Development of Smart IOt Energy Meter with Energy Saving Estimator

Mohamad Aminuddin Jalal, Mohd Ismail Yusof, Ernie Mazuin Mohd Yusof

Abstract*: Energy meter is a device that is widely used to measure home energy consumption for the billing tariff. The meter measuring energy used (in kWh) by the home appliance. Conventional energy meter only provide payable billing tariff by monthly or quarter which results over usage of energy problem. This problem lead to higher energy billing per house. Despite that, there are no billing indication levels that tell the user about how much they had to pay. The problem that happens in this situation is that the user cannot tell how much they have used the energy along with it appliance. This problem cause the user to use the energy without hesitation and uncontrolled. To solve this problem, there are solutions that can help to solve the problem. Then development of the device in which monitor the watt used along with the billing tariff. With this device, the user can tell by how much they had been charges throughout the day. The Smart IoT Energy Meter is a device that is developed to fulfil the requirement in the electrical billing system. This product has come with a realistic design and functional. It consist of microcontroller and electronic part which measure the current flow through the wire. This device will help the two-way communication between the user and the electrical company. The device are developed to measure and monitor the current, voltage, watt, energy and billing tariff that can be monitor through the Thing Speak channel. Since that, user can monitor the electrical consumption usage throughout the smartphone or laptop. The development of project in the future can give awareness to the user about their energy consumption usage in daily life.

***Keywords*: Energy Meter, Internet of Thing, Billing Tariff.**

I. INTRODUCTION

The past decade has seen increasingly rapid advances in the field of energy saving devices to overcome the issues of sustainable energy demand. The ideal solution and recommendation of the problem is to monitor and control the power consumption [1]. The number of consumers is growing rapidly follow by the higher rate of energy uses in household. Thus, the energy is required more used in household. Since that, the energy consumption needs to monitor and control even it losses. This is to ensure the energy can be utilized as it generated. As generation is increasing in turn are the requirements. So there is a technological advancement needed, so it has to develop a system with faster and advanced technology i.e. IoT.

Energy monitoring devices are a gateway to the inner energy for domestic usage. This device connects to the electrical live wire and measured it. It will show how much energy usage in the house and provide information about it. In urban area, consumers consider installing energy meter with a monitoring system since it becomes popular [2]. The device provides real-time visibility into energy usage and other information related. The device measures the energy consumption used in the house and provides information to the user [3].

Concept of Internet of Things (IoT) are means the objects are sensed and controlled remotely in the existing network infrastructure The existing energy meter did not perform two way communications [4]. Internet of Things is a new information processing acquisition technology and also referred as the third wave of information technology after internet, mobiles, computer network [5].

In IoT, everything is configured with Internet Protocol (IP) addresses and it can monitor controlled and access remotely in accordance with web technology. The main advantage of this technology is that devices are connected smartly with the help of sensors and transducers and these are again connected to (Local area Network) LAN, (Wide Area Network) WAN, via Ethernet or Wi-Fi connectivity [6].

The smart energy meter monitoring device is made for the Arduino microcontroller and another electronic component such as current transformer, transistor, capacitor, Wi-Fi module, and LCD shield. The product is wiring and link to each other. The Arduino UNO act as a microcontroller, which embedded programme in it. LCD shield is used to display the information related to the project and the Wi-Fi module is a component that is needed to transmit and receive the data between hardware and software [7]. Energy estimation will be compare with Malaysia energy provider, which is Tenaga National Berhad (TNB) and usage vs cost estimation will be presented in term of Ringgit Malaysia (RM) currency.

II. METHODOLOGY

This project consists of two parts, hardware design, and software design. Hardware design consists of four components; (1) ESP8266 Wi-Fi Shield, (2) Arduino UNO, (3) LCD Shield, and (4) Current Transformer SCT013 100A. Arduino UNO is used as a microcontroller for embedded system. The ESP8266 Wi-Fi Shield is used to connect the hardware to the base station Liquid Crystal Display (LCD) shield is used to display the value desired. Lastly, the current transformer SCT013 100A is used to measure the current flow. Summary of hardware is illustrated in Fig. 1 and Table I.

On the software design (Fig. 2), an Internet of Thing (IoT) is employed to transfer information between hardware to cloud computing , i.e., ThingSpeak. Processing IDE is used to interface with the Arduino UNO as the programming language.

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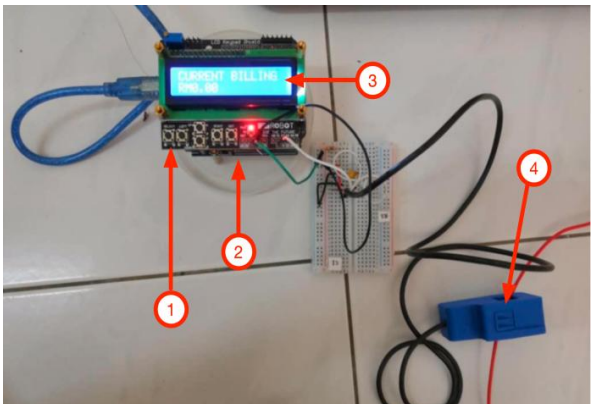

Fig. 1 Hardware design

Table. 1 Component for energy meter project

No.	*Item*	*Unit*
1	*ESP8266 Wi-Fi Shield*	1
2	*Arduino UNO*	1
3	*LCD Shield*	1
4	*Current Transformer SCT013 100A*	1

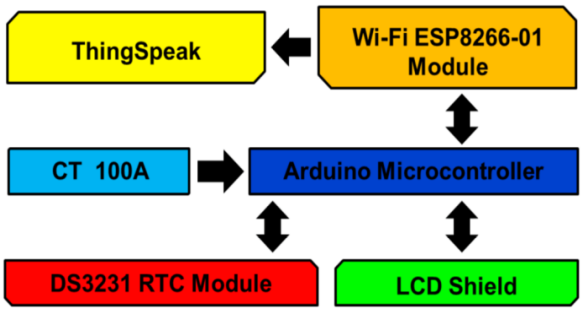

Fig. 2 Software block diagram

Hardware function

Current transformer SCT013 100A is used to measure the current usage. This project considers single-phase current measurement for household usage to monitor the power used. The current transformers measure the current flow within the wire and send the value to the Arduino and LCD to display the value.

Software function

The Arduino UNO integrated with the current transformer to measure the household current usage. The Thing Speak channel and Virtuino are used to monitor and display the data on to the base station and smartphone. Thing speak channel monitors the data for current, power, energy and billing tariff. The data is then linked to the Virtuino Apps on the smartphone to monitor the data related.

The devices consist of a simple electronic part such as Arduino UNO, LCD shield, Current Transformer, Wifi Module, and RTC Module. The device is integrated with the Thing speak channel and Virtual software via Wifi connectivity. This allows the system to be monitor in a wide area.

Functional Flowchart

The overall measurement and estimation of the energy consumption device can be divided into three stages, (a) set-up, (2) billing, and (3) Internet of Thing, as depicted in Fig. 3. In the set-up stage, the energy consumption measurement is started when the non-invasive current transformer is clamped to the energy meter live wire. In order to get appropriate billing tariff, the energy meter will measure current, *I*, and voltage, *V*, in real-time manner. These values are further calculated to get power, *P*, as shown in equation (1)

$$P = \text{V x I}$$

and energy consumed, *E*, as shown in equation (2)

$$E = P \text{ x hour}$$

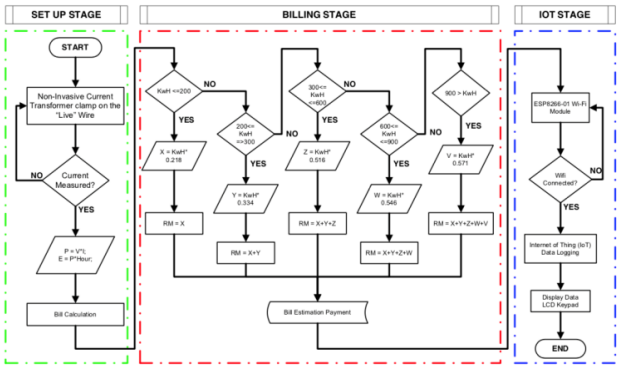

Fig. 3 Process flowchart

At billing stage, bill estimation computation will be produce based on energy unit consumed. There are five energy blocks tariff rating whereby the first energy block is for consumption below 200 kWh. In this category, the cost per unit is only RM0.218. This means, the energy unit consume by user within the first block will be multiply with 0.218. For second energy block tariff, user will be charge further RM 0.334 per unit on top of the first block. However, the calculation for the second block is only takes in the estimation if user consumes more energy between 200 kWh to 300 kWh. For third, fourth and fifth blocks, the energy allocation are 300 kWh to 600 kWh, 600 kWh to 900 kWh and more than 900 kWh, respectively. Meanwhile, tariff per unit for third, fourth and fifth block are RM0.516, RM0.546 and RM0.571 respectively. Total energy consumption will be push to IoT system, i.e., Thing Speak, in the IoT stage.

III. RESULT AND DISCUSSION

Table II shows the current measurement reading of the device and the energy meter. The current are measured from 11th January 2019 until 10th February 2019. The current measurement for the TNB indicates 422kWh and the device indicate 370kWh.

Eventhough there is a slight difference between energy consumption measurement between TNB and Smart IoT Energy Meter device, the percentage of error only indicates 11.06% differences.

Table. 2 Current measurements

	Total measurement from 11 Jan 2019 to 10 Feb 2019 (kWh)
TNB	*422*
Smart IoT Energy Meter	*370*

Table III shows the different billing tariff between the device and TNB. The tariff is measured from 11th January 2019 until 10th February 2019. Hence that, the accuracy of the billing is slightly different. The billings are obtained based on the current measurement. Since the measurement is not accurate. The billing is also not accurate.

Table. 3 Billing Tariff Comparison

	Total tariff from 11 Jan 2019 to 10 Feb 2019 (RM)
TNB	*139.95*
Smart IoT Energy Meter	*113.12*

Fig. 4 and Fig. 5 show line graph between the energy meter and Smart IoT Energy Meter Devices measurement and total tariff respectively. The current measurement play an important roles since it will be used obtain the billing tariff based on the TNB billing payment based on energy consumed.

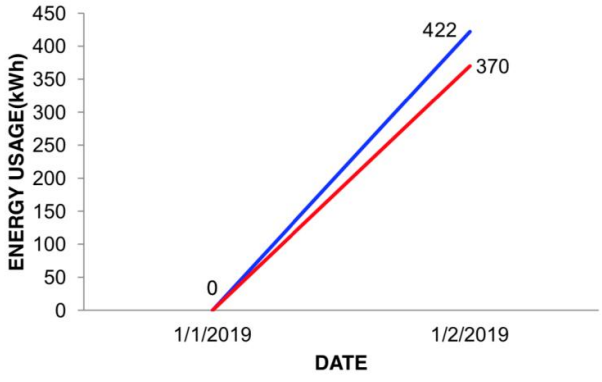

Fig. 4 Month Energy Consumption Comparison between TNB and Smart IoT Energy Meter in kWh.

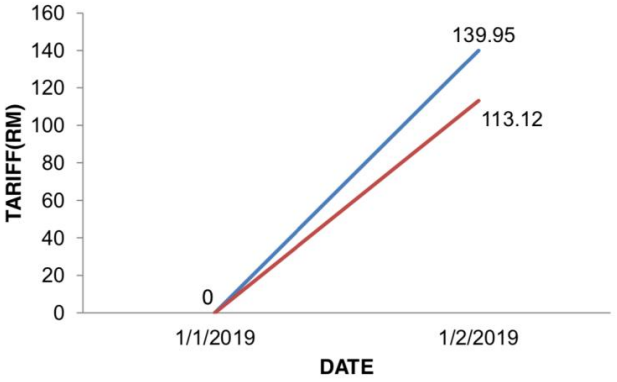

Fig. 5 Month Total Tariff Comparison between TNB and Smart IoT Energy Meter in RM

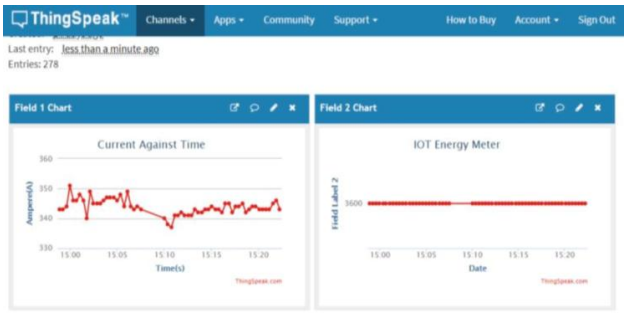

Fig. 6 Thing Speak Energy Data Consumption Visualisation for IoT

Fig. 7 Virtuino apps which also linked to Thing Speak energy data consumption visualisation for IoT

Fig. 6 shows Thing Speak channel for the current and voltage data measurement. The data analysis shows the current consumption usage trending. The reading shows that the values are slightly fluctuating. The situation can be described as energy consumption activities are active and home electrical appliances are frequently consuming energy.

As a result, end user will be able to identify and discard the specific appliances that contribute to the higher energy consumption.

Besides Thing Speak capability for data visualization purposes, the Smart IoT Energy Meter is also employ monitoring panel for smartphone apps designed using Virtuino apps as shown in Fig. 7. The panel is created based on the data measurement. For this smartphone app, the measurement data, namely current, voltage, power, energy and billing tariff can be access directly by the end user. Each of the data are related to each other as the billing tariff calculation are depends on it. The Virtuino apps are link to the Thing speak channel using an IP address.

IV. CONCLUSION

This project includes the combination of Non-Invasive Current Transformer 100A, electronic component, LCD Shield, ESP8266 Wi-Fi Module, an Arduino Uno. This project is aim to develop the IoT Energy Meter monitoring system. The main objective is to evaluate the energy consumption usage especially at home. The current measuring device, which is the current transformer, is clamped into the wire to measure and estimate the house total current consumption safely and with real-time data information. The product measurement will then transmit the information data to the base station that a visual to the user using a Wi-Fi connection.

The smart IoT energy meter is for end users who required detail about power consumption in daily life. Hence, the smart energy meter able to help to gain better understanding of energy consumption for household appliance.

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