Design for Application of Solar Power Plant in the Faculty of Engineering Mulawarman University

Indra Nusantara, Nur Rani Alham(✉), Happy Nugroho, Muslimin, and Restu Mukti Utomo

Department of Electrical Engineering, Mulawarman University, Samarinda, Indonesia
nurrani.alham@ft.unmul.ac.id

Abstract. This research will discuss regarding the design of implementing Solar Power Plants (PLTS) through technical analysis with two systems, namely, the On-Grid system and the Off-Grid system. In addition, it will discuss economic analysis using the Net Present Value (NPV), Profitability Index/Benefit Cost Ratio (BCR) and Payback Period (PP) methods. Mulawarman University which is one of the universities in Indonesia Samarinda City, East Kalimantan. The population in the city of Samarinda is also not less than other big cities. So that Samarinda has a high level of electricity demand as well. Besides that, the power plants in Samarinda still rely on fossil fuel generators such as oil and coal. Likewise, the source of electrical energy at Mulawarman University obtained from PLN and does not yet have an alternative source of electrical energy that is friendly to the environment, including the Faculty of Engineering Building. One of the potential power plants that can be used/applied by Mulawarman University is PLTS which converts electromagnetic energy from sunlight into electrical energy.432.4 kW. The data will be analysed further, so that the data the results of this study are data in the form of a description of the components of the PLTS On-Grid system and the PLTS Off-Grid system, a description of the feasibility of investing in the use of PLTS On-Grid and the PLTS Off-Grid system using economic analysis with the NPV, BCR and PP methods as well as comparisons. Calculation results from technical analysis and economic analysis of the two PLTS systems in the new lecture building of the Faculty of Engineering, Mulawarman University.

Keywords: Economic Analysis · Technical Analysis · Solar Power Generation (PLTS)

1 Introduction

Fossil energy in the form of fuel oil and LPG gas that has been used so far, its reserves are getting less and less. Even nationally, Indonesia has imported fuel oil and LPG gas. For this reason, it is necessary to replace energy that is more environmentally friendly and available in Indonesia, including coal methane gas, hydropower, biomass, solar power and others. For this reason, the policy on the use of new and renewable energy is a

T. D. Larasati et al. (Eds.): ICTROPS 2022, ABSR 31, pp. 64–79, 2023.
https://doi.org/10.2991/978-94-6463-180-7_10

priority in energy management. There are 9 (nine) strategies to increase the use of new and renewable energy, one of which is; increasing the use of solar energy with the PLTS Development program (PDPKT Number 8, 2019) [1].

There is potential and the use of Solar Power Plants (PLTS) by the Government of Indonesia is not optimal from the potential that can be generated and with the Paris Aggregate agreement which states that the increase in the earth's temperature must be controlled by 2C, in which Indonesia promises to reduce greenhouse gas (GHG) emissions (mitigation) by 29% compared to Business as Usual (BAU) and with an additional 12% to 41% with international assistance in 2030 (PDPKT Number 8, 2019) [1].

In 2017, the utilization of new renewable energy only reached about 2% of the total potential of new and renewable energy (EBT). This potential becomes the basis for the NRE development plan and becomes a priority for the utilization of national energy resources which must lead to the main goal of KEN 2050, namely "National Energy Independence and Security". So that the portion of NRE is at least 23% of the total primary energy mix in 2025 and at least 31% of the total primary energy mix in 2050 [2]. To achieve independence and national energy security, energy development priorities are based on four principles, one of which is "maximizing use of renewable energy by taking into account the economic level" (PPRI Number 22, 2017) [3].

Indonesia has a geographical advantage because it is located in the tropics and is crossed by the equator where the radiation intensity is higher than other areas, which is 4.66–5.54 kWh/m^2 per day, this is one of the best to be used as PLTS on a good scale small-medium and medium-upper [4]. Among the many regions, East Kalimantan is a province known for its diverse potential energy sources. Potential energy sources in East Kalimantan Province in 2015 came from renewable energy, namely solar power which converts electromagnetic energy from sunlight into electrical energy of 13,479 MW (PDPKT Number 8, 2019) [5].

The city of Samarinda is one of the largest cities in East Kalimantan, which is not less populated than other big cities. So that Samarinda has a high level of electricity demand as well. Besides that, the power plants in Samarinda still rely on fossil fuel generators such as oil and coal [6]. In the management of regional energy, especially in the implementation of policies, strategies, and programs related to regional energy that have been determined, it will involve government agencies and stakeholders in accordance with their respective duties and functions, one of which is: State Universities (PDPKT Number 8, 2019) [7].

Currently, the main source of electrical energy for Mulawarman University is obtained from PLN and does not yet have an alternative source of electrical energy that is friendly to the environment, including the Faculty of Engineering building. Seeing the situation, conditions, and data described above are also in line with the UNMUL PIP (Principal Scientific Patterns at Mulawarman University). One of the potential power plants that can be used/applied by Mulawarman University is the Solar Power Plant (PLTS) which converts electromagnetic energy from sunlight into electrical energy. PLTS itself has 2 systems, namely the On-Grid system and the Off-Grid system [5].

2 Methods

2.1 Research Location

The time of the research was carried out from August to October 2022 and the place where this research was carried out will be in a new building, namely the lecture building of the Faculty of Engineering, Mulawarman University, which is located in Jl. Sambaliung, Sempaja Sel, Kec. North Samarinda, Samarinda City, East Kalimantan 75242.

2.2 Research Material

The materials and tools in this research are divided into two, namely technical analysis and economic analysis. Technical Analysis requires data in the form of electricity consumption in buildings lectures and laboratory buildings of the Faculty of Engineering to calculate the use of components in PLTS. While the Economic Analysis requires data in the form of electricity sales rules from kWh which are converted into Rupiah to calculate how many Rupiahs PLTS can produce.

2.3 Research Procedures

See Fig. 1.

2.4 Data collection

The materials and tools in this research are divided into two, namely technical analysis and economic analysis. Technical Analysis requires data in the form of electricity consumption in buildings lectures of the Faculty of Engineering to calculate the use of components in PV mini-grid. While the Economic Analysis requires data in the form of electricity sales rules from kWh which are converted into Rupiah to calculate how many Rupiahs PLTS can produce [8].

Data collection is done by taking data on electricity usage on a new building at the Faculty of Engineering, Mulawarman University.

2.5 Data Analysis

Data analysis technique is an activity to process data that has been obtained, then used to obtain conclusions from research conducted and can be accounted for (Fig. 2).

3 Result and Discussions

3.1 Data Retrieval

a. Data collection on electricity usage is done by looking directly at the power meter installed in the new lecture building of the Faculty of Engineering.

   From the data in Table 1, the electricity usage in the New Lecture Building, Faculty of Engineering, Mulawarman University, is: 10377.6 kWh.

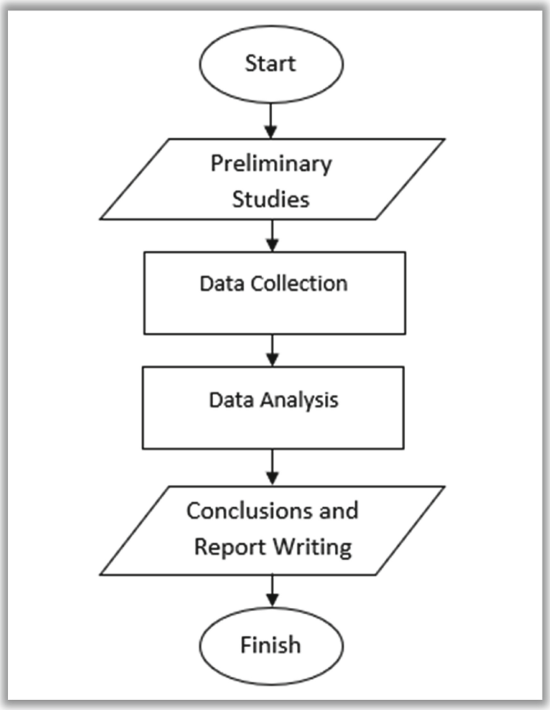

Fig. 1. Flowchart Research Procedures

Table 1. Electricity Usage for New Lecture Building

No.	New Lecture Building	Electrical Power Consumption (kWh)
1.	Data collection date	Total electricity consumption
Total		

b. Solar irradiation data retrieval is viewed through the Solargis application by entering the PLTS installation location plan. After that, the data can be seen how much the value of solar irradiation is in the area of the Faculty of Engineering, Mulawarman University.

   From the results of checking solar irradiation using the Solargis application, it can be seen in Figure 3 Direct Normal Irradiation (DNI) solar irradiation at the Faculty of Engineering, Mulawarman University, worth 2,574 kWh/m^2 per day.

c. Data collection of PLTS electricity sales into Rupiah (kWh/Rp) can be seen in the General National Energy Plan (RUEN) with the following details:

d. The Bank's interest rate value used is the interest rate value of Bank Kaltimtara considering the implementation plan for PLTS installation is located in East Kalimantan Province, with details as follows:

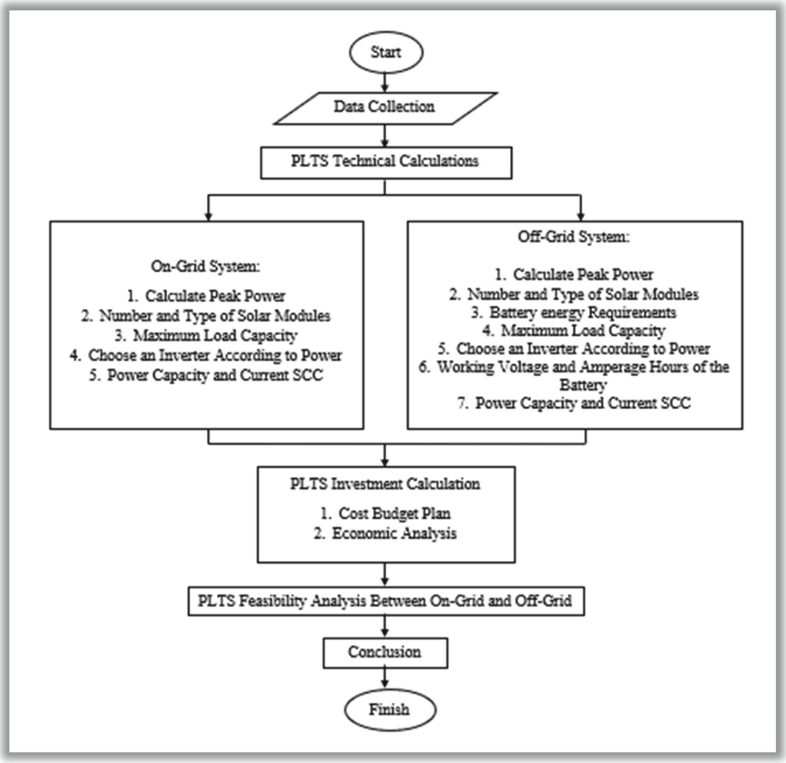

Fig. 2. Flowchart Data Analysis

Table 2. Electricity Usage for New Lecture Building

No.	New Lecture Building	Electrical Power Consumption (kWh)
1.	August 5^{th}	432.4 kW × 24 h = 10377.6
Total		**10377.6**

In accordance with the data in Figure 4 the interest rate that will be used in determining the economic analysis on the Net Present Value (NPV) method is 8.59% (Tables 2 and 3).

3.2 Data Calculation

Data calculation and technical discussion consists of several steps including calculation of PV mini-grid components, such as; Solar Module, Inverter, Battery, and Solar Charge Controller (SCC) [9].

1. Peak power of PV mini-grid installation site

Fig. 3. Solar Irradiation in the Faculty of Engineering

Table 3. Cost of National Electricity Supply

No	NRE	
	Generator	**Price (Rp/kWh)**
1.	PLTS	8,786
2.	PLTP	1.058
3.	hydropower	388

Korporasi	Retail	Mikro	Konsumsi	
			KPR	Non KPR
8.59	8.27	8.27	8.59	7.95

Fig. 4. Bank Kaltimtara Interest Rate Value

The following is the calculation to determine the peak power of the PLTS installation location:

$$\text{kW (peak) PLTS} = \frac{\boldsymbol{kWh}}{\boldsymbol{Daily\ Average\ Irradiation}}$$

$$= \frac{\mathbf{10377,\ 6\,kWh}}{\mathbf{2.574\,kWh/m^2}} = 4.03\,\text{kWp}$$

The above calculation results need to be added with 15%–25% as system losses. Thus, the peak power value after adding system losses is 4.63–4.83 kWp.

2. Number and types of Solar Modules
   To calculate the number of Solar Modules using the formula, as follows:

$$\text{Number of Solar Modules} = \frac{\textit{Solar Module Peak Power (total Wp)}}{Wp/modul} = 19.32\ \text{units}\frac{4830\ \text{Wp}}{250\ \text{Wp}}$$

From the above calculation results obtained a value of 19.32 then the need for solar modules used is a total of 20 units. After obtaining the number of Solar Modules to be installed with specifications of 250 Wp/Module, then you can determine the type of solar module that will be used according to the specifications that have been determined. So, the types of Solar Modules that will be used are as shown in Table 4.

3. Maximum load power capacity (Wmax)
   Calculating the maximum load power (Watts) can be seen through the power meter in each building. The number of details of the maximum load in each building, as shown in Table 5.

From the data in Table 5, it can be calculated the maximum total load on the New Lecture Building, Faculty of Engineering, Mulawarman University, namely:114,900 W.

4. Selecting Inverter according to power

Table 4. Specifications of Solar Module Sunny 250 Wp

Specification	**Information**
Brand	Sunny
Rated Maximum Power (Pmax)	250 Wp
Open Circuit Voltage (Vocs)	37.2 V
Short Circuit Current(isc)	9.00 A
Voltage at Pmax(vpm)	30.0 V
Current at Pmax(imp)	8.34 A
Weight	21.0 kg
Dimension(mm)	1640 × 992 × 40

Table 5. Total Maximum Power of New Lecture Building

No.	**Building Name**	**Maximum Power (Watts)**
1.	New Lecture Building	114.9 kW × 1000 = 114,900 W
Total		114,900 W

In calculating and selecting the inverter, the maximum total load data will be used. However, in this calculation, the researcher divides the calculation per floor in each building [10]. Considerations for choosing an inverter according to the required power is calculated using the following formula:

$$\text{Inverter Capacity (Watts)} = \text{Wmax} + (25\% \times \text{Wmax}).$$

$$\begin{aligned}\text{Inverter Capacity (Watt)} &= \text{Wmax} + (25\% \times \text{Wmax}) \\ &= 114,900\,\text{W} + (25\% \times 114,900\,\text{W}) \\ &= 114,900\,\text{W} + 28,725\,\text{W} \\ &= 143.625\,\text{Watt}\end{aligned}$$

From the results of the above calculations, an inverter with a capacity of 5000 W can be selected. Then calculate the number of inverters used using the formula, as follows:

$$\begin{aligned}\text{Number of Inverters} &= \frac{\boldsymbol{Inverter\ Capacity\ Requirements}}{\boldsymbol{Selected\ Inverter\ Capacity}} \\ &= 28.72 = 29\ \text{Units}\frac{\mathbf{143.625\ Watt}}{\mathbf{5000\ Watt}}\end{aligned}$$

From the results of the above calculations, it can be seen that the number of inverters used in the new Engineering Faculty Building is 58 units. Inverter specifications, as shown in Table 6.

5. Energy Requirement from Battery

   In calculating the energy requirements of the battery, the data required is the number of days of autonomy, which is determined based on cloud conditions in the local area. The number of days of autonomy for the City of Samarinda, East Kalimantan Province is 2 days of autonomy. The formula used, as follows:

$$\begin{aligned}\text{Battery Requirement} &= \text{Total daily energy (Wh)} \times \text{Autonomy Day} \\ &= 114,900\,\text{Wh} \times 2 \\ &= 229,800\ \text{Wh}\end{aligned}$$

6. Working Voltage and Ampere Hour (AH) Battery

   The data needed to determine the working voltage and calculate the Ampere Hour (AH) of the battery are the specifications of the battery and inverter, as well as the energy requirements of the battery which have been calculated in the steps above. Battery specifications can be seen, as shown in Table 7.

The specifications that must be known are 12 Vdc voltage, 200 Ampere Hour (AH), and 80% DOD Battery. The calculation can be seen in the formula, as follows:

$$\text{Number of Battery Series} = \frac{\boldsymbol{System\ Working\ Voltage(Vdc)}}{\boldsymbol{Battery\ Unit\ Operating\ Voltage(\ Vdc)}}$$

Table 6. Inverter Specifications

Specification		**Information**
Product	Model	NXi 150
	Type	*Single Phase Inverter*
	Capacity	5000 W
*Input*DC	*Max*DC Power	6000 W
	*Max*DC Voltage	600 V
	*Full Power*MPPT Voltage Range	180–500 V
	*Operating*MPPT Voltage Range	100–500 V
	*Max Useable Input Current*per MPPT	10 + 18 A
*Input*air conditioning	DC Injection Current	<20 mA
	*Rated*AC Power	5000 W
	*Max*AC Power	5000 W
	Max Overcurrent Protection Device	30 A
	*Max*AC Current	23.8 A
	Nominal AC Voltage/Range	220/230/240/180–270 (adjustable)
	Grid Frequency/Range	50 (47–52)/60(57–62) Hx
Efficiency	*Max. Efficiency*	97.8%
	MPPT Accuracy	>99.9%
Physique	*Dimension*(mm)	339 × 565 × 172
	Weight (Kg)	17.5

$$= \frac{\mathbf{48\ Vdc}}{\mathbf{12\ Vdc}}$$
$$= 4\ \text{Series}$$

$$\begin{aligned}&\text{Number of Battery Parallels}\\&= \frac{\textbf{\textit{Energy equirements From the Battery (Wh)}}}{\textbf{\textit{System Working Voltage (Vdc)}} \times \textbf{\textit{Battery (AH)}} \times \textbf{\textit{DoD}}}\\&= \frac{\mathbf{229.800\ Wh}}{\mathbf{48\ Vdc \times 200\ AH \times 80\%}}\\&= \frac{\mathbf{229.800\ Wh}}{\mathbf{7680}}\\&= 29.92 = 30\ \text{Parallel}\end{aligned}$$

From the above calculation, the total number of batteries needed is 4 series multiplied by 30 parallel to 120 battery units.

7. SCC power and current capacity

Table 7. Battery Specifications

Specification	**Information**
Voltage	12 V
Capacity	200 AH
DOD	80%
Long	500 mm
Wide	237 mm
Tall	220 mm
Total Height	245 mm
Weight	55 kg
Terminal Size	T20
Terminal Type	L/0

Before calculating the power and current capacity of SCC, what must be known first is the statement that the input power and current of the SCC is determined by the peak power of the solar module (Wp), while the output power and current of the SCC is determined by the working voltage of the battery system (Vdc) [11]. Next, determine in advance the SCC specifications that will be used. SCC specifications, as follows:

a. e-Smart 40 A. model
b. MPPT charging mode (maximum power point tracking)
c. Three-stage charging method: constant current (MPPT), constant voltage and floating charge
d. System type DC 12 V/24 V/48 V automatic recognition 12 V system, 24 V system, and 48 V system
e. System voltage 9 V–15 Vdc, 18 V–30 Vdc, and 36 V–60 Vdc
f. MPPT efficiency 96.5% up to MPPT voltage and working range 14 V–100 Vdc, 30 V–100 Vdc, and 60 V–100 Vdc
g. 14 Vdc, 30 Vdc and 60 Vdc. low voltage input protection points
h. 18 Vdc, 34 Vdc and 65 Vdc. low-voltage input recovery points
i. 110 Vdc. input overvoltage protection point
j. 100 Vdc. input overvoltage recovery point

The formula used to calculate the SCC power and current capacity is as follows:

$$\text{Total Current SCC} = \frac{\boldsymbol{Peak\ Power\ of\ the\ Solar\ Module\ (Wp)}}{\boldsymbol{System\ Working\ Voltage\ (Vdc)}}$$

$$= 100.62\ \text{A}\frac{\mathbf{4830\ Wp}}{\mathbf{48\ Vdc}}$$

$$\text{Number of SCC Units} = \frac{\boldsymbol{Total\ Current\ SCC}}{\boldsymbol{CurrentCapacity/SCC}}$$

$$= 2.5 = 3 \text{ units of SCC} \frac{\mathbf{100,62\ A}}{\mathbf{40\ A}}$$

$$\text{Power/SCC} = \frac{\boldsymbol{Peak\ Power\ of\ the\ Solar\ Module\ (Wp)}}{\boldsymbol{Number\ of\ SCC\ Units}}$$

$$= 1.610 \text{ Watts/SCC} \frac{\mathbf{4830\ Wp}}{\mathbf{3\ unit}}$$

Based on the overall calculation of the components above, the specifications for the On-grid and Off-grid PV mini-grid systems are obtained, as shown in Tables 8 and 9.

8. Data calculation and discussion economically

   Before calculating the economic analysis, it is necessary to know in advance how much the PLTS Budget Plan will be used. The total amount of the RAB can be taken according to the specification data for the PLTS components that will be used. Calculation of data and discussion economically consists of three methods, namely;

Table 8. Summary of On-Grid and Off-Grid PLTS System Design

Information	**Parameter**	**Score**	**Unit**
PLTS	Peak Power	4.03	kWp
Module	Selected Capacity	250	Wp
	Amount	20	Unit
Battery	Elected Autonomy Day	2	Day
	Capacity	229,800	Wh
	Selected Voltage Specification	12	Vdc
	Selected Current Specification	200	Ah
	Selected DoD Specifications	80	%
	Amount	120	Unit
Inverter	Capacity	5000	Watt
	Amount	29	Unit
Solar Charge Controller	Amount	3	Unit
	Capacity	1610	Watt

Table 9. Comparison of PV mini-grid designs

Component	***On-Grid***	***Off-Grid***
Solar Module	20 Units (250 Wp)	20 Units (250 Wp)
Battery	0 Units	120 Units (200 Ah)
Inverter	29 Units (5000 Watts)	29 Units (5000 Watts)
Solar Charge Controller	3 Units (40 A)	3 Units (40 A)

Net Present Value (NPV), Benefit Cost Ratio (BCR), and Payback Period (PP) [12, 13].

a. Draft Budget

Before calculating Draft Budget to be used, it is necessary to know the number and specifications of the components that have been calculated in the calculation of the data and the technical discussion above. So, it can be seen the amount of RAB needed, as follows:

b. Net Present Value (NPV)

Before calculating NPV, what must be known in advance is how much kWh/Rupiah electricity sales are generated from the planned Solar Module. The calculation results, as shown in Tables 10 and 11.

$$\begin{aligned}\text{Sales/Hour} &= \text{Solar Module Power} \times \text{Electricity Price (kWh/Rupiah)}\\ &= 4.03\ \text{kWh} \times 8,786\ \text{Rupiah}\\ &= 35,407.58\ \text{Rupiah/Hour}\end{aligned}$$

$$\begin{aligned}\text{Sales/Day} &= \text{Sales/Hour} \times 24\ \text{Hours}\\ &= 35,407.58\ \text{Rupiah/Hour} \times 24\ \text{Hours}\\ &= 849,781.9\ \text{Rupiah/Day}\end{aligned}$$

$$\text{Sales/Month} = \text{Sales/day} \times 30\ \text{days}$$

Table 10. Total Draft Budget PLTS On-Grid System

No.	Equipment and Specifications	Price (Rp)	Quantity (Pcs)	Amount (Rp)
1.	Sunny Solar Module 250 Wp	2.750.000	20	55,000,000
2.	*Solar Charge Controller*40 A MPPT	3,088,000	3	9,264,000
3.	Grid Tie Inverter 5 kW Luminous	19,000,000	29	551,000,000
4.	Battery	-	0	0
Total				**615,264,000**

Table 11. Total Draft Budget of Off-Grid PLTS System

No.	Equipment and Specifications	Price (Rp)	Quantity (Pcs)	Amount (Rp)
1.	Sunny Solar Module 250 Wp	2.750.000	20	55,000,000
2.	*Solar Charge Controller*40 A MPPT	3,088,000	3	9,264,000
3.	Grid Tie Inverter 5 kW Luminous	19,000,000	29	551,000,000
4.	VRLA SMT Battery 12V 200AH	4.660,000	120	559,200,000
Total				**1,174,464,000**

$$= 849,781.9 \text{ Rupiah/Day} \times 30 \text{ Days}$$
$$= 25,493,457.6 \text{ Rupiah/Month}$$

$$\begin{aligned} \text{Sales/Year} &= \text{Sales/Month} \times 12 \text{ Months} \\ &= 25,493,457.6 \text{ Rupiah/Month} \times 12 \text{ Months} \\ &= 305,921,491.2 \text{ Rupiah/Year} \end{aligned}$$

$$\begin{aligned} \text{Sales/5 Years} &= \text{Sales/Year} \times 5 \text{ Years} \\ &= 305,921,491.2 \text{ Rupiah/Year} \times 5 \text{ Years} \\ &= 1,529,607,456 \text{ Rupiah/5 Years} \end{aligned}$$

Then to calculate the NPV, first calculate the Present Value (PV) of receipts or Net Cash Flow with a certain discount rate (in this study using the Bank Kaltimtara interest rate = 8.59%), then compared with the Present Value (PV) of the investment. Calculations will be carried out twice with two different PLTS systems, namely; On-Grid PLTS System and Off-Grid PLTS System. The formula used to calculate NPV is as follows:

$$\begin{aligned} \text{NPV PLTS On-Grid} &= \sum\nolimits_{i=1}^{n} \frac{\boldsymbol{NBi}}{\boldsymbol{(1+i)n}} \\ &= \frac{\boldsymbol{Benefit - Cost}}{\boldsymbol{(1 + Factor\ Discount)5th\ Year}} \\ &= \frac{\mathbf{1,529,607,456 - 615,264,000}}{\boldsymbol{(1 + 8,59\%)5th\ Year}} \\ &= \frac{\mathbf{914,343,456}}{\mathbf{1,51}} \\ &= 605,525,467.5 \end{aligned}$$

$$\begin{aligned} \text{NPV PLTS Off-Grid} &= \sum\nolimits_{i=1}^{n} \frac{\boldsymbol{NBi}}{\boldsymbol{(1+i)n}} \\ &= \frac{\boldsymbol{Benefit - Cost}}{\boldsymbol{(1 + Factor\ Discount)5th\ Year}} \\ &= \frac{\mathbf{1,529,607,456 - 1,174,464,000}}{\boldsymbol{(1 + 8,59\%)5th\ Year}} \\ &= \frac{\mathbf{355,143,456}}{\mathbf{1,51}} \\ &= 235,194,341.7 \end{aligned}$$

c. Benefit Cost Ratio (BCR)

The BCR method calculates the ratio between the PV of receipts or cash flows with the PV of investments. Calculations will be carried out twice with two different PLTS systems, namely; On-Grid PLTS System and Off-Grid PLTS System. The formula used, as follows:

$$\text{BCR PLTS On-Grid} = \frac{\sum \boldsymbol{PVnetBenefit}}{\sum \boldsymbol{PVInvestation}} \mathbf{100\%}$$
$$= \frac{\mathbf{1,529,607,456}}{\mathbf{615,264,000}}$$
$$= 2.48$$

$$\text{BCR PLTS Off-Grid} = \frac{\sum \boldsymbol{PVnetBenefit}}{\sum \boldsymbol{PVInvestation}} \mathbf{100\%}$$
$$\mathbf{=} \frac{\mathbf{1,529,607,456}}{\mathbf{1,174,464,000}} 100\%$$
$$= 1.3$$

d. Payback Period (PP)

The PP method calculates how long the investment will take to return. Calculations will be carried out twice with two different PLTS systems, namely; On-Grid PLTS System and Off-Grid PLTS System. To calculate PP using the formula, as follows:

$$\text{PPPLTS On-Grid} = \frac{\boldsymbol{Investation}}{\boldsymbol{Net\ Cash/Year}} \times 1\ \boldsymbol{Year}$$
$$= \frac{\mathbf{615,264,000}}{\mathbf{305,921,491.2}} \times 1 \text{ year} = 2 \text{ years}$$

$$\text{PPPLTS Off-Grid} = \frac{\boldsymbol{Investation}}{\boldsymbol{Net\ Cash/Year}} \times 1\ \boldsymbol{tahun}$$
$$\mathbf{=} \frac{\mathbf{1,174,464,000}}{\mathbf{305,921,491.2}} \times 1 \text{ year} = 3.8 \text{ years} \ = \ 3 \text{ years } 8 \text{ months}$$

9. PLTS Investment Feasibility Results

The results of the feasibility of PLTS investment can be seen from the calculation results of the three methods above [14]. The assessment of the implementation of PLTS is said to be feasible/not feasible if it is appropriate/not in accordance with the criteria that have been set. The results of the PLTS investment feasibility are as shown in Table 12.

From the results of these calculations, it can be seen that the calculated values of NPV, BCR, and PP from the planned PLTS installation design in the New Building of the Faculty of Engineering, Mulawarman University all meet the eligibility criteria for investment. So, it can be concluded that the PLTS installation design in the New Building of the Faculty of Engineering, Mulawarman University is feasible and can be implemented.

4 Conclusion

In the new Lecture building of the Faculty of Engineering, Mulawarman University, it produces electricity consumption of 10377.6 in one day use on August 15, 2022. The components needed in the design of PLTS On-Grid and Off-Grid are Solar Modules,

Table 12. Investment Feasibility

Investment Eligibility Method	PLTS system		Investment Eligibility Criteria	Investment Eligibility Status (Eligible/Not)	
	On-Grid	*Off-Grid*		*On-Grid*	*Off-Grid*
NPV	605,525,467.5	235,194,341.7	NPV > 0	Worthy	Worthy
BCR	2.48	1.3	BCR > 1	Worthy	Worthy
PP	2 years	3.8 years	PP < Economic life of the project (5 Years)	Worthy	Worthy

Inverters, (Solar Charge Controller and Battery). From the above calculation results obtained alternative electrical energy that can be generated worth 4.03 kWp/day. The amount of the Budget Draft required in this design is Rp. 615,264,000 for PLTS On-Grid and Rp. 1,174,464,000 for PLTS Off-Grid. The feasibility of investing in the design of PLTS On-Grid and Off-Grid both using the NVP, BCR, and PP methods is said to be feasible to implement in the new lecture building of the Faculty of Engineering, Mulawarman University.

References

1. E, S. Application Of Solar Power Plant In Integrated Agricultural Land Ciseeng Parung-Bogor. *Proc. Natl. Technoka Semin.* **4**, E74–E83 (2019).
2. A, H., Z, A., S, H. & R, U. Analysis of The Balang Lompo Island Solar Power Plant. *J. Lit. J. Electr. Telecommun. Electron.* **14**, 6–12 (2017).
3. AR, B. Ptototype of Sea Water Tidal Power Plant in Tugurejo Village, Tugu District Semarang City (Doctoral dissertation, Semarang State University). (2017).
4. Ramadhan, Al, E, D. & SH, M. Analysis of The Design of a Solar Power Plant System With a Capacity of 50 WP. *J. Eng.* **37**, 59–63 (2016).
5. Fama, A., NJ & Budy, S. Techno-Economic Analysis of The Application of On-Grid Solar Power Plants in The Biak Papua Electrical System. *Proced. Semnastek* **1**, (2018).
6. M.Sc, I. B. R. *Solar POwer Plant Installation Dos & Dont's.* (GIZ, 2018).
7. M, I. Design Solar Panels FOr Simple Home Lighting Installation 900 Watt Power. *J. Electr. Electron. Appl. Inf. Technol.* **1**, 17–22 (2020).
8. Kristiawan H, INS, K. & IAD, G. The Potential of Solar Power Generation On The Roof a School Buiding In Denpasar City. *2019* **6**.
9. Saksena. Planning Analysis Of Solar Power Plant In The Faculty Of Industrial Technology Building Islamic University Of Sultan Agung. *2019* (Sultan Agung ISlamic University).
10. BH, P. Efficiency of Using Solar Panels as Alternative Energy Sources. *J. Electr. Eng.* **18**, 10–14 (2018).
11. S, Y. Developing Virtual Power Plant for Optimized Distributed Energy Resources Operation and Integration. (Technical University Of Denmark, 2010).
12. AE, S. & A, K. Application of Solar Power Generation Technology (PLTS) at SMA Negeri 6 Surakarta as An energy Saving and ENvironmentally Friendly School. *Proc. Natl. Conf. Math. Sci. PGRI Univ.* **1**, 215–227 (2019).

13. IA, N., H, S. & H, H. Planning Of Generated Power Measurement On Roof Solar Power Generating System With Import KWH In Housing Area Homenesty Residence SIngkawang West Kalimantan Province. (PLN Institute Of Technology, 2020).
14. Gunawan, NS, Kumara, IS & R, I. Performance of a 26,4 kWp Solar Power Plant (PLTS) in The UNUD Smart Microgrid System. *Spectr. J.* **6** (2019).