# Real-time Monitoring of Energy Meters Using Cloud Storage

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2021 IEEE International Power and Renewable Energy Conference (IPRECON) | 978-1-6654-0137-1/21/$31.00 ©2021 IEEE | DOI: 10.1109/IPRECON52453.2021.9640636

*Abstract*— **The trends and technologies in power systems are rapidly changing. As part of conversion to Smart Grid, there is an increased demand for an efficient and reliable Automatic Meter Reading (AMR) system especially in domestic consumers. Smart energy meters are widely employed in developed countries where there are Smart grids. The immediate transition to smart meters generates huge financial investments for developing countries like India. In order to minimize this initial investment as well as the E-wastes, it is possible to upgrade the functionality of the existing digital meter by incorporating an additional circuitry. This paper presents the design of an energy meter suitable for our traditional power grids, and its associated web interface based on cloud storage, for automating billing and managing the collected data. Here the proposed design converts the conventional digital electronic energy meters into AMRs, capable of communicating with the utility and the consumers. A Long Range (LoRa) WiFi-based wireless communication module is integrated with an electronic energy meter through a gateway and Raspberry pi module. An optocoupler is used to fetch the meter readings from the pulses of LEDs of the energy meter. A LoRa receiver at the other end, with a cloud database, acts as the billing point. The cloud storage used is Firebase. A responsive, user-friendly graphical user interface has developed for monitoring the consumption. With proper authentication, users can access the developed web page from anywhere in the world. The total energy consumption and the due bill of the customers can be obtained from this webpage. The consumers can also set their consumption limits and thereby reduce their overall energy consumption for energy management. The proposed system neglects the regular digital metering system and allows remote access to the electronic meter.**

***Index Terms*—Automatic Meter Reading (AMR); Smart Meter; Long Range Wi-Fi (LoRa WiFi)**

## I. INTRODUCTION

The demand for electrical power is significantly increasing as it is essential for human survival and progress. In India, the grid connectivity is around 96.7%. But even now, we are following the traditional grid system where real-time monitoring of energy meters is difficult and expensive. The conventional meter reading by a human operator is inefficient and laborious and the chances for error are high. Also, the user needs to pay the electric bills either online or by visiting EB offices. So there is an increased demand for Automatic Meter Reading (AMR) systems that collect meter readings remotely and deliver the electricity bill according to specified tariff directly to the consumers.

Smart Energy Meters (SEM) with AMR systems are already available in the market. But they are expensive and are designed to operate in smart grids. So it is not suitable for a traditional grid. In this paper, the proposed system converts an ordinary static Watthour energy meter into a smart energy meter capable of real-time monitoring. It also provides a graphical user interface for monitoring the meter reading through web portals or android application for mobiles. The meter reading is calculated from the pulses of LED in the energy meter using an optocoupler. The readings are then transmitted to the cloud server along with the service number of the particular meter using LoRa WiFi, which has a coverage of about kilometers. Both utility and consumers can access the designed webpage using respective login credentials and see the energy consumption and the corresponding bill amount at any time. It will eliminate the need for a human operator to collect the meter readings by visiting the consumer premises every month. And the users will be aware of the electricity usage in his/her home, thus helping to reduce the overall energy consumption.

## II. LITERATURE SURVEY

In our existing system, static Watt hour energy meters fixed in the consumer premises are widely employed for measuring the electricity usage. The kWh units displayed in the meter have tobe recorded by the meter reader monthly, on foot. The electricity bill for a particular month is generated based on the meter reading and tariff adapted by the utility. For smart metering, the reading from the energy meter needs to be collected without human intervention, and the collected data must be accessible for both consumer and utility at any time.

As a part of this work, the existing meter reading techniques were studied. And many alternative systems build on various platforms, proposed by different research groups have been analyzed. IoT-based AMR systems are introduced in [1], [2], and [3]. In [4] and [5], the long-distance data transmission is via GPS and in [6], the data transmission is based on GPRS. Both

GSM and GPRS are costly and cannot be implemented so easily. The problem of missing SMS will reduce the accuracy and performance. In [1], LoRa WiFi is used for data transmission, which has the coverage of several kilometers and is effective for high-speed data communication. The readings from the energy meter are collected with the help of voltage and current sensors in the systems proposed in [1], [2], [3], and[5]. An optocoupler [6] or microcontroller [4] can also be employed for obtaining the energy meter reading. Arduino-based systems are proposed in [1], [2], [3], and [4]. And in [5] and [6], microcontrollers are used for data processing. Even though Arduino is widely employed, it is not reliable all the time, using various sensors makes the system more complex.

## III. METHODOLOGY

The proposed system will convert the existing energy meter into an AMR, capable of real-time monitoring of energy consumption. The developing technology must address the obstacles presented by the previous technologies. Also, the existing metering system has to accept the quality and effectiveness of the proposed one.

The developed system consists of three main parts: a hardware unit coupled with the static energy meter, a communication network (LoRa gateway), and a software side consist of a billing server at the provider side and a website accessible to both consumers and utility. Overview and functional block details are shown in Fig. 1. Through the website, both consumers and providers can directly know the power consumption details and the respective bill amount at any time, using corresponding login credentials. The website is made responsive so that the users can also access the website through a smart phone without any issues.

## IV. HARDWARE DESIGN

This proposed metering system is constructed using a single Phase 2 wire ac static Watthour energy meter. The energy consumption of the consumer is displayed in kWh. The energy meter has a meter constant of 3200 impulses per kWh. An optocoupler is used to couple the impulse count to the raspberry pi module. The raspberry pi controller is coded such that the units of energy consumed are being recorded based on the count of led blinks in the energy meter. This data is sent to the cloud database via the LoRa gateway. The raspberry pi is integrated into the LoRa gateway through a LoRa node.

In the event of power failure, the last meter reading data get stored in the memory. Upon power restoration, the controller will be able to retrieve the previous value and continue to synchronize with the energy meter.

### *A. Power Supply*

The raspberry pi and LoRa node get a 5 V power supply from the AC to DC adapter or direct ac lines through a voltage regulator. The adapter output voltage will be non-regulated 12V DC. The 7805 voltage regulators are used to convert 12V DC to required 5V DC.

### *B. Optocoupler*

A 4 Pin optocoupler, PC817, consisting of an Infrared Emitting Diode (IRED) and a phototransistor are selected.

### *C. Raspberry Pi*

It is a 3rd Generation powerful high capability computing board with the highest level of performance, connectivity and power management. Raspberry pi 3 Model B is having BCM2832 ARM cortex version 8 and 64 bit QUAD core processor with 1.2 GHz of speed.

### *D. LoRa Gateway*

LoRa gateways are intermediaries that allow sensing nodes to transmit data to the cloud. These long-range WAN sensors can handle millions of nodes. It allows several applications to run on the same network with less infrastructure than Wi-Fi. This module uses SX1278 IC and works on a 433MHz frequency. The stated range of a LoRa module is more than 10 km. The Raspberry pi is connected to the gateway through a Lora node.

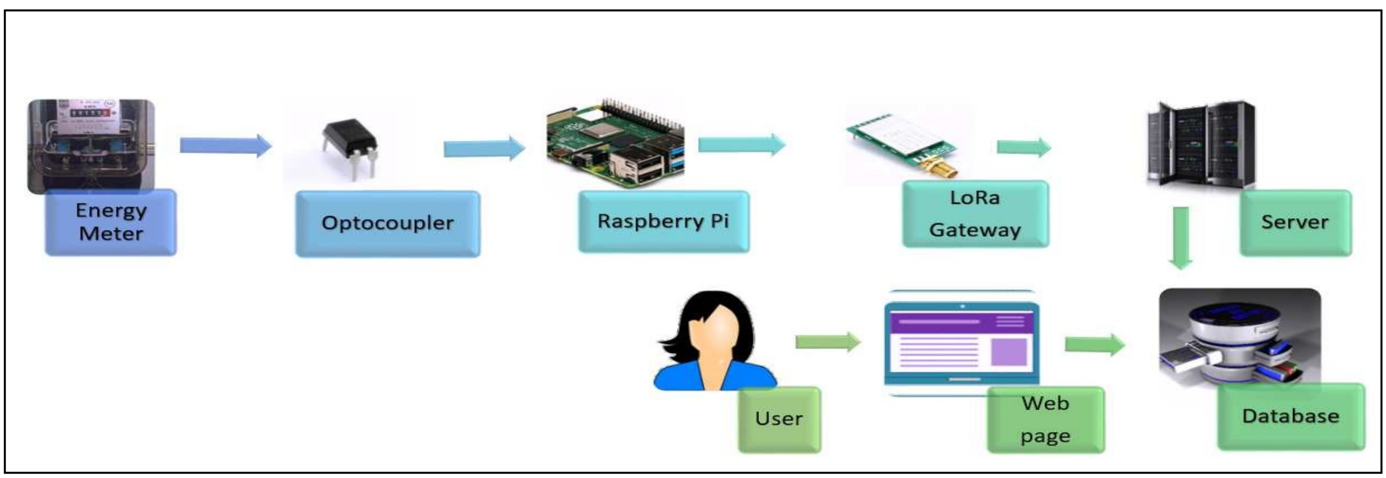


Fig.1 Overview of Proposed System

## V. Software Design

The cloud computing platform used here is Firebase by Google. It will store the client data. Heruko, the cloud platform as a Service (PaaS), is utilized here. The Frontend platform is Angular. HTML, CSS, JavaScript codes can be imported into this platform. For making the backend Express.js is used. It is a framework for Node.js. The webpage is made responsive so that there is no need to make another app for mobile users. Only a single webpage is required, which can be viewed on smartphones without any issues.

The software unit store data to the cloud database and present the inserted information to the consumer or to the electricity board based on the login privilege. The user who logged into a consumer account can view their daily electricityconsumption details and more in-depth details provided by a listed graph. The graph includes each month's consumption variation, which helps the consumer to track their usages. So, based on the consumption, they can work on reducing their electricity usage. Also, the user can set some consumption limits in the website. Both the user modules have separate sections for showing graphs. The views are made under different privileges so that only the corresponding user who hasthe proper authority can view the details.

### *A. Electricity Board*

Under the logged-in electricity board section, a detailed graphical representation of the electricity consumption details of the user is provided in the dashboard. The Electricity Board dashboard is shown in Fig. 2. It shows the total usages of each month. In the proper advanced graphical representation, it is possible to display a more detailed showcase of electricity consumption rise in electricity subsection of each week in consumption charges.

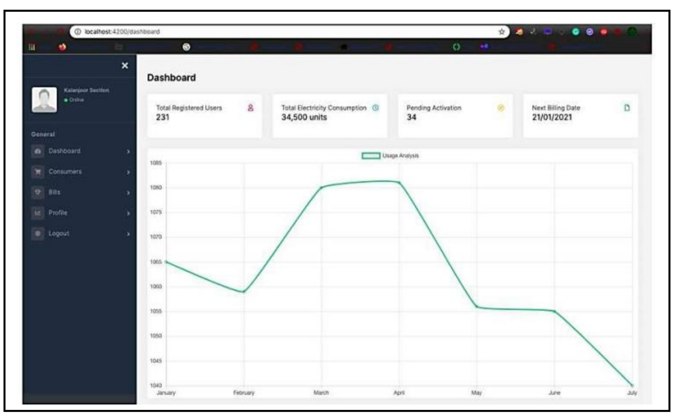


Fig.2 Electricity Board dashboard

### *B. Consumer*

In the consumer portal, the electricity usage insight information is shown graphically based on monthly consumption. A proper implementation will give the weekly and daily details also. In the dashboard, daily usages, last 7-day consumption details, monthly charge and the next bill date of the consumer are displayed. This allows user to understand

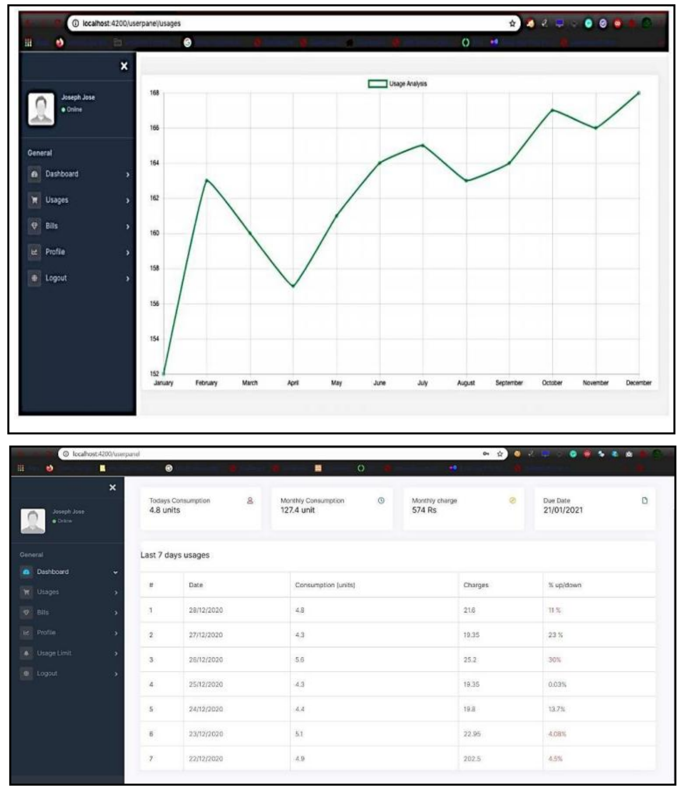


Fig.3 Consumer dashboard

their account information quickly. The Fig. 3 shows the consumer dashboard.

The hardware unit sent details to the database periodically after each hour in a day, so in the cloud database, hourly consumption details are stored and present the details by converting the information to daily, weekly, monthly basis. All these are carried out programmatically, so the users don’t have to worry about the background unstructured information. The user can also set consumption limits on the website or in the android app. So they will get a notificationafter crossing it.

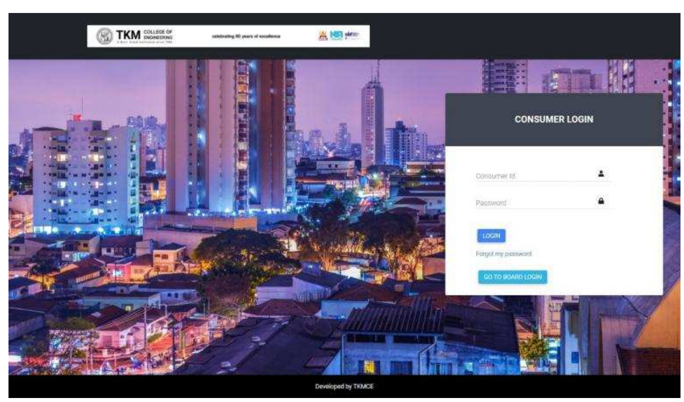


Fig.4 Login page of website

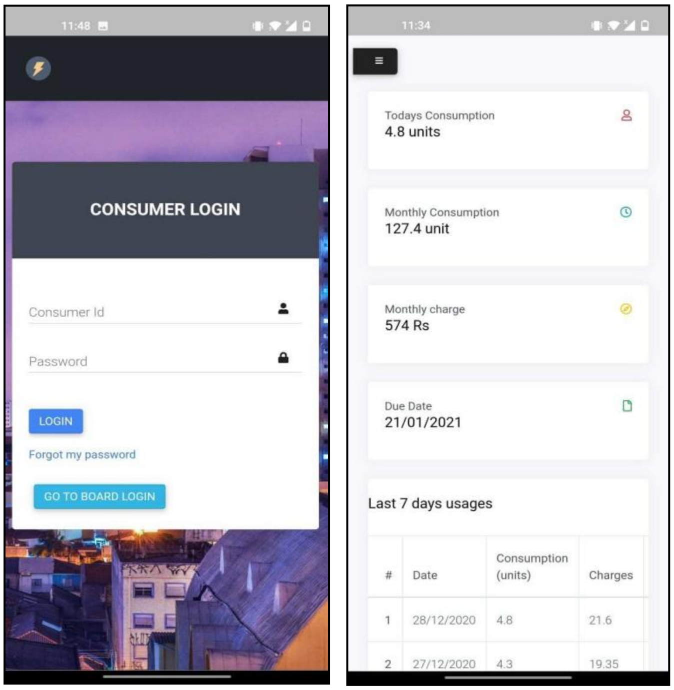


Fig.5 Android application login page and consumption details

## VI. Results

The designed system can send the energy usage data of the consumer to the cloud server.

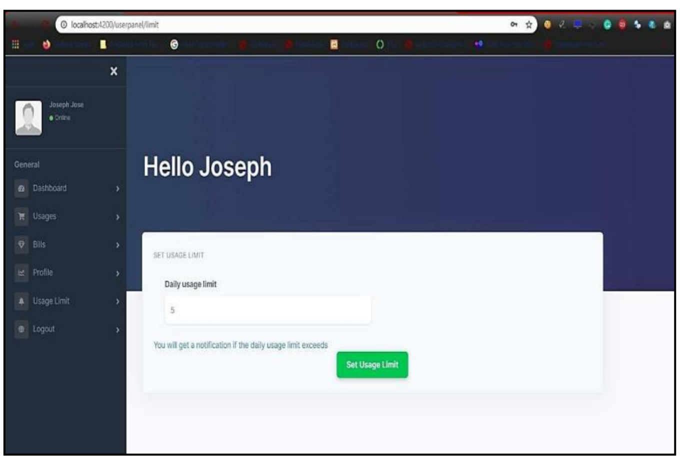


Fig 6 Limit setting option

Through the website created, both consumer and electricity board authority can access the consumption details of the particular user. The login page of thewebsite is shown in Fig.4. The consumer can also utilize the android application for the same. Fig.5 shows the login page and consumption details of user in the android application.

Both the user and consumer can analyze the power consumption through the graphical representation and data provided, and thus they can control their power consumption to reduce the monthly bill. And also, the user can cut down his power consumption by setting up certain limits in prior. Fig.6 shows the option for limit setting in the website.

The users can see their bill status from the website or android application. The electricity bill for the current month and previous months are displayed here. They can effortlessly check the status of their bill, whether it is paid or not. If not,


Fig. 7 Bill Section of the Website

there is an option for payment, which will direct the user to the billing portal of the respective electricity board. Fig.7 shows the bill section of the website.

## VII. Conclusion

Real-time monitoring of energy meters are done by using the existing energy meter without replacing it with Smart meters already available in the market. The developed system is effective, as it eliminates the need for manual meter reading and also provides accurate data to both the consumer and utility.

The user can access their energy consumption continuously through the website or android application. So the system becomes more transparent and convincing for the consumers.

The system can be modified, by adding direct online payment option to the hosted webpage. External devices like temperature sensors, wind meters, etc. can be incorporated. It can also be designed for a net meter. Postpaid energy consumption can also be made possible. This work will be a stepping stone towards Smart grids in our system.

## VIII. Future Scope

Future works include dynamically getting values from the energy meter whenever the user sends a request to the server with minimum constraints of updating the values in the server. A widget for the mobile users can be created to help the users to be more aware of their electricity consumption. Also, the bill information can be sent as push notification to smartphone users; for general users the information can be sent as SMS. Everyday consumption along with graphs can be constructed for more convenient understanding of the consumption by the users. The bills generated can be mailed automatically to the corresponding user's e-mail ID whenever the bill has been generated by the server. An alert system at the server can be set up to check whether the system has failed or the energy meter has been tampered. An algorithm can be implemented in the server for monitoring the energy consumption of the user. This way, if a user steals electricity, the server will notify the EB engineers. This system can be modified slightly and can be used in corporates to monitor their energy consumption in different parts of the building. This way, they can conserve electricity wastage to a greater extent. Replacing the optocoupler makes the system more robust. Taking readings directly from the serial port of the energy meter results in a much accurate measurement of meter reading. Finding an appropriate method to measure power factor and incorporating it to the system makes it feasible to all kinds of energy ratings.

## IX. Acknowledgements

The authors wish to acknowledge the assistance provided by the Electrical and Electronics, Computer Science, and MCA departments of Thangal Kunju Musaliar College of Engineering, Kollam.

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