An IoT Solar Lamp With PV System

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Abstract

This research paper aims to increase the efficiency of electric usage via IoT technology. An IoT Solar Lamp is a system that aims to use solar energy as the alternative green energy to reduce AC power line consumption from our national grid system (PLN). There has been some successful product such as this one (e.g. branded Sonoff switch), but it has not used Solar PV as the main source of green energy. Therefore this system is unique because it promotes green energy usage in household application. This remote controlled lamp has 2 pieces of solid-state relay that choose electricity supplies, either from the AC power line or from the battery. The battery will be charged by a 50Wp solar panel and this system uses NodeMCU-ESP8266 that has connectivity to the internet, such that the users can choose voltage supply source and turn the lamp on or off, with a smartphone. The result of this study shows that the system can be powered by 12Volt-18Ah battery for approximately 3 hours.

Keywords: IoT, Solar PV, NodeMCU-ESP8266, Green Energy, Solid-state Relay.

1. Introduction

As a country that lie in the equator, Indonesia has a lot of advantage because of its location. Of course, the location of Indonesia itself, depends on climate condition, geostrategy, and also on soil condition. And these conditions also influences other sectors of life, such as economy, agriculture, transportation, communication, and etc. Indonesia’s geography as a tropical country, has a sun shining throughout the year. This makes Indonesia has a huge potential in using solar energy as a renewable source of energy. Indonesia has a solar energy of 4.8 KWh/m² per day or equivalent to 112.999 Giga Watt Peak (GWP). This numbers are ten times of what other countries in European has. With such a fact, one of the important green energy source is Solar Panel. Solar panel is the only device that directly convert lights’ energy into electrical energy. Despite of the fact above, Indonesia is lagging behind other ASEAN countries in term on the scale of the Solar PV installation [1]. Therefore this paper tries to show that at household rooftop installation, a small installation of under 1 KW is feasible for urban society. And this paper adds ingenious idea, by combining IoT Lamp technology with Solar PV system, to further increase the efficiency of lightning used in a typical household.

Another paper titled “IOT Based Smart Lamp For Efficient Usage of Electrical Energy” [2] has emphasised on the usage of IoT technology to reduce the electrical energy consumption by turning the lamp off, when it is not in use. So, that paper aligns well with this paper, which improves it even more, by integrating the IoT Lamp with a renewable PV
Solar Energy. Other Lamp IoT related papers [3-4] have also shown how important IoT and PV Solar Energy in a wider area using NB-IoT (Narrow Band IoT). These papers are very much aligned with the Indonesia’s Government policies to make Smart Cities [5]. And even though, ESP8266 is not designed for such a long distance application, this paper points to the same direction toward a better life efficiency in terms of renewable energy usage. Other long-range IoT technology using LoraWAN has also a potential replacement for ESP8266, with regards to Smart City [6].

In order to increase the efficiency of electrical’s usage, this IoT Solar Lamp System uses its connectivity capability to reduce the electrical’s consumption, by controlling it via internet, using the ESP8266 microcontroller with WiFi add-on. This capability is also made possible by the use of Blynk IoT application software. And along with the microcontroller within this IoT Solar Lamp System, that has the ability to choose Solar energy first as its priority and then our national electrical grid system as the second priority. This way, the total consumption of our national grid system is reduced, by the production of solar electrical system. This automated algorithm to switch between Solar energy source and national grid system source, has been prototyped successfully.

2. Research Methodology

The IoT Solar Lamp is designed to control the Lamps with Blynk application through an Android smartphone. This prototype is using a 50Wp Solar Panel with a 12V-18Ah lead acid battery. Table 1 lists all the components needed to build this IoT Solar Lamp system. Notice, that a specific relay is used in this prototype, with a MBB (Make Before Break) characteristic. This relay’s characteristic is very important, so that when a transition is made from solar system to national grid system or vice-versa, the power supply to the microcontroller ES8266 (NodeMCu) is not interrupted and thus can function normally.

Table 1 - The components used in IoT Solar Lamp System.

| Device Name             | Type                        |
|-------------------------|-----------------------------|
| Microcontroller         | NodeMCU ESP8266             |
| Solid State Relay       | Solid State Relay 4CH 2A 240VAC Omron G3MB-202P 5VDC |
| MBB-Relay               | G2A-4L32A Omron             |
| Step Down Converter     | LM2596                      |
| DC Voltage Sensor       | 25V Voltage Sensor Module   |
| Solar Panel             | Dunamos DM50TU-18P          |
| Solar Charge Controller | PWM20-10                    |
| Battery                 | KIJO JS12-18                |
| Inverter                | BELTTT 500W BEH500XT        |
| Load                    | 4 LED Lamps @ 9 Watt        |
Figure 1 - Block Diagram of IoT Solar Lamp

Figure 1 depicts the connection of all the components of IoT Solar Lamp system. The novelty of this design lies in the usage of the automatic algorithm software, which is embedded in the microcontroller. The microcontroller detects if the battery’s capacity is still enough, then it will command the SSR-Solar-Panel to use power from the battery to load the AC Lamps. Otherwise, the microcontroller will command the SSR-AC-Line to use the national grid system to power the AC Lamps directly.
In Figure 2, the flowchart for the Blynk application is depicted. The Blynk application has the ability to control the ac lamp individually. It is also able to choose the main source for powering the ac lamps. But if the battery’s capacity is not available then the microcontroller will override the user selection for main source of the ac lamps to PLN (National Grid Company). From the Android smartphone perspective, when the Blynk application is opened, a screen as in figure 3 is shown. Two push-button, “PLN” and “Battery”, are used to select manually which DC voltage source is used, but by default if battery capacity is available, the battery will be used. This unique algorithm consumes green energy from the Solar PV, whenever the sun is shining. Therefore, the consumption energy from the AC line will be minimized. The battery voltage is also displayed in this Blynk application.
3. **Experimental Results**

Figure 4 shows the implementation prototype used in this experiment.

![Figure 3 - IoT Solar Lamp UI](image)

![Figure 4 - IoT Solar Lamp Implementation](image)
Table 2 shows twenty (20) charging current data taken from the PV panel during full-sun hours or near 12 PM when the sun was right above the PV panel and was shining clearly with no cloud.

| Sampling Count | Current [A] | Sampling Count | Current [A] |
|----------------|------------|----------------|------------|
| 1              | 1.396      | 11             | 1.59       |
| 2              | 1.582      | 12             | 1.376      |
| 3              | 0.804      | 13             | 1.696      |
| 4              | 1.244      | 14             | 1.372      |
| 5              | 1.002      | 15             | 1.354      |
| 6              | 1.15       | 16             | 1.694      |
| 7              | 1.552      | 17             | 1.394      |
| 8              | 0.82       | 18             | 0.808      |
| 9              | 0.878      | 19             | 1.764      |
| 10             | 0.6        | 20             | 1.806      |

The PV Solar Panel of 50 Wp is used in this system, and therefore the maximum current (Imax) when the sun is at full-sun (1000W/m²), is 50Wp/17.6Vm² = 2.84A. And from table 2, the maximum current is not recorded, because of the manual low sampling rate, taken in this measurement.

Table 3 records the discharging of battery’s capacity, from 100% capacity to 50% of its capacity. In theory, a 12 volt battery of 18Ah has an energy storage of 216Wh. The load of 4 lamps of 9 Watt each has a total of 36 Watt. Therefore, the time (t) is equal to E/P, that is 216Wh/36W = 6 hours. But, the lead acid battery has only a 50% DoD (Depth of Discharge), and therefore, this battery capacity is only 6/2 = 3 hours. And this is confirmed with the data from this Table 3.

| No. of Experiments | Discharging Time |
|--------------------|------------------|
| 1                  | 3 hours 44 minutes |
| 2                  | 3 hours 53 minutes |
| 3                  | 3 hours 41 minutes |

4. Conclusions

This IoT Solar Lamp system has combined the IoT connectivity with a renewable energy production from Solar PV. While, this prototyping has only limited to a 50Wp Solar Panel with a 12V-18Ah Lead Acid Battery, it can scale-up to meet the demand of lightning consumption in a typical household application. The proposed automatic and manual switching relay also works as intended. This design of switching relay will increased the efficiency of using the Solar PV energy, whenever the sun is shining.

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