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Cloud Based Smart Energy Meter for Smart Grid

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Abstract: Efficiency in energy utilization is crucial for the creation of a smart grid in a power system. Monitoring and Effective management of energy are essential for both the supplier and the customer in order to conserve it and use it efficiently. The current power system has several problems including the need to balance energy production with ever-rising demand, energy losses, and adequate recovery of consumer incomes. A smart energy meter based on Cloud communication is suggested as a solution to this issue. The suggested Smart system calculates customer demand and energy consumption using a smart energy meter that has an ESP 32 (Wi-Fi module) and uploads it to the cloud using a Home Network (HN) so that customers and suppliers can track the data and regulate their usage. With this technology, consumers and suppliers can communicate wirelessly in both directions, which is the first phase of the soon-to-be-implemented smart grid.

Keywords: smart energy meter, ESP 32, Home Network (HN)

1. INTRODUCTION

Energy is now a crucial necessity for human existence because of the rise of the industrialization and urbanization. The primary issue facing our civilization is the energy crisis. The solution to this crisis is to control, analyse, mange, reduce the wastage of energy and use the energy efficiently. Energy meters play an important role in energy distribution. In India, the current energy metering system primarily employs digital energy meters. Although the digital energy meters has a 0.1 percent error, it is not a smart system. Though it functions well, there are numerous issues with it. Manpower is the primary consideration for meter reading, which is time consuming and does not produce readings based on real-time analysis. Other issues include consumers inability to track their energy consumption, supplier cannot detect fault areas and forecast demand in real time. To overcome these issues, the proposed system, which is a " Cloud-based smart energy meter ", plays a vital role so that it can be compatible with the future smart grid.

Smart energy meters are being integrated into the grid to record and upload the electrical power consumption of all consumers in real-time to a central or local database. Smart meters not only have two-way communication, but they also have real time sensors that can collect data on relevant factors such as the frequencies of energy used by different consumers and appliances.

In this paper, we create a model where the consumer can manage and control the energy consumption of the cloud infrastructure. We developed a management portal between the utility and consumer sides. The consumer and the supplier can continuously monitor the energy consumption and, if desired, consumer can control it. Soon, if time-based energy pricing is introduced, the prices of each period and the failure situations of each moment, if they occurred, can be revealed to public through portal. And it is the consumer's decision whether to continue using the service or stop using it.

2. LITERATURE SURVEY

In paper [1], “IoT-based smart energy metres for smart grid for efficient energy use” by Bibek Kanti Barman*, Sadhan Gope*, Shivam Kumar*, and Shiv Nath Yadav* This study discusses how to use energy efficiently in smart grid by using the IoT based smart energy meter.

In paper [2], Himanshu K. Patel*, Tanish Mody*, and Anshul Goyal*, "Arduino Based Smart Energy Meter Utilizing GSM," in which they describe how they created the smart energy meter using GSM-based communication.

In paper [3], The paper "Designing of Prepaid Energy Metering and network implementation " by Sagar Rathee, Aayush Goyal, and Anup Shukla discusses the design of prepaid energy meters and their deployment in a specific small network utilising PLC-based communication.

In paper [4], "IoT Based Intelligent Energy Meter for Power users," by Md. Mohitul Haque, Zakir Hasan Choudhury, and Fakir Mashuque Alamgir This study developed a smart energy meter based on IoT-based communication, and it primarily focuses on the interaction with users' on real-time energy consumption.

In paper [5], "Design and Operation of Smart Energy Meter for Effective Energy Utilization in Smart Cities" by Qasim Malik, Aamir Zia, Rehan Ahmad, Muhammad Asim Butt, and Zain Ahmad Javed This study directly developed a smart energy meter using Arduino and used GSM system for communication.

In paper [6], “Design and Implementation of an Internet of Things Based Smart Energy Metering” by Mohammad Hossein Yaghmaee and Hossein Hejazi. This research built a node-to-node communication system that uses the Internet of Things and collects data at a central server.

In paper [7], “Smart Energy Metering and Power Theft Control Using Arduino and GSM” by Visalatchi S* and Kamal Sandeep K* builds the smart energy meter using Arduino and GSM.

In paper [8], “Development of Indigenous Smart Energy Meter Complying to Indian Standards for Smart Grid” by Sreedevi V S*, Prakash Prasannan*, Jiju K*, and Indu Lekshmi J I* focuses primarily on the development of advanced metering infrastructure adhering to Indian standards for smart grid.

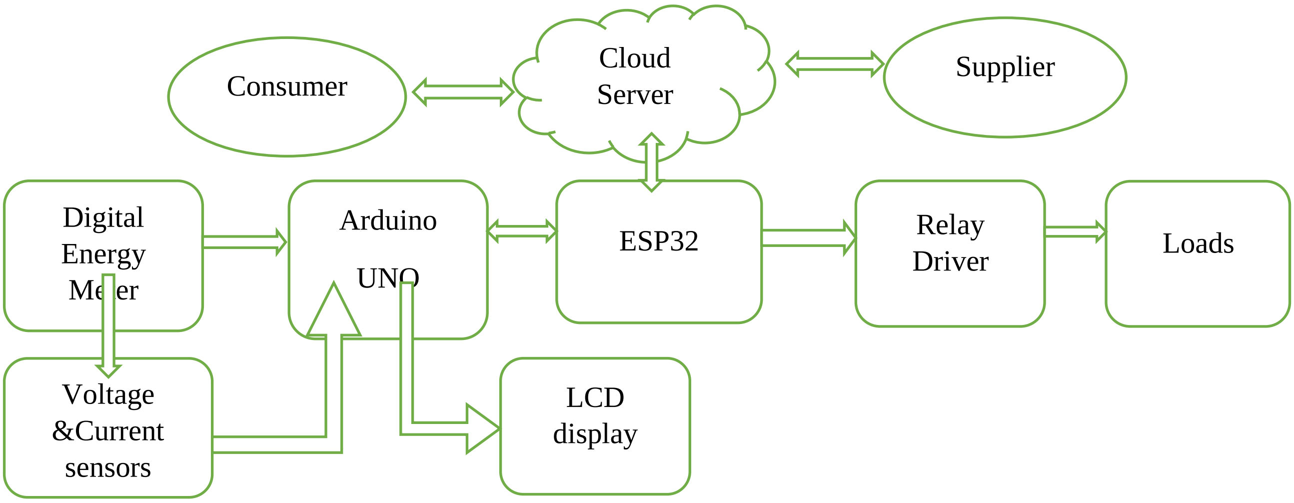
3. PROPOSED SYSTEM

The proposed system will replace the current energy metering system or device by introducing an intelligent system or device called a smart energy meter. The smart energy meter communicates with the consumer and the supplier via a cloud-based, two-way communication method.

The proposed system includes several features for consumers and suppliers, like providing separate interfaces for each. The user interface allows the consumer to monitor his energy consumption in real time. If hourly pricing are implemented in the near future, consumers will be able to analyse their daily energy usage and control it for effective energy use and in accordance with tariff costs. The user interface allows the user to control loads. If the system experiences a sudden voltage drop that exceeds the specified limits due to a fault or other reason, the user has an advanced function to disconnect the loads from the power source.

The supplier can also monitor the energy consumption of all consumers connected to the network in a certain area or within a single distribution station. By analysing consumers' energy consumption data, they can learn the pattern of energy consumption and identify system distribution losses and energy theft. The supplier can monitor the energy consumption of an individual consumer and warn consumers about overloading according to the contract load given to that individual consumer, so that they can collect fines and penalties and interrupt the power supply of that particular consumer if the payment of their energy bill is due.

4. FUNCTIONAL BLOCK DIAGRAM



5. PRACTICAL IMPLEMENTATION OF HARDWARE AND SOFTWARE

The proposed system consists of a digital energy meter, voltage, and current sensors, Arduino UNO, ESP32, LCD display, and relays. The loads are connected to the power supply through the energy meter. Arduino measures voltage and current values using voltage and current sensors. The calibration LED of the energy meter is given to the Arduino by an optocoupler circuit to read the number of pulses of the LED so that we can calculate the energy consumption in units based on the constant of the meter, i.e. 3200 imp/kwh for this system. These three parameters are then sent to the ESP32 and the ESP32 connects to the home network and communicates with the server when the device is turned on and uploads these parameters to the cloud server. From the cloud server, both the consumer and the provider can access real time data through their interfaces. The consumer can manage the usage and control the loads through the user interface using relays. The supplier can control the energy consumption of the connected houses in a certain area and can also interrupt the supply to the consumer if the energy bills are not paid. To implement this project in practice, we need both hardware and software. The prototype of this project includes various parts as mentioned above, and the software required for this project is fully developed for the first time. The whole software consists of a consumer interface, which includes a load management panel, a supplier interface, a cloud server and a database, and the screenshots are shown above.

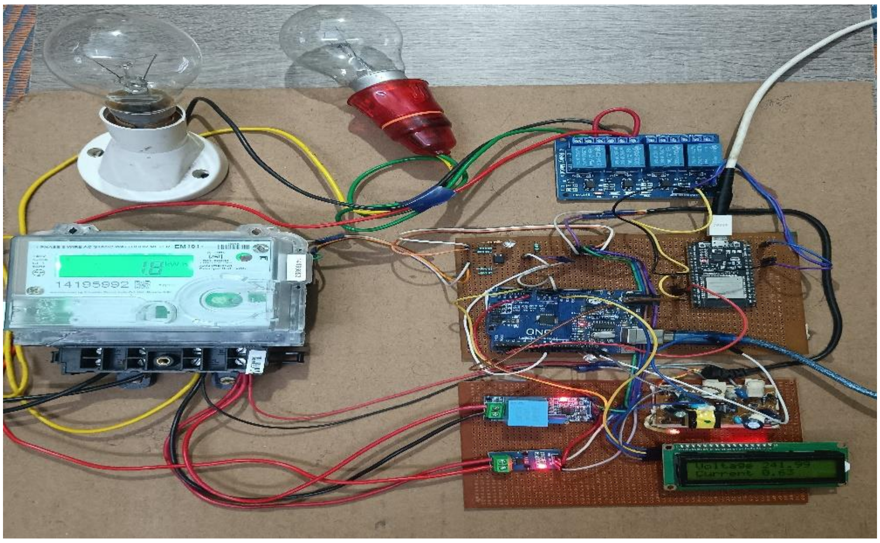


Figure 5.1: Smart Energy Meter

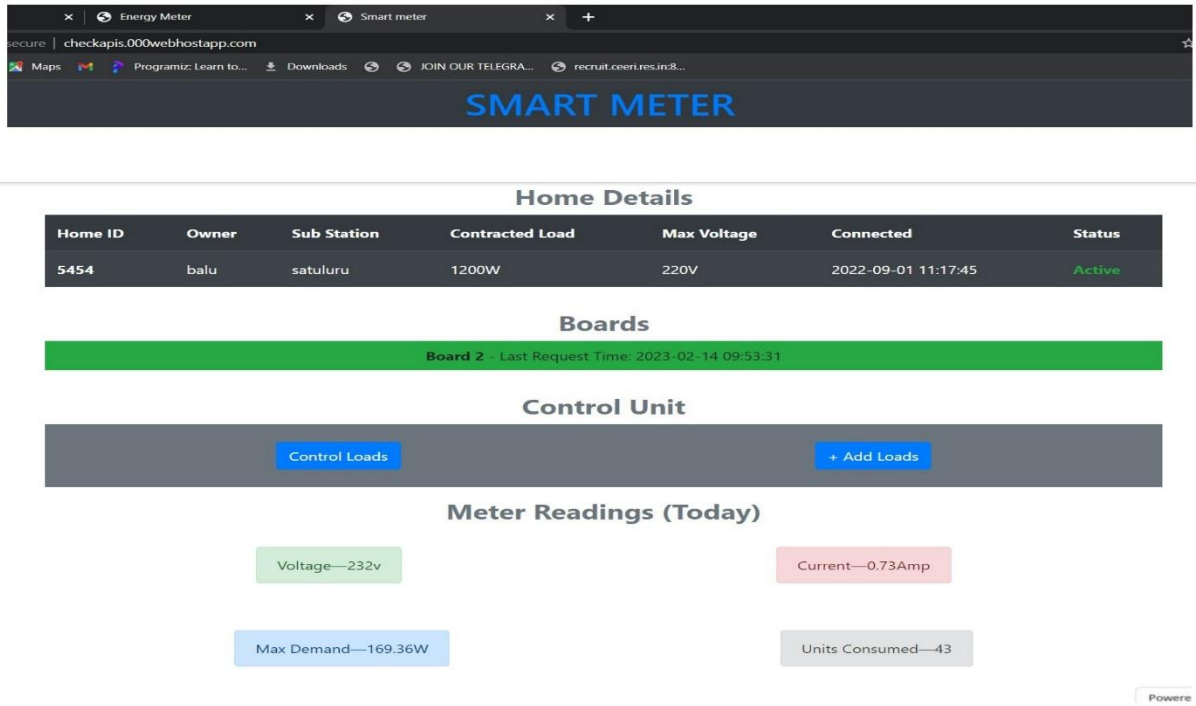


Figure 5.2: Consumer Interface

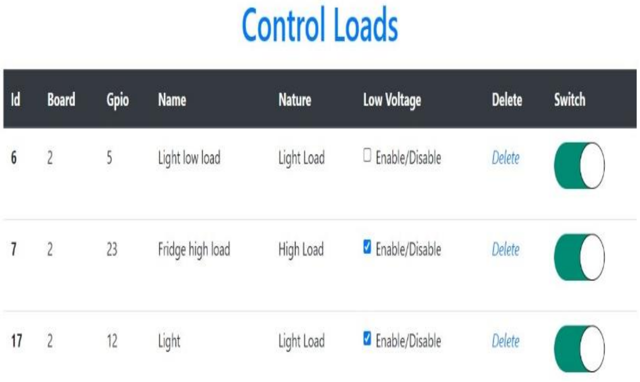


Figure 5.3: Load controlling panel

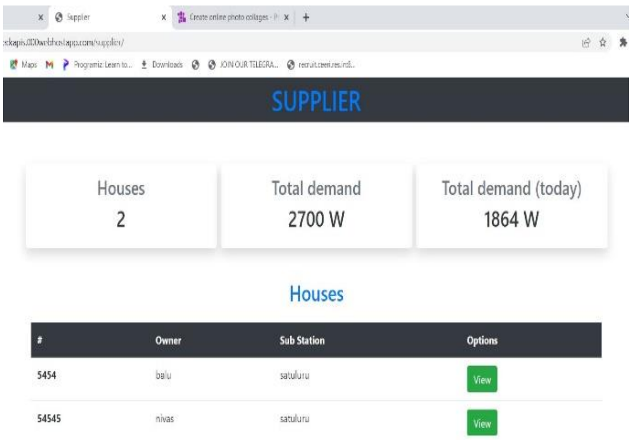


Figure 5.4: Supplier interface

6. EXPERIMENTAL RESULTS AND DISCUSSION

We have done various tests on the prototype of this project to check the functionality of every feature of it. These tests go through the various conditions that a smart meter will encounter after being deployed in the network. Various functional features of this project are shown below with images.

Figure 6.1 shows a device trying to connect to a home network and thereby to a server. When the device is connected to the network, the LCD will show the device is connected and in active mode shown in figure 6.2. After connecting to the network, the device can now communicate with the consumer and the provider through the cloud server.

Figure 6.3 shows the consumer interface where the consumer will able to get his connection details such as home id, owner name, substation name it is connected, status of the smart meter and various parameters like voltage, current, maximum demand and number of units consumed details. From the control loads option the consumer can control the loads and manage the usage shown in figures 6.4 and 6.5.

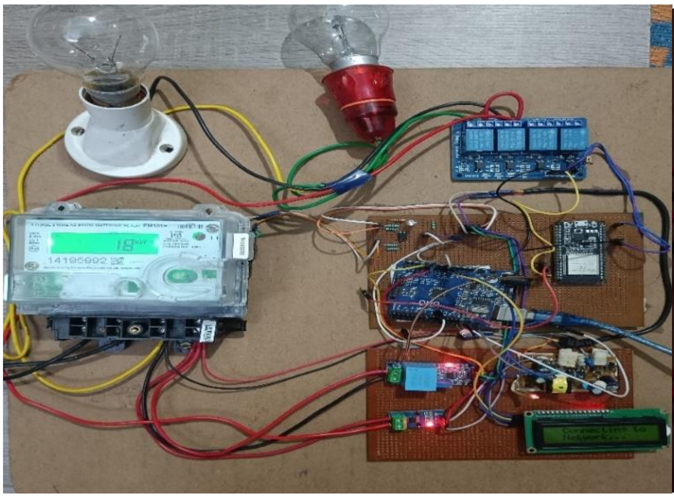


Figure 6.1: Device connecting to network

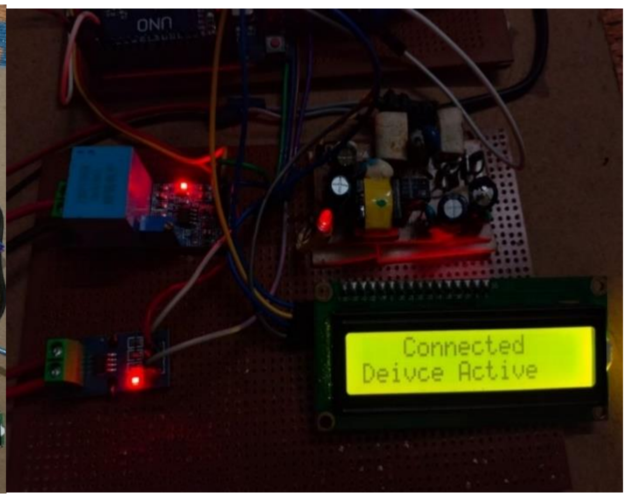


Figure 6.2: Device connected to network and Active

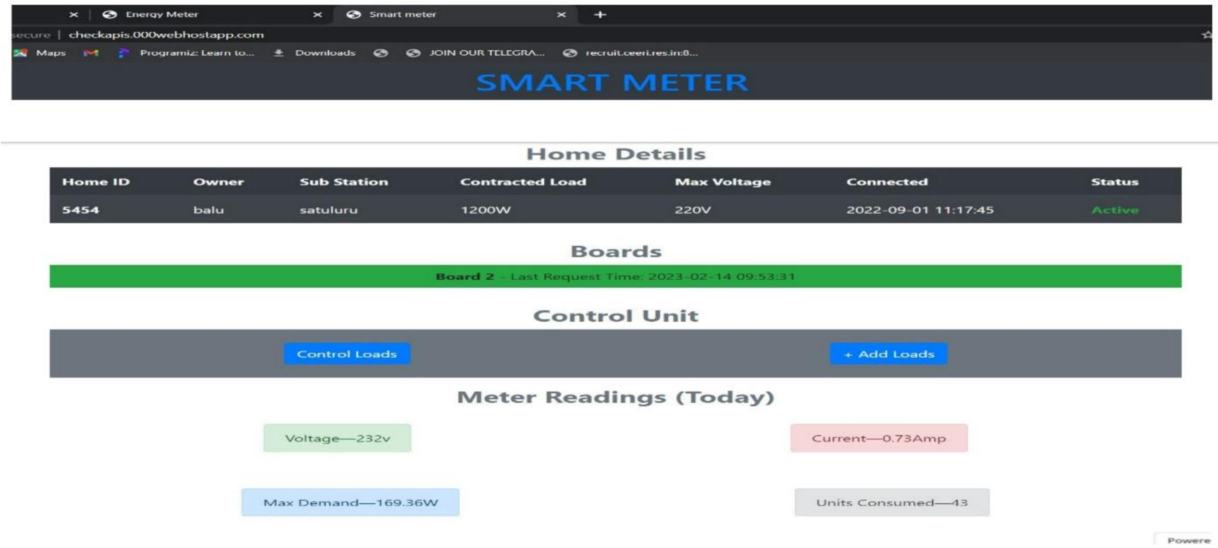


Figure 6.3: Consumer Interface

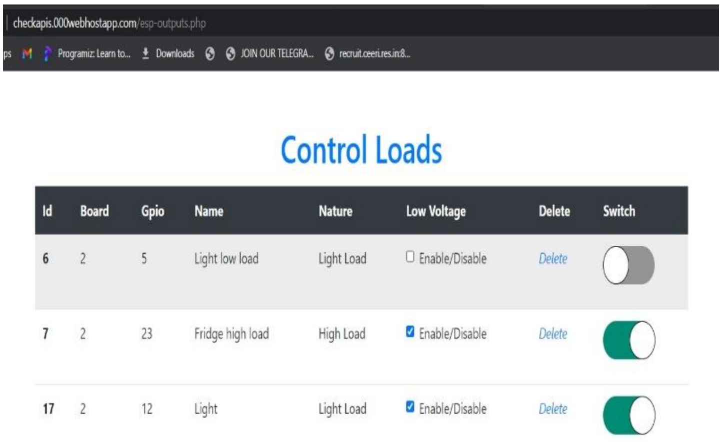


Figure 6.4: Load switches are ON in control panel

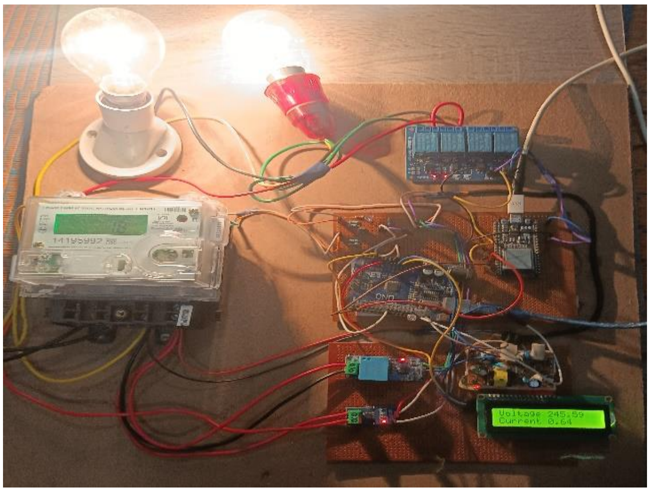
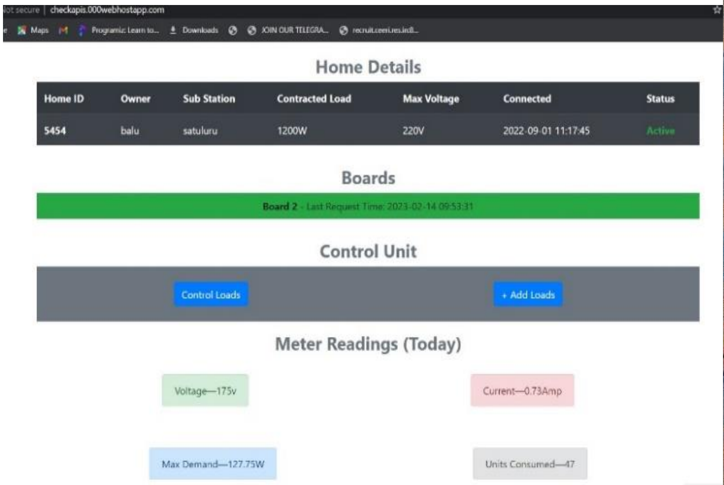


Figure 6.5: Corresponding Loads are ON

The special feature is the disconnection of sensitive loads when the system gets low voltage. By enabling this feature to that particular load, and we can still on the loads such as emergency lighting, even in low-voltage situations when it is required, that is shown in figure 6.6 and 6.7.



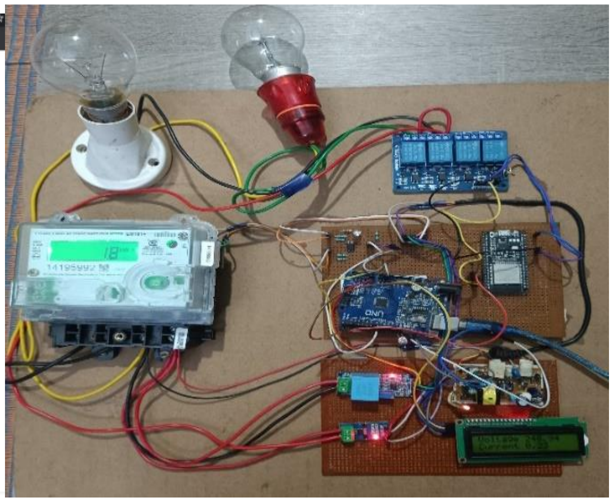
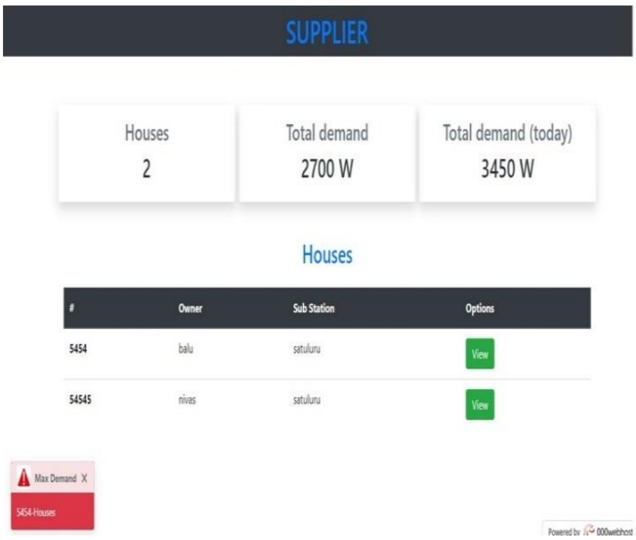


Figure 6.6: Low voltage showing in consumer interface 6.7: Sensitive loads are turned OFF

Figure 6.8 shows that if the consumer exceeds the maximum demand reserved for the relevant service, a warning message appears in the consumer interface, i.e., exceeding the maximum demand reduces loads, while a certain house service exceeds the limit, the supplier receives a warning message. In figure 6.9 the supplier alerted that maximum demand reserved for particular service is exceeded in the supplier interface.



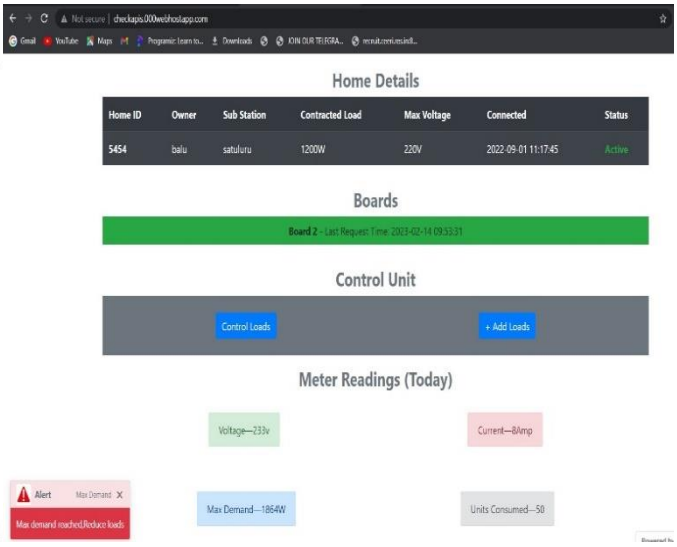


Figure 6.8: Max demand alert in consumer interface Figure 6.9: Max demand alert at consumer interface

Figure 6.10 shows the interface of the supplier, which consists of information about the total number of connections in the relevant area, the current maximum demand, as well as the number of services. connected and the highest demand of the day. The supplier can also monitor the individual consumers energy consumption and can interrupt the supply to the consumers if energy bills are not paid.

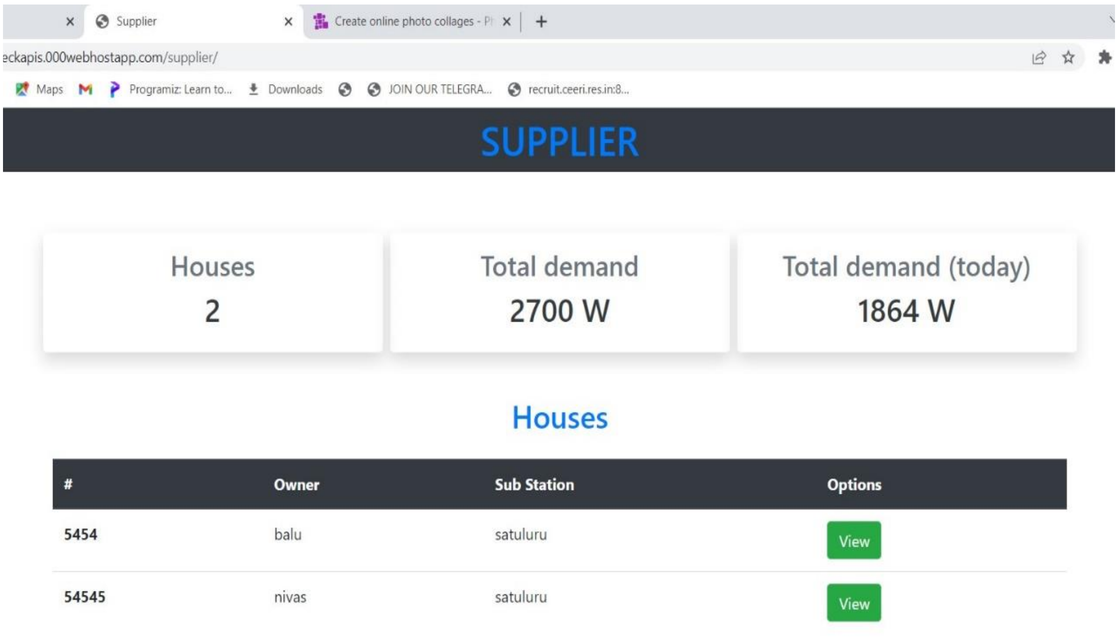


Figure 6.10: Supplier Interface

7. CONCLUSION

This paper proposes an advanced cloud-based smart energy meter for smart grids and microgrids, which has many advantages over the current system. It has been tested in various operating conditions encountered in the network and found that the smart energy meter works more efficiently than the current digital energy meter. The advantages of a smart energy meter are as follows:

- Continuous monitoring of energy consumption and demand can be done.
- Remote control of loads and energy conservation are possible.

- It is possible to locate system faults and losses.

Disadvantages: -

To implement this system, the entire existing metering infrastructure must be replaced with new smart energy meters.

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