Analysis Inverter of PLTS On Grid

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Abstract*—As is known, the potential of Indonesia's natural resources is quite high in solar energy if it is utilized to the best of its ability. By utilizing this energy, the use of electrical energy through PLN will be reduced or assisted in terms of electricity supply so that it can reduce the supply of existing loads. The effect of temperature from the photovoltaic system has an impact on the current and voltage output so that the resulting output will be optimal or not. Based on the data irradiation also affects the power output by the inverter. The inverter will also work properly when the standard value of the inverter specification will work when the minimum voltage value is in the range of 400V-800V and reads well above 800 V according to the experiment and the current is stated to be 12.5 A to 33 A with the data obtained above. So that the performance of the inverter is in its maximum condition, but when the irradiation condition decreases, the performance of the inverter will decrease, which can be seen from the power generated. The measured temperature based on the input data from the inverter shows a value above 25 ^0C will make the inverter work according to standard. When the work efficiency of the inverter decreases, the output power will not be optimal. but when the parameters of the PV system start from temperature to optimal irradiation level, the input and output of the inverter also work optimally.

Keywords— inverter, efficiency, power of solar power plant

I. INTRODUCTION

This research has the purpose of analyzing the impact of GTI installation connected between PLN network and solar cell based on current and voltage measurements of PLN, harmonics of PLN, and measurements connected to solar cell both current, voltage, harmonics and power factor. Based on the data generated, the THDV value of the three phases measured with solar cells is lower than without solar cells due to the additional filter in the inverter. However, the THDA measurements on the R and T phases indicated nonlinear loads whose values were above 10% both without and connected to solar cells [1].

Based on the results of the research conducted, it is concluded that the performance or performance of the GTI type on-grid inverter based on its output power is influenced by solar radiation and PV panel temperature. The resulting efficiency of the GTI performance is 89% because the output power of the GTI is not significant with the radiation level when the temperature on the PV panel is above 350C. So that there are losses arising in the GTI and there is also a decrease in the PLN network voltage below its nominal voltage which affects the efficiency of the inverter. Furthermore, the current generated by PV is 2 A for the minimum value when it starts working at 6:23 AM while when it stops working it produces a current of 1.74 A at 5:53 AM. Thus, the power generated by the PV depends on the PV current generated [2].

Based on research conducted related to PLTS standards and inverter components for rooftop PLTS in Indonesia. In this research, several PLTS standards related to SPLN were obtained, which based on SPLN also has a protection system that is regulated according to its standards. The availability of inverters in Indonesia that meet applicable standards or certifications is very important to support the progress of rooftop solar systems in Indonesia. Based on the available inverter manufacturers have capacities ranging from <1 kW to 9 kW-10 kW. Judging from the circulation of inverter manufacturers, many have efficiencies between 90% and 95% so that it will benefit customers to use the energy produced by the PLTS [3].

The design of the Building Integrated Photovoltaic (BIPV) On Grid System Power Plant in the Laboratory Renewable Energy Rectorate Building has a power capacity of 14 kWp with supporting equipment, namely solar modules and two inverter units. Based on the design made, it is concluded that the SMA Sunny Tripower 17k inverter can supply 60 solar modules used with the resulting power of 14 kilo watts [4].

II. METHOD/RESEARCH DESIGN

In simplifying the management of the preparation of the discussion in terms of this research, there must be a research preparation or design that is realized through a flowchart. The flow chart is shown as shown on Fig 1.

This research observation was carried out by taking data at the laboratory of the Center for Research and Assessment of New and Renewable Energy (P3EBT) IT PLN West Jakarta and from previous related research studies.

The observation method that includes this analysis can be categorized into fourtopics, namely:

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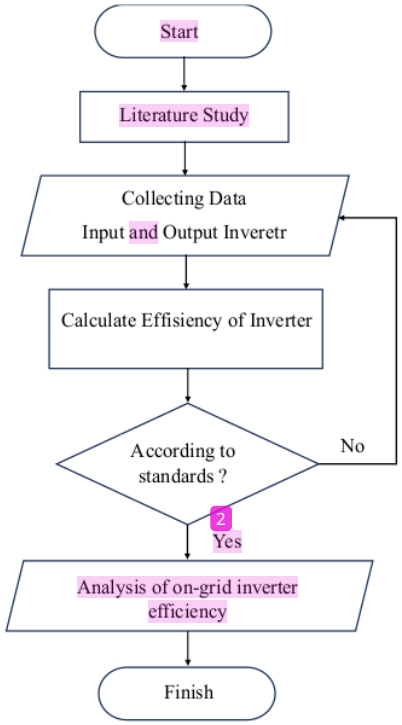

Fig. 1. Research Flowchart

A. *Input and Output Observation of the Inverter*

To get the data to be analyzed, it is done by measuring the inverter output. Output measurements include voltage and current measurements using log data recorded on the inverter.

B. *Inverter Input and Output Power Calculation*

In measuring the inverter output, voltage and current data are obtained, so that a high calculation can be calculated using the formula:

$$P_{input} = Voltage_{DCInput}\ (V) \times Current_{DCInput}\ (A) \quad (1)$$

$$P_{output} = Voltage_{ACOutput}\ (V) \times Current_{ACOutput}\ (A) \quad (2)$$

C. *Efficiency calculation*

The efficiency calculation uses data on the input power and output power of the inverter. The input and output power of the inverter is obtained by multiplying the voltage and current obtained from the voltage and current measurements. So that the efficiency of theinverter can be formulated as a comparison of input andoutput power, namely:

$$\eta = \frac{P_{out}}{P_{in}} x\ 100\% \quad (3)$$

III. Result and Discussion

A. *Sunny Tri Power Inverter Specifications*

The following data is available as input from the sunny tripower 17000TL-10 inverter.

TABLE I. Input Inverter Sunny Tripower 17000TL-10

INPUT	**Standar 17000TL-10**
Max. DC power	17.41 W
Max. input voltage	1000 V
MPP voltage range / rated input voltage	400 V to 800 V
Min. input voltage	150 V / 188 V
Max. input current input A / input B	33 A / 11 A
Max. input current per string input A	33 A
Max. input current per string input B	12.5 A

Based on the above data, the input of the inverter is obtained a maximum standard input of 1000 volts with a maximum power point level that is influenced by the amount of electrical energy generated by the PV module with a minimum input voltage of 150 Volts/188 Volts and a rated MPP (Maximum Power Point) of 400 V to 800 V. There is also an input current according to the 17000TL inverter standard of 33A on strings A and 12.5 A.

TABLE II. Output Inverter Sunny Tripower 17000TL-10

AC OUTPUT	STP 17000TL-10
Rated Power at 230 V, 50 Hz	17000 W
Maximum Apparent AC Power	17000 VA
Nominal AC Voltage	220 V, 230 V, 240 V
Nominal AC Current at 230 V	24.6 A
Rated Power Frequency	50 Hz
AC Power Frequency	50 Hz / 60 Hz
Operating Range at 50 Hz	44 Hz to 55 Hz
Operating Range at 60 Hz	54 Hz to 65 Hz
Power Factor	1
Connection Phases	3

Based on the output table above, the inverter produces minimum and maximum standard data for several output parameters from the inverter. The minimum value of AC current generated starts from 24.6 A and the voltage value is 220 V.

B. *Efficiency of Sunny Tripower Inverter*

Based on the efficiency image of the inverter used, it can be seen that when the efficiency of the inverter starts to approach the maximum output above 90 percent with a voltage range starting from 400V. So we can conclude that this inverter works optimally when the input voltage is close to the range of 400V to 800V.

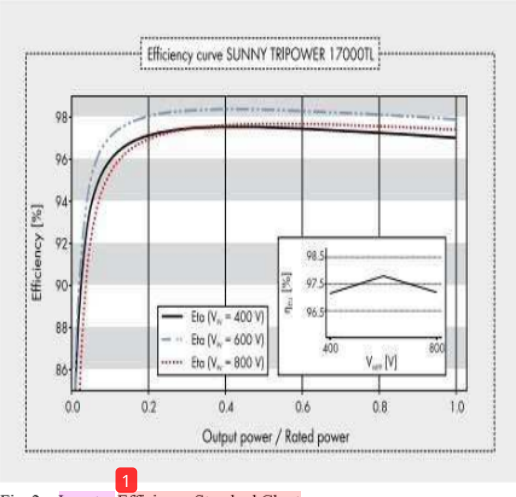

Fig. 2. Inverter Efficiency Standard Chart

C. *PV Irradiation Observation*

TABLE III. PEAK VALUE DATA WEEK 1 JULY 2022

Day	Total Irradiation W/m²
1	852,57
2	1072
3	941,4
4	945
5	1050,42
6	1092,14

Based on the data per month that has been obtained, the amount of irradiation produced by PV has different levels. Where the irradiation produced is the amount of energy in the PV area compared to its surface area. The irradiation parameter itself is carried out in a certain time calculation so that the data obtained starts from hourly, daily, monthly to annual. Based on Table III above, which is about irradiation conditions as input to the inverter. It is recorded that the irradiation level on days 5 and 6 is the best irradiation level according to the Standard Test Condition (STC).

D. *Inverter Input Observation of Decreased Irradiance Condition*

Based on this data, the input and output voltage and current values will be observed when the irradiation level decreases. This will affect the power gain generated by the inverter. The following is the measurement data from the inverter output.

TABLE IV. OBSERVATION RESULTS OF INVERTER INPUT VOLTAGE AND CURRENT IRRADIATION CONDITIONS DECREASED ON JULY 08, 2022

Time (s)	DC Voltage (V)	DC Current (A)	Total Power (W)
08/07/2022 09.15	285	20.4	5814
08/07/2022 09.30	290	22.1	6409
08/07/2022 09.45	312	20.1	6271.2
08/07/2022 10.00	325	22.3	7247.5
08/07/2022 10.10	326	21.1	6878.6
08/07/2022 10.30	331	22.7	7513.7
08/07/2022 10.45	338	21.6	7300.8
08/07/2022 11.00	321	22.4	7190.4
08/07/2022 11.15	343	21.5	7374.5
08/07/2022 11.30	329	21.7	7139.3
08/07/2022 11.45	347	22.8	7911.6

Based on the sample above, it can be seen that the power gain by the inverter is quite small so that the entire power is not supplied by the PLTS system but from the on-grid system connected to the PLN network. Comparison Between Time and Input Voltage and Current can be shown on Fig 3.

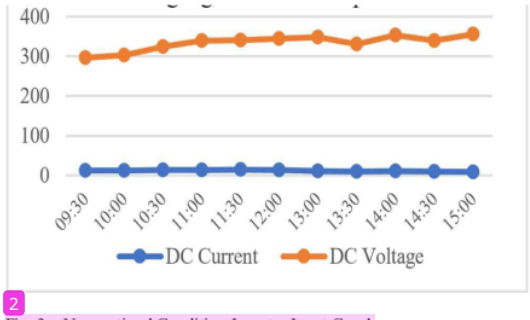

Fig. 3. Non-optimal Condition Inverter Input Graph

Based on the graph it is observed that the input values of both voltage and current are less than optimal for input to the inverter so that the output power of the inverter will be affected. This is due to the weather conditions at that time showing rainfall and also cloudy so that the level of irradiation is quite small which affects the acquisition of DC input current and voltage which affects the output of AC current and voltage from the inverter. Conditions like this can be overcome with the PLTS On Grid system where there is a backup from the PLN distribution network to meet the load requirements in the PLTS Lab.

E. Inverter Input Observation of Optimal Irradiation Condition

TABLE V. OBSERVATION RESULTS OF INPUT VOLTAGE AND INPUT CURRENT OF SUNNY TRIPOWER INVERTER AT STRING 1 AND STRING 2 ON JULY 10, 2022

String 1/ Time (s)	DC Voltage (V)	DC Current (A)	Total Power (W)
10/07/2022 11.30	830.4	13.3	11040.3
10/07/2022 11.45	826.1	14.5	11978.45
10/07/2022 12.00	805.2	14.1	11353.32
String 2/ Time (s)	DC Voltage (V)	DC Current (A)	Total Power (W)
10/07/2022 11.30	842.5	13.2	11121
10/07/2022 11.45	846.7	13.5	11430.45
10/07/2022 12.00	821.7	13.9	11421.63

Based on table V above is the input acquisition data from the inverter when the inverter input conditions are optimal. Sowe can see the data shows the input value has passed 10 kWpfrom the large PLTS configuration of 14 kWp.

From the comparison data in fig.4, namely the current and voltage input to the inverter that when it is above 08:00 the irradiation value increases. This causes an influence on the value of DC current and DC voltage produced by the PV system so that the input to the inverter is optimal and the power produced is quite good as when compared to the calculation of efficiency is above 80% of the resulting power output.

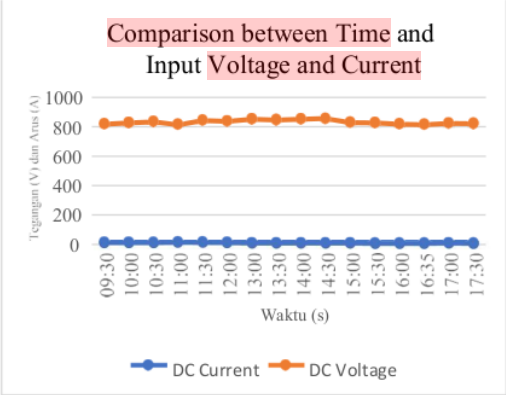

Fig. 4. Comparison Chart Between Time with Voltage and Current on July 10, 2022

F. Observation of Sunny Tripower Inverter Efficiency

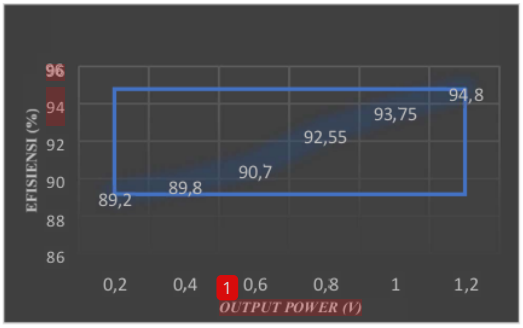

Fig. 5. Inverter Efficiency Chart

Based on the level of efficiency shown from the graph above, it shows that the efficiency level is very good because the efficiency value is above 85% according to the existing standards on the sunny tripower inverter in the PLTS configuration in the PLN IT laboratory. Based on the input and output observation data from the inverter, the efficiency level can be expressed in percentage terms as above. The graph shows the efficiency value when the inverter is in optimal working condition so that the output produced is also very efficient and the power distributed according to the amount of input generated by the PV panel without any interference from the influence of irradiation levels, temperature, shading and so on.

G. Analysis of On Grid Inverter Working System

In this PLTS system, we can see the input and output data from the inverter based on the current and voltage values produced. We can see that at 09:15 the irradiation level is good according to the amount of solar power production of 14 kW, where the total power production is 9.5 kW which is also influenced by several external factors such as the lack of solar radiation so that PV production affects the input to the inverter and the influence of power losses when the inverter converts DC current into AC.

In this inverter we can see where the inverter power production produces a fairly good level of efficiency according to the data calculations above. According to the table of input and output observations, it can be seen that the input value is 9.5 kW while the resulting power output is 8.9 kW. The output of the inverter may not always give a large efficiency or 100% pure to produce the same input power as the output.

TABLE VI. INVERTER PERFORMANCE CONDITION TABLE

Testing Date	Aspects of Inverter Performance Influence	Optimal	Not Optimal
July 08, 2022	Temperature	0	1
	Irradiation Level	0	1
	Input Power	0	1
	Output Power	0	1
	Efficiency	0	1
July 10, 2022	Temperature	1	0
	Irradiation Level	1	0
	Input Power	1	0
	Output Power	1	0
	Efficiency	1	0

H. Effect of Temperature on Inverter Input and Output

TABLE VII. ARRAY TEMPERATURE OBSERVATION ON JULY 10, 2022

TIME S1	T (^{0}C)	*TIME* S2	T (^{0}C)
12:30	34.7	12:30	48.47
13:00	35.84	13:00	50.18
13:30	33.12	13:30	48.47
14:00	31.25	14:00	47.2
14:30	31.01	14:30	47.2
15:00	30.8	15:00	35.34
15:30	29.06	15:30	33.76
16:00	29.07	16:00	29.42

In the log data from the inverter can be analyzed in the form of temperature values obtained by each string in the PLTS system in the PLN IT PLTS Laboratory. Where from the data above we can see that the difference between strings one and two is quite far.

Where in string 1 the temperature value is quite stable according to the standard value of PV which is around 250C, but for the second string has a temperature value that is quite far almost around 70% increase when it is in the middle of the day. In the first string we can see the temperature value at 12:00 around 31.380C while for the second string it is 47.20C quite far from the first string. This causes the data inputted to the inverter as input will also affect the inverter output power value.

IV. CONCLUSIONS

Based on the analysis of observations and calculations that have been carried out to determine the performance of the sunny tripower inverter connected to the PLTS On Grid system, it can be concluded as follows:

a. The on grid inverter performance system connected to the PLN network is used in backing up the power needs of the load in the PLTS laboratory. The inverter used also adjusts the amount of PV output installed. When the inverter input is less than 400V, the inverter will not work because the minimum voltage is still lacking and the work efficiency will not pass 90%. Feasible and inappropriate are adjusted to the specifications of the sunny tripower inverter against the input and output of the inverter.

2. Monitoring based on observations of direct current (DC) current and voltage values has a fairly consistent graph in the results of one day's observation where the average input voltage value ranges from 200 Volts to 800 Volts and also the current is in the range of 11A to 16A. The effect of irradiation level and temperature is very significant in obtaining the value of current and input voltage to the inverter. When the current and voltage are not optimal, the efficiency value of the inverter performance will be below 80%. Therefore, the PLTS On Grid system is very important as a backup power configuration for the consumption of loads connected to the PLTS system in the PLN IT Lab.

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