# Implementation and Testing of Rooftop Solar Power Plant with On-Grid System 1215 Wp Household Scale

*by* Jaka Windarta

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Jaka Windarta
*Magister of Energy*
*Diponegoro University*
Semarang, Indonesia
jokowind@yahoo.com

Denis Denis
*Department of Electrical Engineering*
*Diponegoro University*
Semarang, Indonesia
denisginting@elektro.undip.ac.id

Singgih Saptadi
*Department of Industrial Engineering*
*Diponegoro University*
Semarang, Indonesia
singgihs@lecturer.undip.ac.id

Johanes Soritua Silaen
*Department of Electrical Engineering*
*Diponegoro University*
Semarang, Indonesia
johanessilaen@students.undip.ac.id

Dimas Adi Satrio
*Department of Electrical Engineering*
*Diponegoro University*
Semarang, Indonesia
dimasadi@students.undip.ac.id

***Abstract*—Indonesia has a total renewable energy potential equivalent to 442 GW which can be used for electricity generation, while its utilization in 2018 is only 8.8 GW or 0.019% of the total renewable energy potential. The biggest potential for renewable energy is solar energy at 207.8 GWp. Given the ever-increasing number of household customers, utilizing a rooftop as a solar power plant can be an effective and efficient solution. This study aims to test and implement a rooftop solar-powered PV system with a household-scale on grid system. Testing is done by testing the main components, namely solar modules and inverters, and data collection testing is carried out for 2 days starting at 8:10 to 16.55. Through this test the results show that the surplus of electrical energy generated by solar power plants can be sold to the grid through the EXIM meter.**

***Keywords*—Solar power plants, Solar cell, On-Grid**

## I. Introduction

The use of solar cells throughout Indonesia is increasing every year, as the Government's target set by the Ministry of Energy and Mineral Resources in 2025 should reach 1047 MW throughout Indonesia. The use of solar power plant utilizes solar cells at an affordable cost, does not take much place, and also it has has the potential to become an alternative power plant for households, compared to the Government's electricity that must be paid monthly. The Government electricity which uses solar cells only incurs an initial fee and no longer incur costs tariffs such as electricity usage from the Government at a later time[1].

Solar power plant with on-grid system could be a solutive effort to support the Government's target in 2025. Solar power plant with on-grid system is a generator which interconnected with electricity grid [2]. By connecting the solar power plant to the network, then solar power plant could link the electrical energy to the grid. Therefore, this research involves testing and on-grid system solar power plant implementation with a capacity of 1215Wp at Sambiroto Asri Housing, Semarang City, Indonesia.

## II. Theoretical Background

### *A. Solar Power Plant*

Solar power plant is a generator which utilizes sunray as its main source of energy. Solar cells will be used to convert the sunray or photon sunray radiation into electrical energy.

### *B. Main Components of Solar Power Plant*

#### *1) Solar Module*

Solar module is one of solar power plant's components which structured from such arranged solar cells, whether it is arranged in series or in parallel form to produce voltage or current. These cells merged in one casing or protector. Solar cells are made from semiconductor elements that could convert solar energy into electrical energy by the photovoltaic effect [3]. Afterward, the arranged solar modules will be located into one cantilever, or it is commonly named as an array. Illustration of solar modules is described in Figure 1.

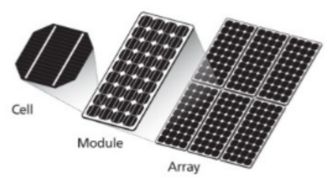


Fig. 1. Illustration of solar modules, solar cells, and solar arrays

#### *2) Inverter*

Inverter in solar power plant functioned as electrical energy conditioner and also as a control system which changes DC that is produced by solar module into AC. This component has also functioned as electrical energy quality control that will be sent to load or network.

### *C. Solar Module Testing*

Solar Module Testing will be conducted by testing the conformity of technical specifications from the factory to provide technical description of solar module performance.

- Irradiation

  Electrical energy production is mainly affected by the irradiation level received by photovoltaic module. Figure 2 compares the voltage characteristic and current characteristic curve. The result is the lower solar irradiation level that can be received by the photovoltaic module, the lower the resulting current will be [4].

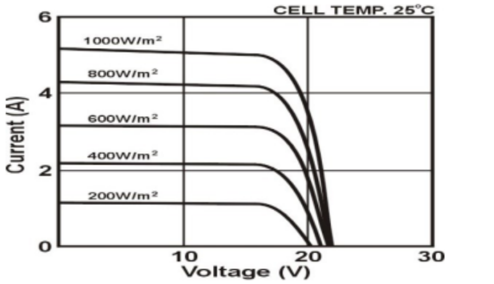


Fig. 2. The Voltage Characteristic and Current towards Solar Irradiation Shown in Characteristic Curve

- Solar Module Temperature

The temperature around solar module takes an important role in electricity current produced by photovoltaic module. Air temperature is required to maximize the productivity of electricity production. Figure 3 shows characteristic curve between temperature's effect towards power (W) which is produced by photovoltaic module and output current (V) of photovoltaic module [5].

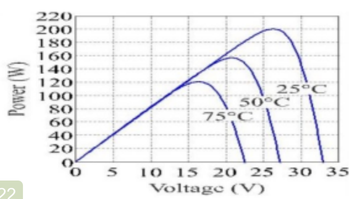


Fig. 3. The Effect of Module Temperature towards the Produced Power and Output Current Photovoltaic Module Shown in Characteristic Curve

- Input Power

The equation to calculate solar power plant's input power is shown below [6]:

$$P_{in} = G \times A \quad (1)$$

Where: $P_{in}$ = Solar modules input power (W)
G = Irradiance (W/m$^2$)
A = Surface area of modules (m$^2$)

- Open-Circuit Voltage and Short-Circuit Current

The core of solar module testing is on the short-circuit current magnitude and open-circuit voltage magnitude. This is essential due to calculate the peak power amount that can be achieved from a solar module.

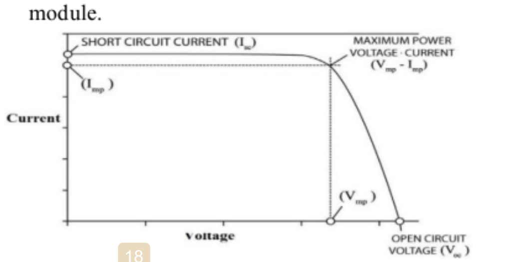


Fig. 4. The Effect of Short-Circuit Current and Open-Circuit Voltage towards Photovoltaic Module Shown in Characteristic Curve.

- Fill Factor

Fill factor is a ratio value between the maximum condition of voltage and current and open-circuit voltage and short-circuit current. The calculation of the fill factor value uses the following equation [7]:

$$V_{mp} = V_{oc}\,measured \times \frac{Vmp\ Nameplate}{Voc\ Nameplate} \quad (2)$$

$$I_{mp} = V_{sc}\,measured \times \frac{Imp\ Nameplate}{Ioc\ Nameplate} \quad (3)$$

$$FF = \frac{Vmp \times Imp}{Voc \times Isc} \quad (4)$$

Where: FF = Fill factor
Vmp = Maximum voltage (V)
Voc = Open circuit voltage (V)
Imp = Maximum current (A)
Isc = Short circuit current (A)

- Maximum Power Output

The calculation of maximum power output uses the equation below [4]:

$$P_m = V_{oc} \times I_{sc} \times FF \quad (5)$$

Where: $P_m$ = Maximum power output (Watt)
$V_{oc}$ = Open circuit voltage (Volt)
$I_{sc}$ = Short circuit Current (Ampere)

- Solar Module Efficiency

Power Efficiency is defined as a comparison between produced electrical energy and received input power. Low-efficiency value may affect electrical power and solar module output. Solar Module efficiency can be calculated using this following equation [8]:

$$\mu = \frac{Pm}{Pin} \times 100\% \quad (6)$$

Where: μ = Efficiency of solar modules (%)
$P_m$ = Maximum output power (W)
$P_{in}$ = Solar module input power (W)

### *D. Loading Test*

Loading test utilizes three different load conditions which are: $I_{load} < I_{inverter}$; $I_{load} = I_{inverter}$; dan $I_{load} > I_{inverter}$

### *E.* Solar Power Plant System Testing

Solar Power Plant System Testing aims to analyze the energy production effect of electricity consumption from the grid..

## III. Testing, Result, and Analysis

### *A. Testing*

This research is located at Sambiroto Asri Housing no A9, Semarang City, Indonesia. Solar power plant with on-grid system testing is astronomically located in 7°1'56.06" South Latitude and 110°27'28.58" East Longitude.

Fig. 5. Research Area in Sambiroto Asri Housing, Semarang *City*

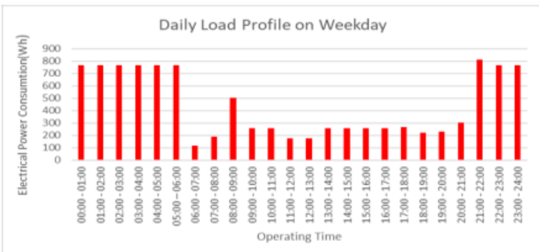


Fig. 6. Daily Load Profile on Weekday

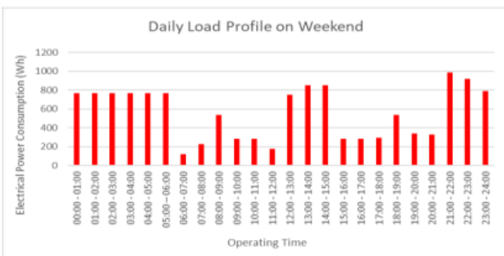


Fig. 7. Daily Load Profile on Weekend

Daily load profile estimation at the research area is carried out employing manual and periodic observations to determine the estimated daily load inexact. On the weekday, the research area utilizes 10,69kWh of electrical energy, while during the weekend, the research area utilizes 13,34kWh of electrical energy.

This research chose a solar power plant with a capacity of 1215Wp. This solar power plant consists of three solar modules with a capacity of 405Wp on each module.

TABLE I. CANADIAN SOLAR CS3W405P SPECIFICATIONS

| Specs | Value |
|---|---|
| Maximum Power (Pmax) | 405 Wp |
| Open Circuit Voltage (Voc) | 47.4 V |
| Short Circuit Current (Isc) | 10,98 A |
| Maximum Voltage (Vmp) | 38,9 V |
| Maximum Current (Imp) | 10,42 A |
| Modul efficiency | 18,3 % |
| Modul Operating Temp (°C) | 42°C |
| Dimension (mm x mm x mm) | 2108 x 1048 x 40 |

TABLE II. INVERTER SOLAX X1-1.1-S SPECIFICATIONS

| Specs | Value |
|---|---|
| Maximum Solar Array Power | 1250 W |
| Maximum DC Voltage | 400 V |
| Maximum Input Current | 12 A |
| MPPT Voltage Range | 55-380 V |
| Maximum Output Power | 1100 W |
| Nominal Grid Voltage Range | 180-280 V |
| Maximum Output Voltage | 5.5 A |
| Maximum efficiency | 97,1 % |

## B. *Result*

Irradiation, temperature, Voc, and Isc testing are conducted to analyze maximum input and output power and also solar module efficiency. The examination is conducted on July 29, 2020, with 15 minutes data-taking interval. The result of this examination is attached in Table III.

TABLE III. SOLAR MODULE RESULT TEST DATA

| Time | Irradiance ($W/m^2$) | Pin (W) | Temp (°C) | Voc (V) | Isc (A) |
|---|---|---|---|---|---|
| 08:00 | 736.5 | 4881.19 | 38.1 | 129.05 | 8.45 |
| 08:15 | 768.1 | 5090.62 | 38.6 | 129.23 | 8.96 |
| 08:30 | 852.3 | 5648.66 | 40.0 | 129.71 | 8.99 |
| 08:45 | 872.6 | 5783.20 | 41.6 | 129.24 | 9.00 |
| 09:00 | 916.3 | 6072.82 | 41.6 | 130.04 | 9.03 |
| 09:15 | 1027.4 | 6809.15 | 43.1 | 130.18 | 9.09 |
| 09:30 | 959.0 | 6355.82 | 43.2 | 127.42 | 9.00 |
| 09:45 | 951.2 | 6304.13 | 45.8 | 127.02 | 8.97 |
| 10:00 | 889.6 | 5895.87 | 46.5 | 128.10 | 8.95 |
| 10:15 | 937.5 | 6213.33 | 45.5 | 127.34 | 8.89 |
| 10:30 | 921.3 | 6105.96 | 44.2 | 127.51 | 8.87 |
| 10:45 | 901.3 | 5973.41 | 43.8 | 127.36 | 8.86 |
| 11:00 | 842.4 | 5583.05 | 43.9 | 127.57 | 8.83 |
| 11:15 | 818.7 | 5425.98 | 45.2 | 127.89 | 8.82 |
| 11:30 | 817.0 | 5414.71 | 46.1 | 128.04 | 8.80 |
| 11:45 | 749.1 | 4964.70 | 47.2 | 128.37 | 8.36 |
| 12:00 | 785.6 | 5206.60 | 48.6 | 128.65 | 7.70 |
| 12:15 | 712.1 | 4719.48 | 47.4 | 128.69 | 7.11 |
| 12:30 | 704.4 | 4668.45 | 47.2 | 127.72 | 6.95 |
| 12:45 | 695.1 | 4606.81 | 47.6 | 127.54 | 6.63 |
| 13:00 | 670.1 | 4441.12 | 47.2 | 127.85 | 6.30 |
| 13:15 | 607.9 | 4028.89 | 46.6 | 127.89 | 5.82 |
| 13:30 | 534.4 | 3541.76 | 46.5 | 127.72 | 4.95 |
| 13:45 | 446.1 | 2956.55 | 46.2 | 127.51 | 4.23 |
| 14:00 | 376.3 | 2493.95 | 46.5 | 126.49 | 3.34 |
| 14:15 | 320.1 | 2121.48 | 45.7 | 125.93 | 2.86 |
| 14:30 | 287.8 | 1907.41 | 42.5 | 124.29 | 2.54 |
| 14:45 | 228.6 | 1515.06 | 43.2 | 122.62 | 2.24 |
| 15:00 | 192.2 | 1273.81 | 44.7 | 122.14 | 1.88 |
| 15:15 | 150.4 | 996.78 | 42.2 | 121.72 | 1.46 |
| 15:30 | 117.4 | 778.07 | 42.6 | 121.47 | 1.35 |
| 15:45 | 64.1 | 424.83 | 42.1 | 120.84 | 0.72 |
| 16:00 | 49.0 | 324.75 | 41.6 | 119.39 | 0.59 |
| 16:15 | 41.1 | 272.39 | 41.3 | 118.83 | 0.48 |
| 16:30 | 35.4 | 234.61 | 41.3 | 117.35 | 0.42 |
| 16:45 | 28.4 | 188,22 | 40.6 | 117.36 | 0.39 |

Loading test is conducted by using three variations which are: $I_{inverter} > I_{load}$; $I_{inverter} > I_{load}$; and $I_{inverter} > I_{load}$. Loading testing result could be seen in the Table IV below.

TABLE IV. LOADING TESTING RESULT DATA

| $I_{load}$ (A) | $I_{inverter}$(A) | I grid (A) | Condition |
|---|---|---|---|
| 0.53 | 2.14 | 1.74 | $I_{inverter-grid} > I_{load}$ |
| 1.24 | 2.49 | 1.40 | $I_{inverter-grid} > I_{load}$ |
| 2.06 | 2.28 | 0.40 | $I_{inverter-grid} > I_{load}$ |
| 2.00 | 1.99 | 0.08 | $I_{inverter-grid} = I_{load}$ |
| 2.87 | 2.35 | 1.00 | $I_{inverter-grid} > I_{load}$ |
| 3.19 | 2.20 | 1.00 | $I_{inverter-grid} > I_{load}$ |
| 4.60 | 1.77 | 2.85 | $I_{inverter-grid} > I_{load}$ |

Data-taking and solar power plant system testing is conducted on August 30-31 2020. The average electrical energy produced by solar power plants can be seen in Figure 8.

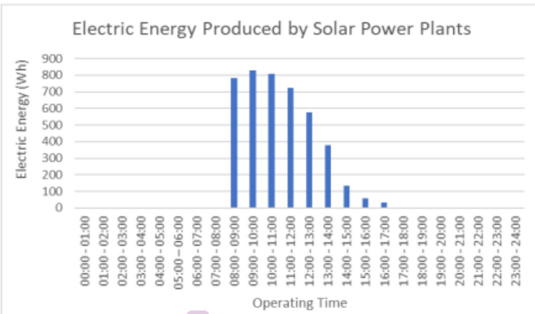


Fig. 8. Electrical Energy Produced by Solar Power Plants

According to Figure 8, solar power plant can produce electrical energy of 4,32kWh starting from 08:00 to 17:00 WIB.

## C. Analysis

### 1) Solar Module Testing

### A. Correlation Between Irradiation and Maximum Solar Module Power Output

Maximum Solar Module Power Output can be calculated by using (2), (3), (4), and (5) equation. Based on the equation calculation, a graph of irradiation and maximum solar module power output correlation is made below in Figure 9.

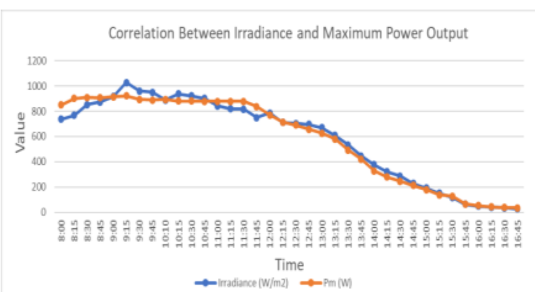


Fig. 9. Correlation Between Irradiance and Maximum Power Output

According to the graph above, it can be concluded that maximum solar module power output is greatly influenced by solar irradiation. When the irradiation reached a maximum value of 1027.4W/m$^2$, the maximum output power also shows maximum value of 914.54W. On the other hand, when the irradiation reached a minimum value of 28.4W/m$^2$, the maximum output power is also getting a smaller value of 35.65W. This shows that when the irradiation value is greater, the more output power that can be generated by the solar module, and vice versa [9].

### B. Correlation Between Module Temperature and Module Efficiency

Solar Module Efficiency Value can be calculated by using (6) equation. This resulting in average solar module efficiency value of 15.13%, however, this has a smaller value than the nameplate's efficiency value. This happens because the temperature on solar module is higher than the optimal solar module temperature of 25°C. The correlation between module temperature and module efficiency graph can be seen below in Figure 9.

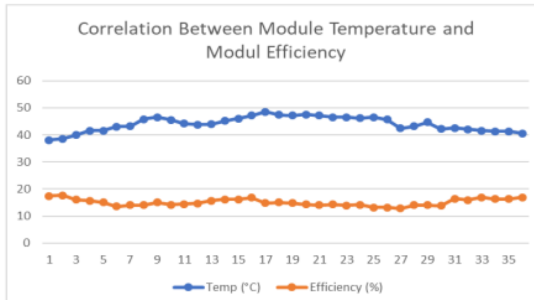


Fig. 10. Correlation Between Module Temperature and Module Efficiency

Based on the Figure 10, it can be seen that the solar module temperature influences the solar module efficiency. When the solar module temperature is 38.6°C, the solar module efficiency is 17.4%. Moreover, when the solar module temperature is 48.6°C, the solar module efficiency turns into 14.82%. This shows that the lower the temperature, the higher the efficiency, and vice versa[10].

### 2) Loading Tests

Loading test is conducted to analyze the load sharing between the grid and solar power plant. The result can be concluded in the Table V below:

TABLE V. COMPARATION BETWEEN IGRID WITH ILOAD DAN IINVERTER DEVIATION

| $I_{load}$ (A) | $I_{inverter}$ (A) | $\lvert I_{load} - I_{inverter} \rvert$ (A) | I grid (A) | Condition |
|---|---|---|---|---|
| 0.53 | 2.14 | 1.61 | 1.74 | $I_{inverter} > I_{load}$ |
| 1.24 | 2.49 | 1.25 | 1.40 | $I_{inverter} > I_{load}$ |
| 2.06 | 2.28 | 0.22 | 0.40 | $I_{inverter} > I_{load}$ |
| 2.00 | 1.99 | 0.01 | 0.08 | $I_{inverter} = I_{load}$ |
| 2.87 | 2.35 | 0.52 | 0.47 | $I_{inverter} < I_{load}$ |
| 3.19 | 2.20 | 0.99 | 1.00 | $I_{inverter} < I_{load}$ |
| 4.60 | 1.77 | 2.83 | 2.85 | $I_{inverter} < I_{load}$ |

It can be seen from Table V that $\lvert I_{load}$- $I_{inverter} \rvert$ value is almost similar with $I_{grid}$. The deviation appears because of the shifting load current.

At no load condition or $I_{Load}$ = 0A and $I_{inverter}$=3.34A, the Igrid value $I_{Grid}$ = 3.34A is obtained. This shows that when it has no load, the power generated from solar power plant system is exported to the grid of 3.34A. This happens because of the solar power plant production conditions are greater than the operating load.

When $I_{load}$=2A and $I_{inverter}$=1.99A, the result is $I_{grid}$ = 0.08A or close to 0A. This shows that all loads are borne by solar power plants without importing or exporting power to the grid. This mainly happens because of the adequate condition between solar power plant production conditions and the operating load.

When $I_{load}$ = 4.6A and $I_{inverter}$ = 1.77A, the result is $I_{grid}$ = 2.85A. This shows that all loads are borne by the solar power plant of 1.77A by importing electrical energy from the grid of 2.85A. This is due to the solar power plant production is smaller than the operating load.

*3) System Testing*

This testing aims to analyze the solar power plant production contribution to the electrical energy consumption from the grid, regarding the daily load profile in Figure 6 and Figure 7. This testing is conducted on August 30 to 31, 2020, on 2 days average on data taking.

*A. The Effect of Solar Power Plant Electricity Production on the Weekdays*

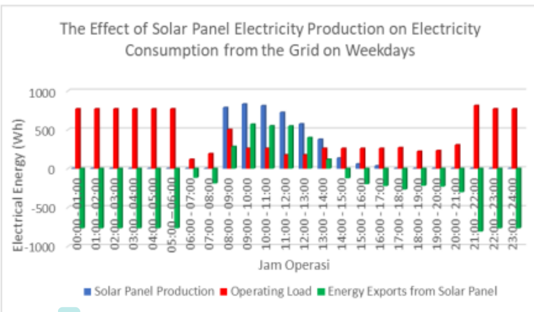


Fig. 11. The Effect of Solar Power Plant Electricity Production on the Weekdays

As per the graph in Figure 11, it can be seen that during the operating hours at 00:00 – 08:00 the production of solar power plant electrical energy is less than the electrical energy required by the load to operate. This causes the export of electrical energy value from the solar power plant to be negative. This shows that the operating load requires electrical energy imports from the grid of 4.91 kWh because lack of electrical energy from the solar power plant.

During operating hours at 08:00 – 14:00, the electrical energy production from the solar power plant is greater than the operating load. This causes the electrical energy export value from the solar power plant to be positive. This shows that the operating load does not require electrical energy imports from the grid, and the surplus-value can be exported to the grid of 2.46kWh.

During the operating hours at 14:00 – 17:00, the electrical energy produced from solar power plants is 0.26kWh, however, the operating load requires the electrical energy of 0.77kWh. This shows that the load requires the electrical energy import from PLN of 0.55kWh. During the operating hours at 17:00 – 24:00, solar power plant does not produce any electrical energy, so that it needs electrical energy import from the grid of 0.33kWh.

Therefore, it can be concluded from Figure 11 that during weekdays, the research object could produce electrical energy of 4.32kWh and used to fulfill the load consumption of 1.86kWh. Moreover, it is found that this device could export the electrical energy of 2.46 kWh and needs electrical energy import from the grid of 8.84 kWh.

*B. The Effect of Solar Power Plant Electricity Production on the Weekends*

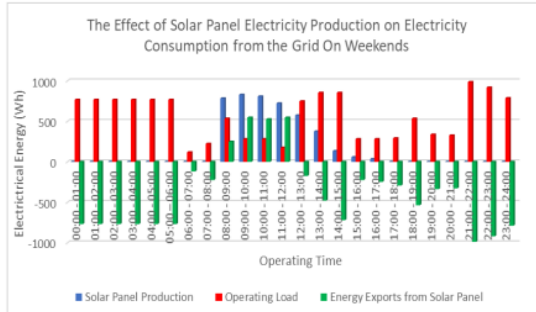


Fig. 12. The Effect of Solar Panel Electricity Production on Electricity Consumption from the Grid on Weekends

As per the graph in Figure 12, it can be seen that during the operating hours at 00:00 – 08:00 the production of solar power plant electrical energy is less than the electrical energy required by the load to operate. This causes the export of electrical energy value from the solar power plant to be negative. This shows that the operating load requires electrical energy imports from PLN of 4.95 kWh because lack of electrical energy from the solar power plant.

During operating hours at 08:00 – 12:00, the electrical energy production from the solar power plant is greater than the operating load. This causes the electrical energy export value from the solar power plant to be positive. This also shows that the operating load does not require electrical energy imports from the grid, and the surplus-value can be exported to PLN of 1.86kWh.

During the operating hours at 12:00 – 17:00, the electrical energy produced from solar power plants is 1.17kWh, however, the operating load requires the electrical energy of 3.02kWh. This shows that the load requires the electrical energy import from the grid of 18.4kWh.

During the operating hours at 17:00 – 24:00, solar power plant does not produce any electrical energy, so that it needs electrical energy import from the grid of 4.18kWh.

Therefore, it can be concluded from Figure 12 that during weekends, the research object could produce electrical energy of 4.32kWh and used to fulfill the load consumption of 2.45kWh. Moreover, it is found that this device could export the electrical energy of 1.87 kWh and needs electrical energy import from the grid of 10.97 kWh.

## IV. CONCLUSION

As per the research results, the solar panel has an efficiency value of 15.13% which has a smaller value from the nameplate efficiency value. This is due to the temperature of the solar panel is higher than the optimal temperature of solar panel of 25°C. Based on the analysis of electricity production on the electricity consumption from the grid system calculation, the results show that solar power plant could produce electrical energy of 4.32 kWh. On the weekday, the solar power plant can export the electricity to the grid of 2.46kWh. On the other hand, on the weekend, it can export the electricity to the grid of 1.87kWh. This shows that the less load that operates during the time, the more electrical energy that can be exported to the grid.

## REFERENCES

[1] H. Hardianto, "Utilization of Solar Power Plant in Indonesia: A Review", Int. J. Environ. Eng. Educ., vol. 1, no. 3, pp. 1-8, Dec. 2019.

[2] N. Manojkumar, S. K. Yadaf, S. S. Copra, U. Bajai, R. P. Gupta, S. Padmanaban, F. Blaabjerg, "Operational Performance Of On-Grid Solar Photovoltaic System Integradted Into Pre-Fabricated Portable Cabin Buildings In Warm And Temperate Climates", Energy for Sustainable Development, Vol. 57, pp. 109-118, Aug.2020

[3] B. Parida, S. Iniyan, R. Goic, "A Review Of Solar Photovoltaic Technologies", Renewable and Sustainable Energy Reviews, pp. 1625-1636, 2011.

[4] ABB, Technical Application Papers N0.10 Photovoltaic Plants, Bergamo Italy, 2008

[5] J. Adeeb , A. Farhan , A. Al-Salaymeh, "Temperature Effect on Performance of Different Solar Cell Technologies", Journal of Ecological Engineering, Vol. 20, pp. 249-254, May. 2019.

[6] Keithley, "Making I-V And CV Measurement On Photovoltaic Cells Using The Model 4200-SCS Semiconductor Characterization System", Aplication note series No. 2876, 2007

[7] M. Stolterfoht, V. M. L. Corre, M. Feuerstein, P. Caprioglio, L. J. A. Koster, and D. Neher, "Voltage-Dependent Photoluminescence and How It Correlates with the Fill Factor and Open-Circuit Voltage in Perovskite Solar Cells", ACS Energy Lett. pp. 2887–2892, 2019

[8] R. Arshad, M. Jamil, "Improvement in Solar Panel Efficiency Using Solar Concentration by Simple Mirrors and Cooling", International Conference on Robotics and Emerging Allied Technologies in Engineering (iCREATE), 2014

[9] D.L. King, W.E. Boyson, J.A. Kratochvil, "Analysis of Factors Influencing the Annual Energy Production of Photovoltaic Systems", IEEE, 2002

[10] I. Timothy, J. Silverman, M. G. Decegrie, I. Subedi, N. J. Podraza, I. M. Slauch, V. E. Ferry, " Reducing Operating Temperature in Photovoltaic Modules", IEEE Journal of Photovoltaics, Vol. 8, pp. 532-540

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