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CONFERENCE PAPER

NEXT-GENERATION IOT SMART METERING FOR REAL-TIME ELECTRICITY ANALYTICS AND AUTOMATION

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Abstract

In recent years, the energy sector has undergone remarkable transforma tion, largely driven by the integration of intelligent technologies. From electricity generation to end-use consumption, smart systems have become increasingly influential. The Internet of Things (IoT) ecosyste m, in particular, has introduced numerous smart devices and home automation solutions. Among these innovations, smart energy meters have emerged as an effective tool for residential energy management. With technological advancements, it is now possible to monitor electricity usage in a non-intrusive manner using smart meters,enabling efficient control of household appliance consumption. In this study, an IoT-based smart meter is implemented to measure real-time power usage in different rooms of a house by tracking the electricity flow through power lines. The collected data is automatically transmitted to a real-time database for further analysis. This system enables users to identify which appliances are operating in each room and determine their corresponding energy consumption. If the power usage in any room exceeds a predefined threshold set by the user, the system provides options to either disconnect the power supply to that room or send an email alert. Additionally, users can remotely manage power supply—either for specific rooms or the entire house—via internet connectivity. These features empower consumers with better insight and control over their electricity consumption, ultimately helping them reduce energy usage and lower costs.

Introduction:-

Recent technological advancements have significantly improved the efficiency of energy utilization. However, there remains a growing need for intelligent systems capable of monitoring, controlling, and automating electricity consumption.

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As modern lifestyles demand greater convenience and accessibility, the development of energy-efficient solutions has become essential to maintain a balanced relationship between power generation and consumption.The proposed system focuses on providing a cost-effective and efficient solution for remote power monitoring, offering advantages over conventional methods. It includes the development of a web-based platform that allows users to securely log in and monitor the electricity consumption of individual rooms in real time. Through intuitive graphical representations, users can easily identify areas of excessive power usage. If consumption exceeds predefined thresholds, users can take timely corrective actions, thereby promoting energy conservation and optimizing overall electricity usage.

Literature Review:-

In this study, the conventional electricity metering system used by the power suppliers in Bangladesh has been analyzed, and several limitations and operational challenges have been identified. Various existing approaches aimed at mitigating the issues associated with manual meter reading have also been reviewed. In India, Praveen Kumar et al. (2015) proposed a GSM-based energy metering system to address the shortcomings of traditional meter reading methods. This system employed a digital energy meter installed at each consumer unit, integrated with a GSM module for data transmission, along with an automated billing mechanism at the utility provider's end. However, a major limitation of this approach was its dependency on GSM network coverage, making it ineffective in regions lacking reliable or stable communication infrastructure.

Proposed System:-

The methodology of this work comprises two sections. The first section is the system design and the hardware construction and the second is the Web-based system.

Hardware Design and Implementation:-

The IoT-based smart meter has been devised with Nodemcu which contains a built-in ESP8266 wifi module, current sensors, voltage sensors, Analog-Digital converter systems, and relay circuits. To measure the energy consumption, for each room a CT(Current transformer) is assigned and the data from each CT is collected through the serial port of the Nodemcu. For the entire system, we have a Voltage Transformer. On each second the nodemcu will read the data from the current transformer and the voltage transformer through PIC16F876 Analog to Digital converter IC. The PIC16F876 ADC converter has 5 channel digital input port. when we apply a digital signal '0' to each channel, data from the corresponding sensor will be transferred to the nodemcu. The nodemcu is working in 3.3v. so the digital value that is to be sent to nodemcu corresponding to the analog sensor value can be calculated using,

ADC reading = (Resolution of the ADC X Analog voltage Measured) / System Voltage:-

The Nodemcu is linked with the adjacent point of access utilizing its SSID and Password and also connected to a real- time database through the Authentication key. The power consumption taken by each room is calculated using Irms and Vrms values collected from the sensors by the given formula,

Power usage = Irms x Vrms:-

This power usage is uploaded to the real-time database along with the consumer_id, room_id, and timestamp. The hourly usage data is also uploaded to the database. The hourly consumption is calculated by,hourly consumption = Irms x Vrms x 3600 For controlling the room, we create streaming with the database, where the room is controlled using a logic 1 or 0. If the bit is 1 the relay for the particular room will be turned on and if the bit is 0 then the relay for the particular room will be turned off. Fig 1 displays the flow diagram integrating the hardware design.

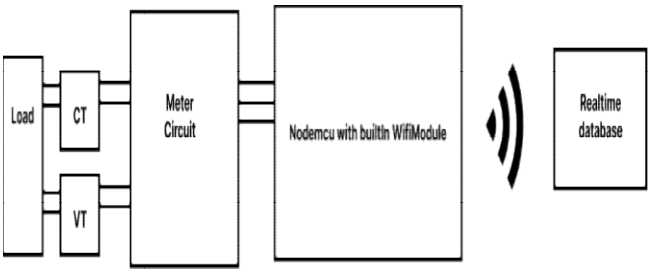

Fig.1 Flow diagram of hardware system

India possesses substantial biomass resources, estimated at nearly 500 million metric tonnes annually, of which about 120–150 million metric tonnes are currently used for energy generation. The government has set an ambitious target of producing up to 50,000 MW of electricity from biomass. During the 2013–14 financial year, LPG production stood at 13,123.29 TMT, while demand reached approximately 16,824.72 TMT, indicating a significant supply gap. Bioethanol derived from biomass fermentation represents a considerable energy resource and can be used as an alternative automotive fuel, as successfully demonstrated in countries like Brazil. The Indian government has also planned to expand biodiesel production to meet nearly 20% of the nation's diesel demand by 2021. Advancing and modernizing biomass energy systems in India can provide notable socio-economic benefits for both rural and urban communities. When efficiently developed and implemented, biomass energy systems can serve as environmentally sustainable energy solutions that support long-term development goals. However, to make a meaningful contribution to current energy demands, biomass production must be scaled up significantly. Biomass is not only cost-effective but also environmentally friendly, offering a sustainable alternative to conventional energy sources while maintaining efficient production practices. Future projections indicate a substantial rise in biomass energy demand up to 2025. This growth is expected to be driven by increasing population, expanding industrial activities, and technological advancements that enhance biomass fuel quality and improve its conversion into efficient energy carriers.

Implementation:-

Software tools:-

The text editor used for this project is visual studio code. Visual Studio Code is a lightweight powerful source code editor, with built-in javascript support. It natively supports many programming languages, and functions can be attached by users with extensions.The server setup is done node, its 'http.createServer()' method creates an HTTP server object and starts running the application. For the database, we use MongoDB Atlas and Firebase real-time database. The MongoDB Atlas is a multi- cloud database service, that deploys and scales MongoDB in the cloud. Firebase Real-Time database is a cloud-hosted NoSQL database that lets us store and sync and query data between users in real-time, and data is stored as a JSON and synchronized in real-time to every connected client.The firmware for the microcontroller is created using Arduino IDE software. Arduino IDE is open-source software, which can be used to write and upload code to development boards. It supports C and C++ programming languages.

Hardware tools:-

Hardware requirements for this development are a laptop with an i3+ processor, 4GB+ Ram, and 2GB+ SSD space. For the smart meter, we need a Nodemcu development board, Current Transformer, Voltage Transformer, PIC16F876 IC, resistors, diodes, potentiometers, etc. The nodemcu board is used to read the data and upload it to the database. The current and voltage transformers are used to sense the voltage and current usages and provide the necessary analog output. The PIC16F876 IC is a 5-channel 10-bit Analog-to-Digital converter, that helps to convert the analog output of sensors to digital serial output for the nodemcu to read.

Result:-

Fig.2. Dashboard of the smart meter.

The above image shows what the dashboard of the smart meter looks like. Consumer can see the total consumption history over the graph.The consumer can use the control of each room separately, using the button given on the room card. also, users can see the status of the room and the real-time electricity usage of each room through the dashboard. The dashboard also provides the monthly usage and automation-based details.

Future Scope And Conclusion:-

In this paper, we have discussed a method related to a smart meter for real-time electricity load analysis and control. Such a smart meter is needed in society to ensure and maintain the use of electricity through a low-cost intelligent energy metering system. Through this system, we can analyze, control and automate the electricity usage in our house.We can also add machine learning algorithms to evaluate electricity usage and provide better electricity usage tips for saving energy.

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