Power Energy Export Import Metering Performance System On PLTS On Grid In The Laboratory Renewable Energy Institute Of Technology PLN

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***Abstract*—Installation of solar power plants as of September 2019 there were 1,435 PLTS installed with details of approximately 800 new PLN consumers since the policy on power plant was launched in December 2018. PLTS is a variant of Renewable Energy utilization made from the Government so that the utilization of Renewable Energy, especially for solar power, continues to increase. This study aims to determine the performance of the EXIM kWh meter system configured on the PLTS in the EBT Laboratory of IT - PLN, determine the power used in the load in the Laboratory with the installation of the EXIM kWh Meter Configured on the PLTS, and determine the cost of electricity bills and efficiency with the utilization of kWh EXIM in the PLN Institute of Technology Laboratory. While the research method is quantitative. The results of this study are the production of PLTS power installed in the Renewable Energy IT - PLN laboratory, not all of the power produced will be sent or exported to PLN, where some of the power that is not exported will supply to the load in the Renewable Energy IT - PLN laboratory. From the data obtained, the average percentage of savings per month in 7 months is about 13%. If the total average power is converted to Rp. 1,423,830 and if the total kWh usage is converted to Rp. 811,15 and provides savings on monthly electricity bills of around Rp. 612,673. The total production generated for 7 months from December 2020 - June 2021 is 53% of the total power production of this solar power plant which is imported to PLN and with this efficiency is good so that it can save tariff bills cost.**

Keywords— Power, Solar PV, kWh meter, export - import, On Grid

I. Introduction

Nowadays, there are so many electricity users in Indonesia or PLN (State Electricity Company) consumers with types of household customers [1-3], office businesses, government, and industry that use Solar Power Plants (PLTS). The installation of PLTS as of September 2019 there were 1,435 PLTS installed with details of approximately 800 new PLN consumers since the policy on PLTS was launched in December 2018. PLTS is a variant of EBT utilization made by the Government so that the utilization of EBT, especially for solar power, continues to increase [4].

There are several installation systems for PLTS with the Off Grid system, in which the installation is not connected to PLN but the storage of the power generated by the PLTS is stored in batteries, and On Grid, in which the installation is connected to PLN without storing power but can send excess power generated by PLTS so that any surplus can be used later [5]. Off Grid and On Grid each have different functions and installation applications, but in terms of utilization it is still the same as the Off Grid system which utilizes solar energy which is converted through solar panels into electrical energy, the difference between the two systems is that the Off Grid system is not directly connected to PLN [6].

The use of PLTS in households, businesses, offices, government, or industry aims to save / reduce electricity bills and can open the role of the community in the utilization and management of new and renewable energy [7]. The PLTS system if using an On Grid system with solar panels or PV (Photovoltaic) installed on the roof of the building, inverters, protection panels, kWh Expor Import (EXIM). In Indonesia, the use of EXIM kWh meters has been regulated in the Ministry of Energy and Mineral Resources (ESDM) regulations with PLN as the electricity utility network provider.

PLN customers without the installation of PLTS, the kWh meter used is the usual kWh meter in general only measures the power that has been used, in contrast to PLN customers with the installation of PLTS on kWh meters using kWh meters Export Import (EXIM). kWh meter EXIM is a device or energy counting device just like a regular kWh meter that distinguishes from kWh meters in general with kWh meter EXIM is kWh meter EXIM can receive / import from the power sent by PLN and send / export more power generated by the PLTS network system then sent to PLN and then reduce the cost of electricity bills [9]. Although the installation of PLTS using EXIM kWh meters is very helpful in reducing the cost of electricity bills, not so many Indonesians have switched to using EXIM kWh meters, because the cost of installing PLTS is not affordable for Indonesians whose economy is not yet adequate. Based on this research, several problems can be formulated which will be discussed as follows:

1. How is the performance of the export import energy power system configured on the PLTS at the PLN Institut of Technology Laboratory Renewable Energy.

2. What is the energy power used in the load at the Laboratory with the export import system configured on the PLTS.
3. What is the cost of electricity bills and efficiency with the utilization of the export import system at the PLN Institut of Technology Laboratory.

The objectives to be achieved in this research are as follows:

1. Knowing the performance of the energy export import power system configured on the PLTS in the Renewable Energy Laboratory of the PLN Institute of Technology.
2. Knowing the amount of energy power used in the load in the Laboratory with the configured export import system on the PLTS.
3. Knowing the cost of electricity bills and efficiency with the utilization of the export import system at the PLN Institut of Technology Laboratory Reneweble Energy.

The benefits of research include This research is expected to increase knowledge about how to analyze the performance of the energy export import power system configured on the PLTS in the Institut Technology PLN Renewable Energy Laboratory and get the opportunity to analyze problems in the field based on the theory of reference materials [10]. In addition, the benefit of this research is that it can be used as reference material for future research.

II. Research Method/Design

A. Research Methods

The location of this research was only carried out in 1 place which took place at the Renewable Energy Laboratory of the IT - PLN Jakarta campus on the 14 kWp On - Grid PLTS. Where the location of the IT - PLN campus is at the PLN Tower, Jl. Lingkar Luar Barat, Duri Kosambi, Cengkareng, West Jakarta City, Jakarta Special Capital Region.

B. Data Analysis Methods

1. Planning stage

In this planning stage, the place that will be used to conduct research is in the Renewable Energy IT PLN Jakarta laboratory and as for the research tools, namely in the form of several inverters with an on-grid system [11].

2. Implementation stage

At the implementation stage we can test the inverter with the ongrid system, the ongrid inverter test is divided into two tests, namely:

a. Load data collection at the Renewable Energy IT PLN Jakarta laboratory
b. Data collection to PLN kWh usage in the Renewable Energy laboratory IT PLN Jakarta

3. Evaluation Stage

At this evaluation stage we can analyze the tests that have been carried out, at this evaluation stage there are several components that can be analyzed including:

a. Analysis of the production of PLTS energy power distributed to the load
b. Analysis of the use of energy power in the IT laboratory – PLN
c. Analysis of export - import energy power.

To conduct research on the "Power Energy Import Export Performance System on PLTS On Grid at the EBT Laboratory of the PLN Institute of Technology" for the flowchat like the following figure:

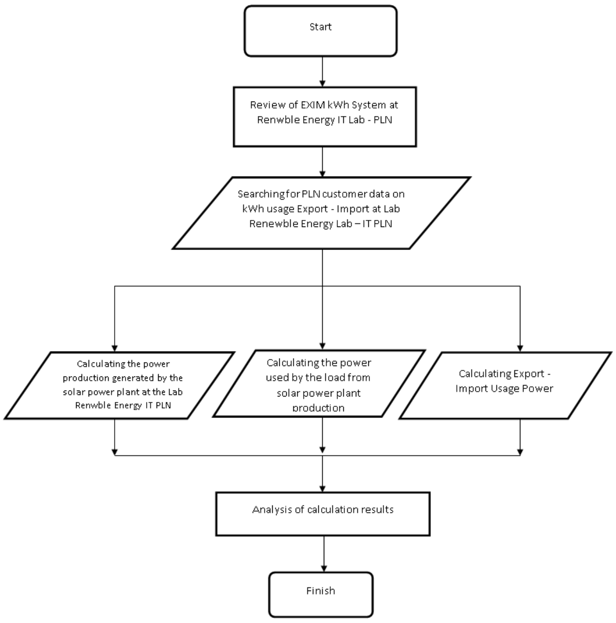

Fig. 1. On Grid Inverter Technology Research Flow Diagram

III. Result and Discussion

A. PLTS System On Grid Renewable Energy Laboratory IT - PLN

The Laboratory Renewable Energy Solar Power Plant - PLN has been operating since 2017 with a capacity of 15 KWp on-grid with a network from PLN. During the 4 (four) years of operation, it has produced energy of around 49 MWh used for self-use and sold to PLN through an export-import kWh meter.

The power generated at the Solar Power Plant comes from 60 photovoltaic modules with the capacity of each module is 260 Wp The output of the photovoltaic module is direct current so it uses a Sunny Tri Power Inverter which can produce 3-phase alternating current which is connected directly to the load for self-use and the PLN network [12].

TABLE I. Total Power Production of Solar Power Plant From 2017-2021

Year	MW
2017	7,415,992
2018	17,108,585
2019	11,780,821
2020	7,595,551
2021	5,351,740
Total	49,252,689

B. Single Line Diagram of IT Laboratory – PLN

In the single line diagram there is a collection of several photovoltaic modules with a capacity of one photovoltaic module of 260 Wp where there are 4 strings. In each 1 string there are 24 photovoltaic modules arranged in series which are then paralleled and enter the sunny tri power inverter. The sunny tri power inverter has two direct current inputs and then converts them into 3-phase alternating current. Before entering the connection box there is a circuit breaker to break the circuit when there is a short circuit on the network [13]. Inside the connection box there is a distribution of flow to the load for self-use and connected to the PLN network through an export-import kWh meter. If the load cannot be supplied by the PLTS, the PLN network can help supply the load through the export-import KWh meter. So that there is no blackout when the energy production from the PLTS does not meet the needs of the load.

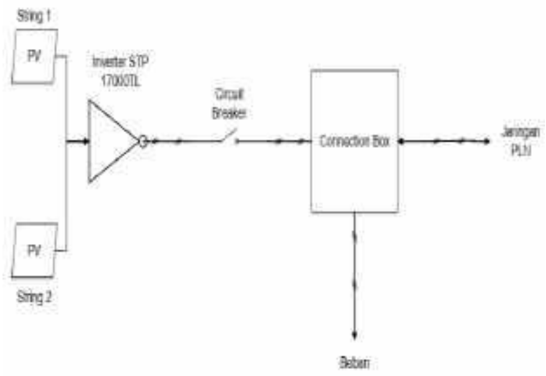

Fig. 2. Single Line Diagram

C. Specification of 260 Wp PV Module

To generate power in solar power plants, the main component used is the photovoltaic module. Photovoltaic module is a device that can convert solar energy into electrical energy using the photoelectric principle. Especially for the 14 KWp solar power plant in the Renewable Energy IT - PLN laboratory, one of them uses 260 Wp photovoltaic modules with polycrystalline silicon type as in table II. This specification is based on standard test conditions with irradiation of 1000 W/m^2, Module Temperature 25°C.

TABLE II. 260 WP PHOTOVOLTAIC SPECIFICATIONS

STC	Modul Fotovoltaik 260 Wp
Maximum Power (Pmax)	260 W
Power Tolerance	0/+5 W
Optimum Operating Voltage (Vmp)	30.9 V
Optimum Operating Current (Imp)	8.42 A
Open Circuit Voltage (Voc)	37.7 V
Short Circuit Current (Isc)	8.89 A
Maximum System Voltage	1000 Vdc
Solar Cell	Polycrystalline Silicon
No. Of Cell	60 (6 x 10)
Dimension of Cell	156 mm X 156 mm
STC : Irradiance 1000 W/m^2, Module Temperatur 25^{0}C dan AM = 1.5	

D. Inverter On Grid 17 kw PV Module

Electrical energy in solar power plants comes from photovoltaic modules [14]. The output of the photovoltaic module is direct current, so an inverter is needed to convert direct current into alternating current. The sunny tri power inverter is a device that can convert direct current to alternating current 3 phases with the same power for each phase.

Fig. 3. Inverter Ongrid 17 kw at Lab RE IT PLN

TABLE III. ON GRID INVERTER SPECIFICATIONS INPUT

DC INPUT	STP 17000TL-10
Maximum DC Power	17.41 W
Maximum Input Voltage	1000 V
MPP Voltage Range	400 V to 800 V
Minimum Input Current, Input A	33 A
Maximum Input Current, Input B	11 A
Maximum short – circuit current, Input A	50 A
Maximum short – circuit current, Input B	17 A

TABLE IV. ON GRID INVERTER SPECIFICATIONS OUTPUT

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

E. EXIM EDMI MK10E KWh Meter Specifications

To calculate the measurement of power used in the Renewable Energy laboratory of the PLN Institute of Technology or arguably be able to record power usage for a month or a year, namely using a kWh Meter. The kWh meter used in the Renewable Energy Laboratory of the PLN Institute of Technology is a type of kWh Export - Import, this kWh can receive power sent from PLN and send more customer power to PLN. KWh type is the type of EDMI MK10E.

Fig. 4. Exim MK10E kWh specifications

F. PLTS Power Production is Distributed to the Load

In Indonesia, especially the capital city of DKI Jakarta, the potential for solar power plant energy is very abundant and endless because it comes from the sun and is on the equator. Installation of an on-grid solar power plant at the PLN Institute of Technology laboratory with a capacity of 15 kWp. The data monitored includes the energy production generated to the load during December 2020 - June 2021.

TABLE V. ENERGY DISTRIBUTED TO THE LOAD FROM PLTS ON DECEMBER 2020 - JUNE 2021

Month	Total Energy Usage (kWh)
December 2020	538.59
January 2021	214.96
February 2021	515.86
March 2021	532.6
April 2021	537.32
May 2021	485.37
June 2021	142.61

In the production of solar power plants installed in the Renewable Energy IT - PLN laboratory, not all of the power produced will be sent or exported to PLN, where some of the power that is not exported will supply to the load in the Renewable Energy IT - PLN laboratory.

The installation of PLTS in this laboratory has obtained the amount of electrical energy production from solar power plants with a capacity of 15 kWp, the data obtained in monitoring includes PLTS production generated during December 2020 - June 2021. [15] The following is a table and graph of the energy results obtained by PLTS.

TABLE VI. TOTAL PRODUCTION DECEMBER 2020 - JUNE 2021

No	Month	Energy Generated per month (kWh)
1	December 2020	980.69
2	January 2021	746.38
3	February 2021	857.45
4	March 2021	978.75
5	April 2021	984.48
6	May 2021	967.77
7	June 2021	652.01
Total		6,167.55

From Table VI above, it can be seen the amount of PLTS energy production for 7 months where the lowest production is lowest in June 2021 and the highest in December 2020, of course, there are many factors that affect production every month.

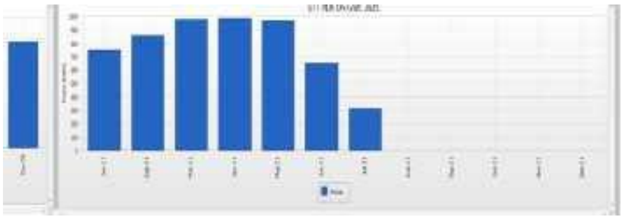

Fig. 5. Energy Production Chart

From Figure 5, it can be seen the amount of PLTS energy production in the IT - PLN laboratory in 7 months December 1, 2020 - July 30, 2021 where in a year, the energy yield is not stable, namely where the lowest production is on June 2021 and the highest is April 2021, of course there are many factors that can affect the difference from each month.

The highest monthly energy data profile in April 2021 can be seen that the peak energy obtained is very high regardless of the good weather and also a good system, so obtained in April can be considered optimal. It can be seen from the graph above that the monthly production reached 984.48 kWh.

The lowest monthly energy data profile in June 2021 can be seen that the peak energy obtained is very low, it is obtained in June which is arguably is not optimal. It can be seen from the graph above that the monthly production reached 652.01 kWh.

In the Installation of Solar Power Plants used in IT laboratories - PLN has power production results every month and will be sent to PLN every month according to PLN calculations. The following data is exported from the IT - PLN laboratory PLTS to PLN [16].

TABLE VII. IMPORTED ENERGY PRODUCTION TO PLN

Time		Import	
Month	Day	Total Monthly (kWh)	Average per day (kWh)
Dec-20	31	442,090	14,261
Jan-21	31	531,420	17,143
Feb-21	28	341,590	12,200
Mar-21	31	447,160	14,425
Apr-21	30	470,270	15,676
May-21	31	481,400	15,529
Jun-21	30	509,400	16,980

The average imported energy is 243,223 kWh/month

In the PLTS on grid installation system using kWh EXIM, it also gets a supply of shipping power from PLN every month. The following is a table of imported power received by the IT laboratory – PLN.

TABLE VIII. EXPORTED ENERGY FROM PLN

Time		Export	
Month	Day	Total Monthly (kWh)	Average per day (kWh)
Dec-20	31	1,872.84	60.41
Jan-21	31	1,409.84	45.47
Feb-21	28	1,667.85	59.56
Mar-21	31	1,414.03	45.61
Apr-21	30	1,648.30	54.94
May-21	31	1,594.67	51.4
Jun-21	30	1,447.15	48.23

The average exported energy is 1,576.34 kWh/month

In the IT-PLN EBT Laboratory, there is power that will be supplied to the load to power electronic components and equipment in the IT-PLN laboratory. The power supplied to the Renewable Energy IT - PLN laboratory load. Estimated total laboratory energy power for one month:

75,304 Wh X 30 Days = 2259120 Wh = 2259.12 kWh

So the total estimated power used to supply loads in the laboratory for 1 month is 2259.12 kWh. Then the following solid table will display data on the energy power supplied to the load used for 7 months from December 2020 - January 2021.

G. *Energy Power Export & Import*

Renewable Energy Laboratory IT - PLN with S2 tariff customer group with the installed PLTS capacity is 16,500 VA with the reference electricity tariff used is production for 1 year. If a PT PLN customer who installs PLTS with PLTS ownership status in the EBT IT - PLN laboratory, the calculation of export - import of electric power with the On - Grid system to the PLN network, the rules according to Permen ESDM NO. 49 of 2018 Chapter III article 6 paragraph 1, namely "the electric energy of PLTS customers with the status of ownership of PLTS in the EBT IT - PLN laboratory". 49/2018 Chapter III article 6 paragraph 1, namely "the exported electrical energy of rooftop PLTS customers is calculated based on the export kWh value recorded on the EXIM kWh meter multiplied by 65% (sixty-five percent)".

TABLE IX. EXPORT - IMPORT KWH CONSUMPTION

Month	Total Consumption (kWh)	Total Export Usage (kWh)
Dec-20	0	1,872.84
Jan-21	0	1,409.84
Feb-21	1,446	1,667.85
Mar-21	1,123	1,414.030
Apr-21	1,342	1,648.3
May-21	1,282	1,594.670
Jun-21	1,116	1,447.150
Average per years (kWh)	0.837833	1,576.34

It can be calculated how much energy saving efficiency is produced by PLTS in December 2020 - June 2021.

a. Energy consumption (Rp) = kWh Consumption X PLN tariff
b. Energy Export consumption (Rp) = Export kWh Consumption x PLN tariff
c. Efficiency = ((Energy Export – Energy Consumption)/Energy Export) x100%

TABLE X. SAVING OF EXPORT & IMPORT POWER CONSUMPTION

Month	Consumption (Rp)	Export (Rp)	Saving
Des-20	Rp. 0	Rp. 1,685,556	1%
Jan-21	Rp. 0	Rp. 1,268,856	1%
Feb-21	Rp.1,301,400	Rp. 1,501,065	13%
Mar-21	Rp.1,010,700	Rp. 1,501,065	32%
Apr-21	Rp.1,207,800	Rp. 1,272,627	1%
Mei-21	Rp.1,153,800	Rp.1,435,203	19%
Jun-21	Rp.1,004,400	Rp.1,302,435	22%
Average	Rp. 811,157	Rp. 1,423,830	13%

From the data obtained, the average percentage of savings per month in 7 months is around 13%. If the total average power of imports is converted into Rp. 1,423,830 and if the total kWh usage is converted into Rp. 811,157. If you look at the table in December 2020 - January 2021, kWh usage is 0 kWh because the PLN system will be stimulated and will be 0 at the end of the year and the beginning of the year.

The production of power generated from the Renewable Energy IT - PLN laboratory plts will be exported to PLN to reduce the payment of costs which will later be calculated by PLN. [17] The power generated from the production of this solar power plant is not entirely exported. The following is the Efficiency table data.

TABLE XI. EXPORT & IMPORT POWER CONSUMPTION EFFICIENCY

Month	Power Import (kWh)	Power Production (kWh)	Effisiensi
Des-20	442.09	980.686	45%
Jan-21	531.42	746.383	71%
Feb-21	341.59	857.454	39%
Mar-21	447.16	979.759	45%
Apr-21	470.27	984.48	47%
Mei-21	481.4	967.771	49%
Jun-21	509.4	652.016	78%
Average			53%

H. *Analisis Daya Energi Export – Import*

This is the real export data from PLN sent from the production of solar power plant power to PLN. From the data generated by PLN, this is the imported power absorbed by PLN. In sending this imported power, not every month the amount of power sent is the same.[19] The difference in the amount of power sent there are factors that influence not only the size and size of solar irradiation but, rather, excessive load usage causes little imported power, such as in January 2021 the highest imported power to PLN was 531,420 kWh [18].

From the data table 11. this is data from PLN which shows the amount of kWh usage which will be summed up with the S2 customer tariff of Rp. 900 and shows the total kWh export usage which will be totaled with the customer tariff of Rp. 900. From the data obtained, the average percentage of monthly savings in 7 months is around 13%. If the total average export power is converted to Rp. 1,423,830 and if the total kWh usage is converted to Rp. 811,157. Reduced electricity costs every month provide savings for the IT EBT Laboratory - PLN. then with the installation of kWh EXIM greatly provides savings on the cost of electricity bills per month around Rp. 612,673.

The power production generated by the solar power plant in the EBT IT - PLN laboratory will be exported by PLN but not all of the production results will be sent or imported to PLN because it will be calculated by PLN where the PLN calculation of the imported power is seen from the use of power in the laboratory, for example if the load is used a lot and the power generated by this production cannot exceed the power used by the load then the exported power will be small but PLN will send power or export power that is sufficient for the load at that time.[20] When viewed from the data in Table XI, the average efficiency of imported power with power production is 53%. So it can be said from this average efficiency that the total production generated for 7 months from December 2020 - June 2021 is 53% of the total power production of this solar power plant which is imported to PLN and with this efficiency is good so that it can save tariff bills cost.

IV. Conclusions and Suggestion

From the results of data observations that have been processed, the work of the kWh meter export - import (EXIM) is on the exported power from the power generation product of solar power plant and the imported power sent from PLN will cover the existing load in the laboratory.

From the data obtained, the average percentage of savings per month in 7 months is about 13%. If the total average power is converted to Rp. 1,423,830 and if the total kWh usage is converted to Rp. 811,15 and provides savings on monthly electricity bills of around Rp. 612,673.

The total production generated for 7 months from December 2020 - June 2021 is 53% of the total power production of this solar power plant which is imported to PLN and with this efficiency is good so that it can save tariff bills cost.

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