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Design And Implementation Of Rooftop Solar Power Plant On Entrance Guard Post Lighting Of President University Based On IoT And Google Sheet As Database Record

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Abstrak.

Pembangkit listrik tenaga surya merupakan salah satu sumber energi alternatif yang sangat aman digunakan, ramah lingkungan, bersih, dan mudah digunakan. Dengan berkembangnya teknologi IoT saat ini, aplikasi pembangkit listrik tenaga surya ini juga dapat digunakan untuk memantau sistem yang dihasilkan dan merekam data waktu terkini yang telah dihasilkan oleh sistem ke Google Spreadsheet. Prinsip kerja dari sistem pembangkit listrik tenaga surya ini adalah pengisian baterai dengan sistem 12 V dan menggunakan beban DC 12 V untuk 2 buah lampu dengan sistem hybrid (suplai PLN sebagai cadangan). Sistem ini dilengkapi dengan sensor arus dan tegangan serta NodeMCU esp8266 untuk memonitoring parameter pengisian dan pengosongan daya listrik, sistem ini dapat mengontrol nyala-mati lampu dan memonitoring nilai listrik dari smartphone dengan menggunakan aplikasi Blynk, dan nilai listrik tersebut juga direkam ke Google sheet sebagai database. Hasil pengujian menunjukkan bahwa panel surya mampu mengisi daya hingga 13,4 V ke baterai. Energi yang dihasilkan selama pengujian mencapai 141,4 Wh (kondisi 100% dari pengujian) dan energi pengisian minimum panel surya dapat mengisi daya sebesar 58,4 Wh (41% dari produksi maksimum saat pengujian). Untuk pemakaian, beban dapat disuplai semalam 3 kali selama sekitar 12 jam dengan baterai, waktu terpendek baterai menyuplai beban adalah 5,5 jam. Jika daya baterai tidak cukup untuk memasok beban pada malam hari, ATS akan memindahkan suplai dari baterai ke Perusahaan Listrik Negara hingga pukul 06.00.

Kata kunci: Pembangkit listrik tenaga surya, NodeMCU esp8266, IoT, Aplikasi Blynk, Google Sheet.

Abstract.

Solar power plant is an alternative energy source that is very safe to use, environmentally friendly, clean, and easy to use. With the development of current IoT technology, this solar power plant

application can also be used to monitor the system generated and record the real-time data that has been produced by the system to Google Sheets. The working principle of this solar power plant system is charging the battery with a 12 V system and using a DC 12 V load for 2 lamps with the hybrid system (the Electric State Company supply for backup). This system is equipped with the current and voltage sensor and NodeMCU esp8266 to monitor the charging and discharging electrical parameters, this system can control the on-off of the lamp and monitor the electrical value from the smartphone using the Blynk app, and the electrical value is also recorded to the Google sheet as database. The testing result is the solar panel able to charge up to 13.4 V to the battery. The energy generated during testing is up to 141.4 Wh (100% condition from testing) and the minimum charging energy of the solar panel can charge 58,4 Wh (41% from the maximum production when testing). For the discharging, the load can be supplied overnight 3 times for about 12 hours with the battery, the shortest time battery supply the load is 5.5 hours. If the battery power is not enough to supply the load during night the ATS will move the supply from the battery to the Electric State Company until 06.00 o'clock. Google Sheets can record the data of date and time, charging voltage, charging current, charging power, charging energy, load voltage, load current, load power, and load energy. The data can be saved and downloaded for review and archive data in the future.

Keywords: *Solar power plant, NodeMCU esp8266, IoT, Blynk App, Google Sheet.*

Introduction

Based on SNI 8395:2017, Solar Power Plant is a power generation system whose energy is sourced from solar radiation, through the conversion of photovoltaic cells. Photovoltaic systems convert solar radiation into electricity. The higher the intensity of solar radiation (irradiation) that hits the photovoltaic cell, the higher the electrical power it produces. With the condition of solar radiation in Indonesia, which is located in the tropics and at the equator, solar power plants are one of the potential electricity supply technologies to be applied. By the provisions in the Minister of Energy and Mineral Resources Regulation No. 49 of 2018, jo. Candy No. 13 of 2019, jo. Permen No. 16 of 2019, rooftop Solar Power Plant generate electricity using photovoltaic modules placed on roofs, walls, or other parts of buildings belonging to PLN customers [1].

Solar power plant is an alternative energy source that is very safe, environmentally friendly, clean, and easy to use, especially in areas without electricity from PLN or in areas that often experience power outages. The solar power plant application is very suitable for use in Indonesia, considering that geographically Indonesia is in a tropical climate that has good sunlight, the use of Solar Power Plant has also begun to be widely applied in Indonesia, both for individual applications (On Grid / Off Grid) and Hybrid systems (for PLN electricity backup).

The author's background in determining the final project title is that the first solar power plant is one of the alternatives to renewable energy. It is very important because if we use fossil fuels continuously, they will run out and can damage the environment. Second, this solar power plant will be applied at the President University's (PU) entrance post because there is no solar power plant application at the President University's entrance post.

The application of this module can be applied to individual or group installations so that it can be carried out independently by individuals, communities, and companies or coordinated by PLN. In terms of funding, Solar power plant projects are very likely to become a means of foreign assistance/cooperation, participation of companies and groups (community development) to support rural electricity programs or the provision of energy services such as [2]:

1. Electricity for household lighting
2. Energy services for public facilities: Pumps/water purification, houses of worship, public or rural telephones, public television, street lighting, and others
3. Energy supplier for production facilities
   Integration of photovoltaics for rural electricity

With the development of current IoT technology, this Solar Power Plant application can also be used to monitor the system generated by Solar Power Plant such as the solar panel charging voltage, the solar panel charging current to the battery, and also the use of the load, and can be used to control the load, turn on and turn off the load remotely using a mobile phone connected to the internet and also records the real-time data that has been produced by the Solar Power Plant system to google sheet.

Therefore, the authors of this final project want to use environmentally friendly solar power plants as renewable energy applications with a hybrid system, with the solar power plant as the main supply and the State Electrical Company as the backup supply. Also use IoT technology in solar power plant applications to monitor the Solar Power Plant system (voltage, current, and power) generated and power consumption on the load. Therefore, the author would like to raise the title " Design And Implementation Of A Rooftop Solar Power Plant For President University Guard Post Lighting Iot-Based And Google Sheet As Database Record". Hopefully, this research can facilitate the use of renewable energy and also IoT technology and its contribution to the environment to be useful for students, lecturers, and all users.

Methodology

In this study, the main objectives in the development of landslide detection are as follows:

1. Designing a solar panel system at the entry guard post at the president's university.
2. Measure the voltage, current, power, and energy (electrical parameter) of the solar panel system and monitor based on IoT with the Blynk application on Android.
3. Create and record measurement results remotely via Google Sheets.

The flow chart of propose system can be depicted in the Fig. 1 as follows:

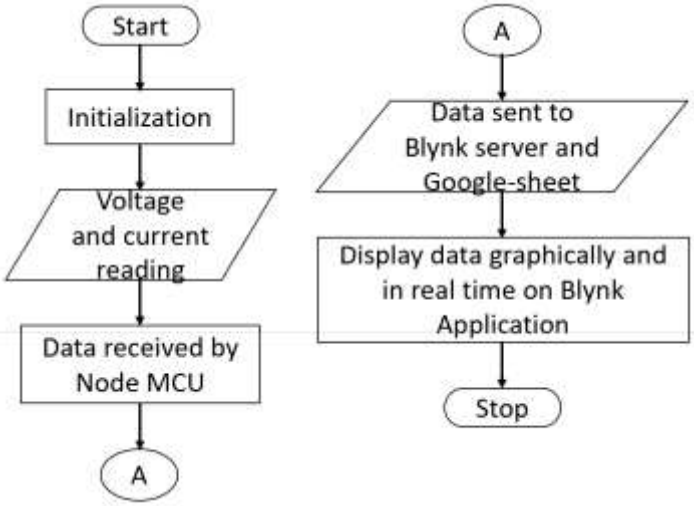


Figure 1. Flow chart of propose system

The prototype developed has a charging and discharging process and the electrical parameters (Voltage, current, power and energy) can be monitored on a smartphone and recorded to the Google Sheet. The components used in this study consist of solar panel, solar charge controller, battery, ATS (Automatic Transfer Switch), NodeMCU esp8266, INA219 sensor, Expansion module TCA8266, photocell, relay module, LVD (Low Voltage Disconnect).

Solar Panel

A solar panel is a semiconductor device that can absorb sunlight and then convert it into electrical energy with a photovoltaic effect using solar cells inside the panel. The photovoltaic effect is a sign

of the emergence of an electric voltage used for electricity generation and as a photosensor when it gets energy from sunlight [3]. Fig. 2 shows a picture of a solar panel.

Figure 2. Solar panel module [10]

Solar Charge Controller

A solar charge controller (Fig. 3) is a device or component used in a solar power plant with an off-grid system that has three terminals. These terminals include terminals for solar cells, terminals for batteries, and terminals for loads. The three terminals are equipped with clear Polarity, namely a negative (-) sign, and a positive (+) sign, so errors do not occur in their installation [4].

Figure 3. Solar Charge Controller

Battery

Batteries are devices containing cells and electricity that can store energy converted to power. Batteries generate electricity through a chemical process. A battery or accumulator is an electric cell where a reversible electrochemical process takes place (can be reversed) with its efficiency [5]. The parts of the battery are shown in Fig.4.

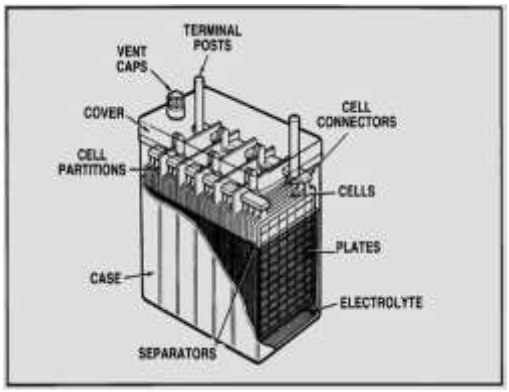


Figure 4. Battery construction

ATS (Automatic Transfer Switch)

ATS is an abbreviation of the word Automatic Transfer Switch. If understood based on its meaning, The ATS is an automatic switch. However, it works automatically based on the possibility that if the

power source from the PLN is cut off or experiences a blackout, the switch will switch to another power source, such as inverters.

NodeMCU esp8266

Arduino Company recently started working on developing a new microcontroller. This struggle succeeded when a new MCU, popularly called the ESP8266 NodeMCU module, was created (see Fig. 5). The module was made regardless of AVR processors and partially used the same as Arduino MCU. Hence, the module works based on the Arduino IDE C++ compiler. New specifications were added to the ESP8266 module to shrink the components and shields required to perform a specific task. The module works under the supervision of 802.11n and 802.11b networks. This means it can serve as an Access Point AP, Wi-Fi station or both station and AP together [6].

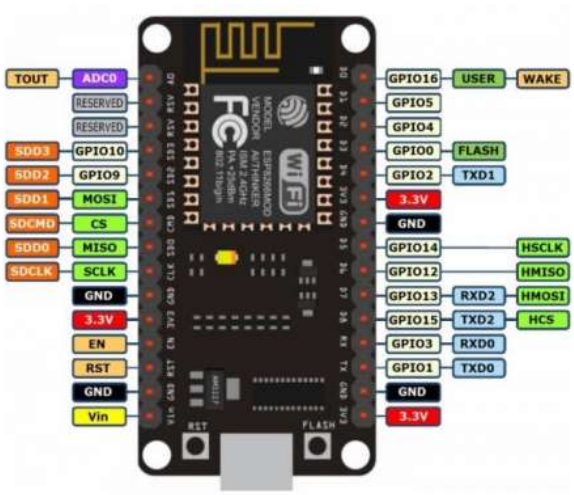


Figure 5. NodeMCU esp8266

INA219 Sensor

INA219 is a sensor module that can monitor the voltage and current in an electricity circuit. INA 219 is supported with an I2C interface or SMBUS-COMPATIBLE where this equipment can monitor the shunt voltage and supply bus voltage with program times conversion and filtering. INA 219 has a maximum input amplifier of ±320mV, which means it can measure currents up to ±3.2A. With internal data 12-bit ADC, resolution at 3.2A range is 0.8 mA. With the internal gain, which is set at min div8, the max current is ±400mA and 0.1 mA resolution. INA 219 identifies the shunt voltage on the bus 0 – 26 V[7]. The schematic of this sensor is shown in Fig. 6.

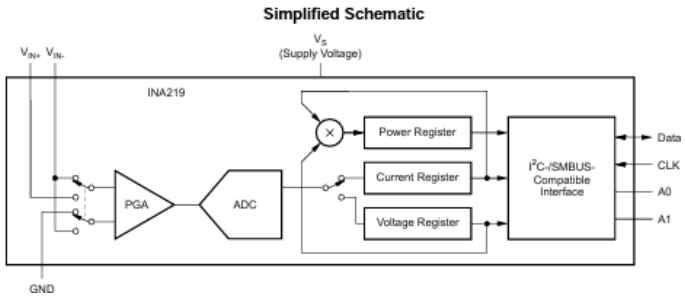


Figure 6. INA219 Schematic

Relay Module

A relay is an electronic component in the form of an electronic switch that is controlled by an electric current. In principle, the relay works as a switch lever with a wire wound on a nearby iron rod

(solenoid). When the solenoid is energized, the lever will get pulled by the magnetic field generated by the solenoid so that the switch contact will close. When the current is not received by the solenoid, the force will disappear, and the switch will open again [8]. The module's physical appearance is shown in Fig. 7.

Figure 7. Relay module

LVD (Low Voltage Disconnect)

Low Voltage Disconnect / LVD is a tool used to keep the battery from draining over-discharge / empty, which will damage the battery. This module can regulate the voltage desired minimum [9]. The LVD module is shown in Fig. 8.

Figure 8. LVD module

Results and Discussion

Results

This chapter is the implementation part of the prototype designed and implemented for the rooftop solar power plant system. This prototype was made using a 50 Wp solar panel with dimensions of 45 cm x 56 cm x 2.5 cm, a control panel box with dimensions of 40 cm x 20 cm x 60 cm, and a bracket for the battery with dimensions of 23 cm x 25 cm x 30 cm. Fig. 9 shows the prototype solar panel implementation.

Figure 9. Solar Panel Installation

The control panel box is installed on the outside of the building as shown in Fig.10, but there is still a roof on the outside of the building so that this panel box does not get rained on directly, besides that this panel also uses an outdoor type panel which has a hat on the top of the panel box so it is safe from splashing water, on The inside of this panel door is also equipped with a seal gasket so that it can prevent water splashes from entering the panel.

Figure 10. Control panel box installation

Fig. 11 shows the bracket for the battery holder. This battery is installed in the guard post building because it is in an open condition, so it is not safe to put it outside the building. This bracket has dimensions of 23 cm x 25 cm x 30 cm.

Figure 11. Battery installation

Charging Test Before Installation

This charging test is carried out when the sun has reached peak heat just before noon so that maximum results can be obtained on the system. From the table above, the shortest charging test is 2 hours. It was performed in the middle of the day in Sunny- Cloudy weather. Even though the testing time was short, the results were quite maximum within 2 hours, producing a voltage increase of 0.5V on the battery (from 12.4 V to 12.9 V). The longest charging test is 6 hours, and it was performed from 09.00 to 15.00. The battery voltage increased by 1.0 V from 12,4 v to 13,4 V (max battery voltage 13.5 V), when the battery was almost full, and the charging current was decreased due to safety protection from Solar Charge Controller. Then, testing was performed after the prototype was installed on the President University guard post. The result is shown in Table 1.

Table 1. Changing Test Before Installation

Start Time	Stop time	Charging Duration (hours)	Weather	Battery Voltage (Volt)		Differential Battery Voltage (Volt)	Average Power (W)	Energy Generated (Wh)
				Initial	Final			
11.30	13.30	2.0	Sunny-cloudy	12.4	12.9	0.5	19.6	36.3
10.00	13.00	3.0	Sunny-cloudy	12.7	13.4	0.7	15.4	43.8
11.00	13.30	2.5	Cloudy	13.0	13.4	0.4	7.8	23.1
09.30	12.30	3.0	Sunny	12.1	12.7	0.6	20.0	54.6
10.00	13.00	3.0	Sunny-Cloudy	12.3	13.0	0.7	19.3	46.4
10.30	12.30	3.0	Cloudy	12.5	12.9	0.4	10.5	32.7
09.30	13.00	3.5	Sunny	12.2	13.1	0.9	23.9	64.2
09.00	15.00	6.0	Sunny-Cloudy	12.4	13.4	1.0	22.2	91.3
10.00	13.30	3.5	Cloudy	12.6	13.1	0.5	15.1	38.4
09.30	13.30	4.0	Sunny-Cloudy	12.5	13.2	0.7	18.0	57.9

Charging Test after Installation

From the table above, we can see that under normal conditions when the weather is sunny, the solar panel produces energy large enough to charge the battery up to 141.4 Wh (battery almost fully charged) for 1 full day. However, when the weather is cloudy, this can reduce the productivity of solar panels or even when it rains, these solar panels can only produce 58,4 Wh (41% of the largest energy from the test results). This has a big impact on the charging capacity of the battery which will be used to supply the light load at night.

Table 2. Changing Test After Installation

Start Time	Stop Time	Charging Duration (hours)	Weather	Battery level (Volt)		Differential Battery Voltage (Volt)	Average Power (W)	Energy Generated (Wh)
				Initial	Final			
06.00	18.00	12.0	Sunny-Cloudy	12.4	13.2	0.8	20.2	96.7
06.00	18.00	12.0	Sunny	12.0	13.3	1.3	22.7	131.2
06.00	18.00	12.0	Sunny-Cloudy	12.1	12.9	0.8	13.4	84.3
06.00	18.00	12.0	Cloudy – Rain	12.0	12.5	0.5	9.3	58.4
06.00	18.00	12.0	Sunny-Cloudy	12.2	13.0	0.8	15.7	85.4
06.00	18.00	12.0	Sunny-Cloudy	12.0	12.8	0.8	19.8	115.5
06.00	18.00	12.0	Sunny-Cloudy	12.3	13.2	0.9	20.5	117.3
06.00	18.00	12.0	Cloudy – Rain	12.2	12.7	0.5	10.1	69.2
06.00	18.00	12.0	Sunny-Cloudy	12.1	13.0	0.9	21.7	139.6
06.00	18.00	12.0	Sunny	12.1	13.4	1.3	23.4	141.4

4. **Discharging Test.** From the test results in Table 3 with a test duration of around 3.25 - 4 hours, ten tests obtained quite stable results, with the fastest test time of 3.25 hours consuming a battery voltage of 0.4 V with an average power of 13 Watts and consuming energy of 42.3 Wh.

Table 3. Discharging Test Before Installation

Start Time	Stop Time	Discharging total time (hours)	Battery usage Duration (Hours)	Electric State Company supply Duration (hours)	Initial Battery Voltage (Volt)	Final Battery Voltage (Volt)	Differential Battery Voltage (Volt)	Average Power (W)	Energy Consumed (Wh)
19.15	23.15	4.00	4.0	0.0	13.1	12.6	0.5	13.2	52.8
20.20	23.40	3.30	3.3	0.0	12.6	12.1	0.5	12.4	40.9
19.30	23.00	3.50	3.5	0.0	13.4	12.9	0.5	13.1	45.9
20.00	23.15	3.25	3.2	0.0	13.0	12.6	0.4	13.0	42.3
19.00	22.30	3.50	3.5	0.0	12.6	12.1	0.5	12.4	43.4
19.30	23.00	3.50	3.5	0.0	13.2	12.7	0.5	12.8	44.8
20.00	23.30	3.50	3.5	0.0	12.6	12.1	0.5	12.3	43.1
19.00	23.00	4.00	4.0	0.0	13.3	12.7	0.6	13.2	52.8
19.00	23.00	4.00	4.0	0.0	12.8	12.2	0.6	12.6	50.4
20.00	23.40	3.60	3.6	0.0	13.0	12.6	0.4	12.9	46.4

Meanwhile, the longest test was 4 hours, carried out three times with a battery voltage consumption of 0.5 – 0.6 V with an average power of 12.6 and 13.2 Watts and consuming energy of 50.4 and 52.8 Wh. After the prototype was installed in the entrance guard pos of President University, we monitored the discharging result and got the data as presented in Table 4.

Table 4. Discharging Test After Installation

Start Time	Stop Time	Discharging total time (hours)	Battery usage Duration (Hours)	Electric State Company supply Duration (hours)	Initial Battery Voltage (Volt)	Final Battery Voltage (Volt)	Differential Battery Voltage (Volt)	Average Power (W)	Energy Consumed (Wh)
18:00	06:00	12.00	8.78	3.22	12.9	12.0	0.9	13.27	150.36
18:00	06:00	12.00	12.00	0.00	13.3	12.1	1.2	12.21	145.38
18:00	06:00	12.00	7.60	4.40	12.9	12.1	0.8	12.65	143.08
18:00	06:00	12.00	5.50	6.50	12.5	12.0	0.5	12.65	151.81
18:00	06:00	12.00	7.75	4.25	12.8	12.0	0.8	12.92	155.08
18:00	06:00	12.00	9.62	2.38	13.0	12.1	0.9	12.75	146.40
18:00	06:00	12.00	9.97	2.03	13.0	12.0	1.0	12.86	145.20
18:00	06:00	12.00	6.12	5.88	12.7	12.1	0.6	13.28	148.76
18:00	06:00	12.00	12.00	0.00	13.3	12.1	1.2	12.40	145.70
18:00	06:00	12.00	12.00	0.00	13.4	12.2	1.2	12.30	148.42

From Table 4, it can be seen that not all load usage can be supplied by the battery for 12 hours. From the 10 data taken, only 3 times of which the battery can supply fully throughout the night, the battery can only supply total electricity when the previous battery capacity is enough. From the testing the energy consumed around 143.08 Wh until 155.08 Wh, the shortest time battery usage was 5.5 hours and the longest time battery usage was 12 hours when the battery could not supply overnight fully until 06.00 o'clock (< 12 hours), the load would be supplied by the State Electricity Company which was used as a backup to turn on the load until morning (until 06.00 o'clock).

Table 5. Discharging Test After Installation

Start Time	Stop Time	Charging Duration (hours)	Weather	Battery level (Volt)		Differential Battery Voltage (Volt)	Average Power (W)	Energy Generated (Wh)
				Initial	Final			
06.00	18.00	12.0	Sunny-Cloudy	12.4	13.2	0.8	20.2	96.7
06.00	18.00	12.0	Sunny	12.0	13.3	1.3	22.7	131.2
06.00	18.00	12.0	Sunny-Cloudy	12.1	12.9	0.8	13.4	84.3
06.00	18.00	12.0	Cloudy – Rain	12.0	12.5	0.5	9.3	58.4
06.00	18.00	12.0	Sunny-Cloudy	12.2	13.0	0.8	15.7	85.4
06.00	18.00	12.0	Sunny-Cloudy	12.0	12.8	0.8	19.8	115.5
06.00	18.00	12.0	Sunny-Cloudy	12.3	13.2	0.9	20.5	117.3
06.00	18.00	12.0	Cloudy – Rain	12.2	12.7	0.5	10.1	69.2
06.00	18.00	12.0	Sunny-Cloudy	12.1	13.0	0.9	21.7	139.6
06.00	18.00	12.0	Sunny	12.1	13.4	1.3	23.4	141.4

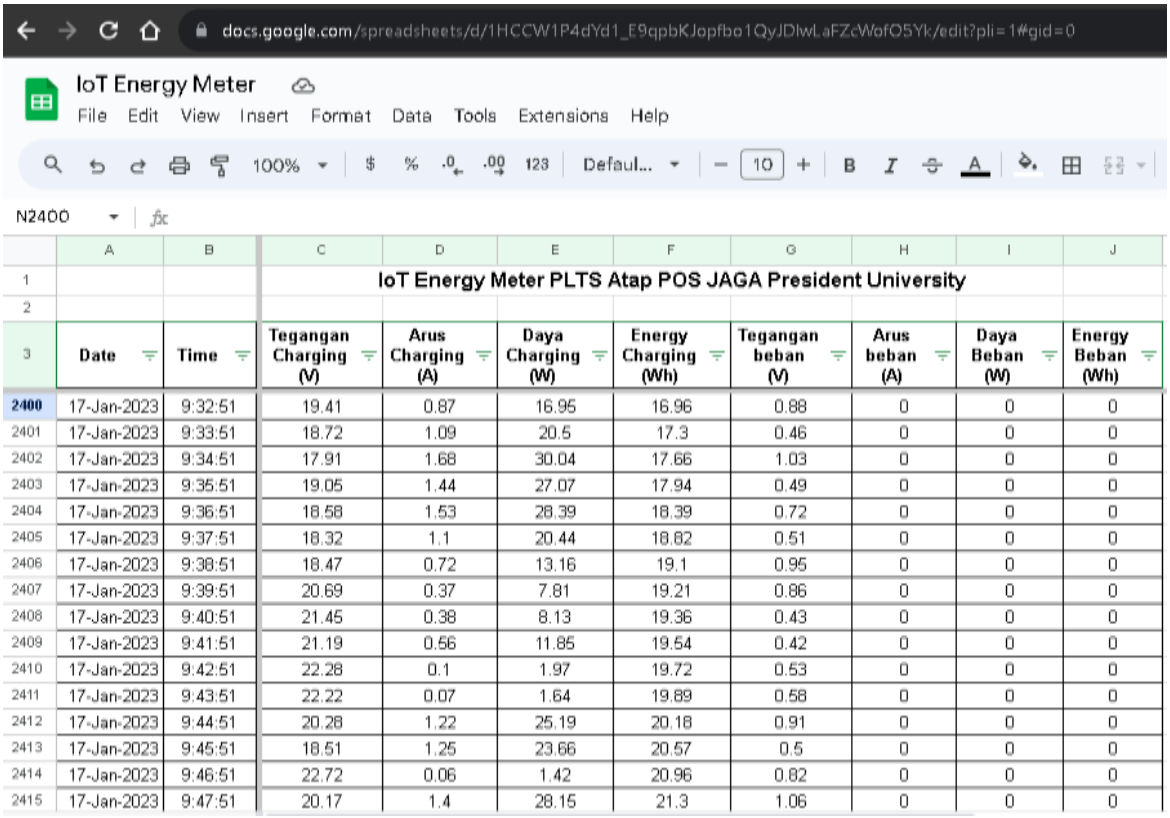
5. **IoT Control and Monitoring Test**. In this project, the Blynk application, an IoT platform, is used to monitor electrical parameters and control lights on and off remotely via a mobile phone. In this Blynk application, electrical parameters can be known in real-time and also their history on charts. On the chart, we can choose the desired time frame or time interval.

Figure 12. The charging and discharging state on the Blynk app displays (a) Charging state, (b) Discharging state

Gogglesheet Recording Test

The data recording time has been set via the Arduino IDE program, the time selection can be adjusted based on our wishes, data recording can be set from seconds to hours, and the recording speed is also influenced by the internet speed used on the NodeMCU esp8266 and also on the computer or laptop which is used to read data on the goggle sheet. So when there is a delay in recording data, it can be caused by a slow internet connection, sometimes the latency reaches 11 seconds, but mostly, the latency is just under 5 seconds.

Fig. 13 shows the data recorded every 1 minute in the Google Sheets, the record has no delay when the internet connection is fast and Figure 4.7 shows the recording has no latency all recorded data is shown in 51st seconds in every minute



docs.google.com/spreadsheets/d/1HCCW1P4dYd1_E9qpbKJopfbo1QyJDlwLaFZcWofO5Yk/edit?pli=1#gid=0

IoT Energy Meter

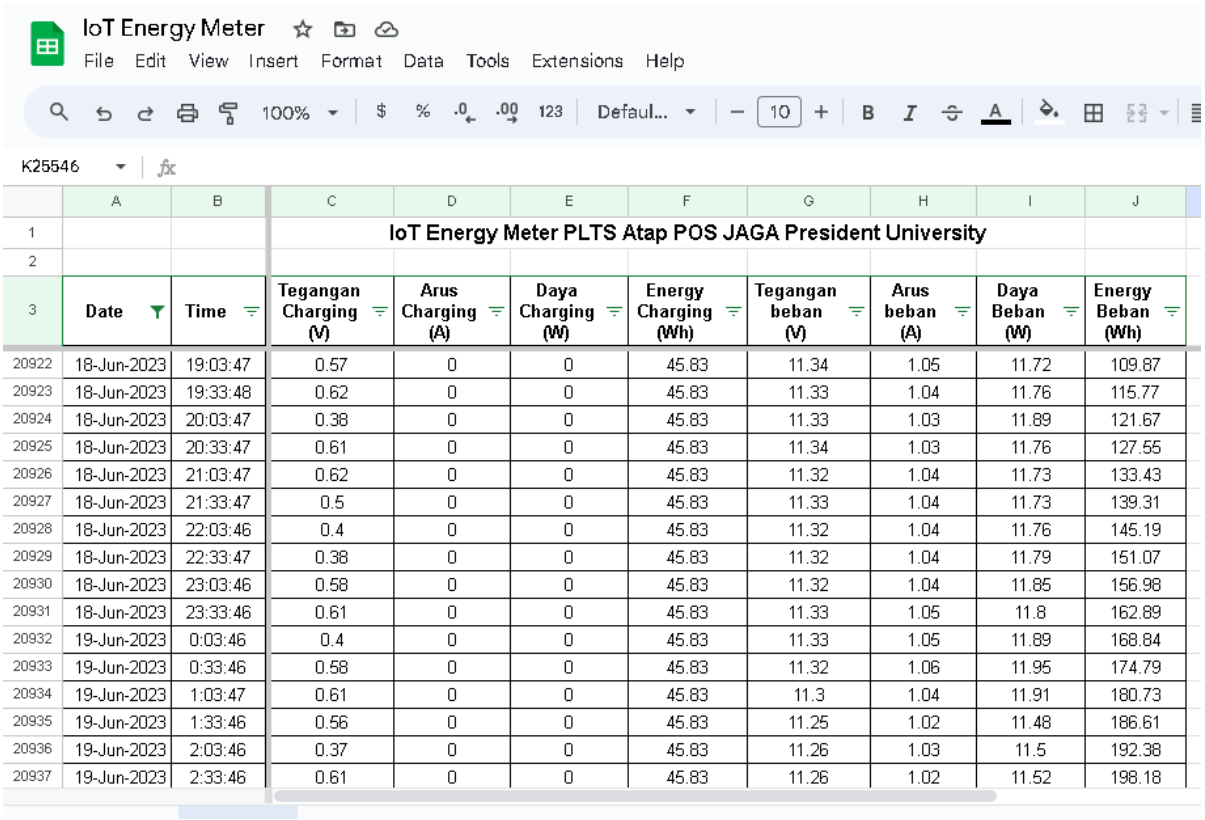
File Edit View Insert Format Data Tools Extensions Help

N2400

	A	B	C	D	E	F	G	H	I	J
1			IoT Energy Meter PLTS Atap POS JAGA President University							
2										
3	Date	Time	Tegangan Charging (V)	Arus Charging (A)	Daya Charging (W)	Energy Charging (Wh)	Tegangan beban (V)	Arus beban (A)	Daya Beban (W)	Energy Beban (Wh)
2400	17-Jan-2023	9:32:51	19.41	0.87	16.95	16.96	0.88	0	0	0
2401	17-Jan-2023	9:33:51	18.72	1.09	20.5	17.3	0.46	0	0	0
2402	17-Jan-2023	9:34:51	17.91	1.68	30.04	17.66	1.03	0	0	0
2403	17-Jan-2023	9:35:51	19.05	1.44	27.07	17.94	0.49	0	0	0
2404	17-Jan-2023	9:36:51	18.58	1.53	28.39	18.39	0.72	0	0	0
2405	17-Jan-2023	9:37:51	18.32	1.1	20.44	18.82	0.51	0	0	0
2406	17-Jan-2023	9:38:51	18.47	0.72	13.16	19.1	0.95	0	0	0
2407	17-Jan-2023	9:39:51	20.69	0.37	7.81	19.21	0.86	0	0	0
2408	17-Jan-2023	9:40:51	21.45	0.38	8.13	19.36	0.43	0	0	0
2409	17-Jan-2023	9:41:51	21.19	0.56	11.85	19.54	0.42	0	0	0
2410	17-Jan-2023	9:42:51	22.28	0.1	1.97	19.72	0.53	0	0	0
2411	17-Jan-2023	9:43:51	22.22	0.07	1.64	19.89	0.58	0	0	0
2412	17-Jan-2023	9:44:51	20.28	1.22	25.19	20.18	0.91	0	0	0
2413	17-Jan-2023	9:45:51	18.51	1.25	23.66	20.57	0.5	0	0	0
2414	17-Jan-2023	9:46:51	22.72	0.06	1.42	20.96	0.82	0	0	0
2415	17-Jan-2023	9:47:51	20.17	1.4	28.15	21.3	1.06	0	0	0

Figure 13. Google sheet data recording every 1 minute

Figure 14 shows the recording test performed in 30 minutes. In this test, the recording data has a latency of about 1 – 2 seconds. The data shown is recorded from the 46th to the 48th second.



IoT Energy Meter

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	A	B	C	D	E	F	G	H	I	J
1			IoT Energy Meter PLTS Atap POS JAGA President University							
2										
3	Date	Time	Tegangan Charging (V)	Arus Charging (A)	Daya Charging (W)	Energy Charging (Wh)	Tegangan beban (V)	Arus beban (A)	Daya Beban (W)	Energy Beban (Wh)
20922	18-Jun-2023	19:03:47	0.57	0	0	45.83	11.34	1.05	11.72	109.87
20923	18-Jun-2023	19:33:48	0.62	0	0	45.83	11.33	1.04	11.76	115.77
20924	18-Jun-2023	20:03:47	0.38	0	0	45.83	11.33	1.03	11.89	121.67
20925	18-Jun-2023	20:33:47	0.61	0	0	45.83	11.34	1.03	11.76	127.55
20926	18-Jun-2023	21:03:47	0.62	0	0	45.83	11.32	1.04	11.73	133.43
20927	18-Jun-2023	21:33:47	0.5	0	0	45.83	11.33	1.04	11.73	139.31
20928	18-Jun-2023	22:03:46	0.4	0	0	45.83	11.32	1.04	11.76	145.19
20929	18-Jun-2023	22:33:47	0.38	0	0	45.83	11.32	1.04	11.79	151.07
20930	18-Jun-2023	23:03:46	0.58	0	0	45.83	11.32	1.04	11.85	156.98
20931	18-Jun-2023	23:33:46	0.61	0	0	45.83	11.33	1.05	11.8	162.89
20932	19-Jun-2023	0:03:46	0.4	0	0	45.83	11.33	1.05	11.89	168.84
20933	19-Jun-2023	0:33:46	0.58	0	0	45.83	11.32	1.06	11.95	174.79
20934	19-Jun-2023	1:03:47	0.61	0	0	45.83	11.3	1.04	11.91	180.73
20935	19-Jun-2023	1:33:46	0.56	0	0	45.83	11.25	1.02	11.48	186.61
20936	19-Jun-2023	2:03:46	0.37	0	0	45.83	11.26	1.03	11.5	192.38
20937	19-Jun-2023	2:33:46	0.61	0	0	45.83	11.26	1.02	11.52	198.18

Figure 14. Google sheet data recording every 30 minutes

Discussion

From the results and data analysis above, the next step is to discuss the results and data analysis. Several things need to be discussed as a reference for the level of success in this final project:

1. The creation of prototype support for solar panels, control panel boxes, and battery support has been successfully implemented and installed at the entrance guard post of President University.
2. Testing before installation is carried out to ensure that the system can function properly, on the test results before installation. The results of this test, the solar panel can charge the battery so the system can function normally. when the charging test is carried out, the solar panel can charge the battery, and when the discharging test the battery can supply the load normally and the ATS can function according to design, when the battery voltage runs out or is insufficient, the load supply will move to the Electric State Company supply automatically, and when the battery voltage is full, the load supply will move back from the battery automatically.
3. The IoT system functions according to the desired design. IoT system that uses Blynk application that can be used to control the load on and off remotely and also monitor electrical values such as voltage, current, power and energy in the charging and discharging process can be displayed on the Blynk application.
4. Google Sheet which is used as a database record of reading voltage, current, power and energy values in the charging and discharging process can be recorded according to the desired time, the minimum time that can be recorded is 1 minute. The speed of recording data is very dependent on the speed of the internet used, if the speed of the internet network used is very slow, the recording time will be delayed which causes the recording process not to match the set time.

Conclusion

Based on the final research project entitled Prototype of Design And Build A Rooftop Solar Power Plant For President University Guard Post Lighting Iot-Based And Google Sheet As Database Record, it can be concluded as follows:

1. Development of a system design in the form has been successfully carried out and is running well as the design describes the actual conditions. The testing showed the solar panel able to fully charge to the battery when the weather is sunny with the energy generated is until 141,4 Wh (100% condition from testing data) but when the weather is rainy the solar panel just able to charge 58,4 Wh (41% from the maximum production when testing). For the discharging, the load can be supplied overnight 3 times for about 12 hours with the battery, the shortest time battery supply the load is 5.5 hours. If the battery power is not enough to supply the load during night the ATS will move the supply from the battery to the Electric State Company until 06.00 o'clock.
2. Implementation of each sensor used is by the functions that have been implemented. Parameter data is generated by the voltage and current sensor. The sensor can read data for the charging and discharging voltage and current and is displayed in the Blynk App on an Android smartphone. We can also control the lamp on and off from the Blynk app remotely.
3. The data that was measured from the sensors was already recorded successfully to the Google Sheets remotely in real-time, the recording time can be set from the Arduino IDE program which has been downloaded to the NodeMCU esp8266. The Google Sheets can record a minimum of every one minute. The actual recording time depends on the internet speed. When the internet has low speed, the recording data will be late and not recorded as set time. Sometimes the latency reaches 11 seconds, but mostly the latency is just under 5 seconds.

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