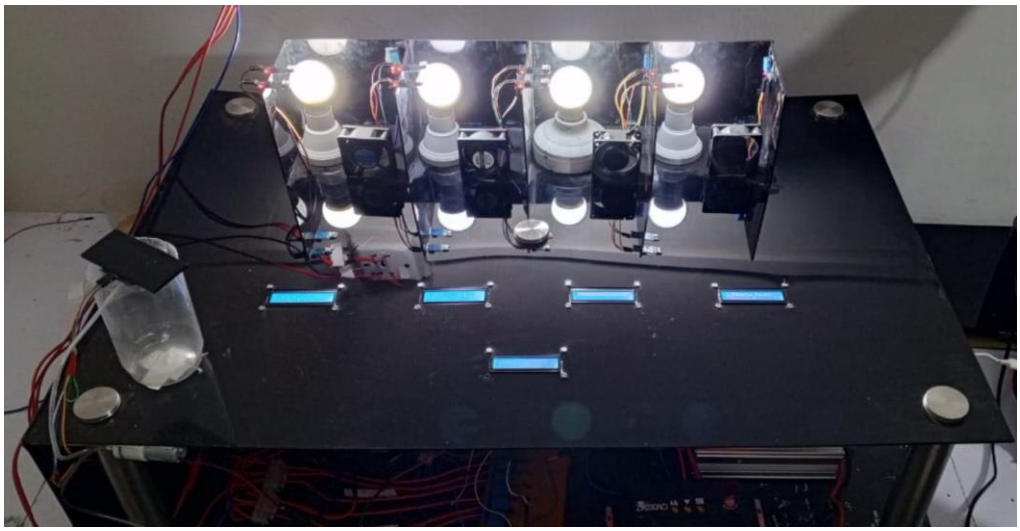

Figure 5.1 Prototype of BEMS

5. Discussion:

The outcome of the BEMS testing delivered positive overall findings. Sensor data analysis supported the implementation of the system and its results in energy saving and peak hour demand reduction, proving the optimization of operations in buildings. The majority of the user's feedback via the mobile app as well as display LCD was positive, which is a good sign of the room for the additional improvements. Overall, these findings indicate the capability of the BEMS to strengthen the sustainability of building operation in actual application.

Future Suggestions

The BEM system can be improved in the future in multiple ways. Here are a few suggestions:

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- Add more rooms and sensors.
- Integrate more devices and actuators.
- Use machine learning for better energy management.
- Create smarter system algorithms.

. Limitations

The existing BEMS system has some drawbacks. Here are a few limitations:

• The specific application is only meant for a four rooms setup.

• The device records data of just a few environmental parameters.

• It may be that the technique might be just able to monitor a few appliances.

• The technology of the system is considered primitive because it doesn't use machine learning and the most advanced control mechanisms.

BEMS systems offer cost-effective, energy-efficient, and scalable building power management with significant electricity bill reduction potential.

6: Conclusion

The BEMS (Building Energy Management System) project has been designed and implemented successfully in the building sector for energy consumption and management. The test phase verified the design objectives of realizing energy saving and reducing the peak hour demand by the fact that the system was able to accomplish the set goals. Sensor's analysis data at all times build up optimal control strategies and as a result, energy costs optimization occurs. The user interfaces, mobile app and LCD display were employed as the tools that would allow for the interaction between the system and the user and give detailed insights on the trends in energy consumption. In general, the BEMS project has an ongoing role for the sustainable building management nevertheless, is also a great start towards building automation and energy efficiency.

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