JURNAL PENDIDIKAN TEKNOLOGI KEJURUAN
Vol. 6, No. 2 May 2023 P-ISSN: 2621-3273
E-ISSN: 2621-1548

Economic Analysis of Solar Photovoltaic Power Plant Planning at Taman Melati Depok Apartment

Romadhona[1*], Rinaldy Dalimi[2]
[1,2] Electrical Engineering, Faculty of Engineering, Universitas Indonesia, 10430, Indonesia
[*]Corresponding author, e-mail: Romadhona@ui.ac.id

Received 20th April 2023; 1st Revision 8th May 2023; 2nd Revision 22th May 2023; Accepted 28th May 2023
DOI: https://doi.org/10.24036/jptk.v6i2.32823

ABSTRACT

Currently, Indonesia is still using fossil fuel power plants. The high use of fossil fuels will harm the environment, therefore to reduce the use of fossil fuels, it is necessary to develop renewable energy power plants, one of which is a solar photovoltaic power plant. This study discusses the economic analysis of planning a soalr photovoltaic power plant at the Taman Melati Depok Apartment which is connected to the PLN network with the PVsyst software. This PLTS plan will be built on the roof of the apartment using an area of 437 m^2 with generated power of 90,400 Wp. Using solar modules with a capacity of 565 Wp as many as 160 modules. This PLTS can generate electricity per year 116600 kWh/year. The Cost of Energy (COE) for this PLTS is Rp.735.39/kWh. Economic analysis uses Net Present Value (NPV), Profitability Index (PI), and Discounted Payback Period (DPP) to determine whether this PLTS is feasible or not. Based on the calculation result, the NPV value is Rp. 608,793,939.29, while the PI value is 1.587 and the DPP value is around 12 years and 9 months, which is faster than the project age, which is 30 years. Thus the investment in the Taman Melati Apartment PLTS project is feasible to continue.

Keyword: *PVsyst, COE, NPV, PI, DPP*

Copyright © Romadhona, Rinaldy Dalimi
This is an open access article under the: https://creativecommons.org/licenses/by/4.0/

INTRODUCTION

The Ministry of Public Works and Public Housing (PUPR) and the Ministry of BUMN work together to encourage the development of TOD (transit Oriented Development)-based housing in various regions. TOD (transit Oriented Development) is a residential development that is integrated with the public transportation network such as terminals and stations. If TOD-based residential development increases, this can cause electricity demand to increase as well. The high use of electrical energy will have an impact on high carbon emissions. Because the building only gets electricity supply from PLN which uses fossil fuels. In the Enhanced Nationally Determined Contribution (ENDC) document, the Indonesian government increased its emission reduction target from 29% to 31.89% in 2030 with its capabilities and increased its emission reduction target from 41% to 43.2% with international assistance (Ministry of Environment and Forestry., 2022). In addition, in the October 2022 edition of the Indonesia Energy Transition Outlook report, the share of renewable energy in the national energy mix in the 2015-2021 range in Indonesia has increased. In 2015, the portion of new renewable energy was 4.9% of the national energy mix. always increases so that in 2021 it reaches 12.16% (Indonesia Energy Transition Outlook., 2022).

Indonesia has a high potential for sunlight, one of which is in the area of the island of Java with a range of 2.0 – 6.4 kWh/m2 (Deputy for Climatology BMKG., 2023). If the potential of sunlight can be developed to become the main energy for power generation, it is hoped that this will be the best solution to this problem. In addition, the application of PLTS is to reduce the cost of electrical energy. There have been several similar studies related to Rooftop PLTS planning that have been carried out, including in the UNG Faculty of Engineering Building conducting Rooftop PLTS planning (Rafli., Jumiati, I., & Sardi, S., 2022), this study aim was to analyze the technical aspects and economical in planning PLTS Rooftop, but PLTS Rooftop does not explain the amount of gas emissions stored if PLTS is used during its lifetime. Then another study entitled Techno-economic Analysis of Solar Photovoltaic Power Plant for Mass Transportation Integrated Apartment (Ryan., 2022), this study has shown an analysis of economic, technical, and environmental aspects that take into account the amount of stored carbon gas emissions if the Rooftop PLTS is raised, but the difference with previous research lies in the selection of inverters in terms of price, methods for determining maintenance and operational costs, and generator load data which is uncertain which will influence the determination of PLTS in fulfilling the electricity supply in the building. Therefore, this study is expected to be feasible to be developed at the Taman Melati Apartment. In addition to increasing the penetration of renewable energy, this study is expected to reduce energy costs and reduce CO2 emissions to meet the NDC target.

This study uses the help of PVSyst software which produces optimal PV capacity, as well as manual calculations for proper economic analysis. This study aims to analyze the economic feasibility of planning a rooftop PLTS at the Taman Melati Apartment.

METHOD

The total amount of energy potential is calculated based on Global horizontal irradiation (GHI) in units of kWh/m2, this value is obtained from the solar atlas by entering the coordinates of the location, namely latitude (Latitude) -6.3766314°, longitude (Longitude) 106.8110135° the values obtained in table 1. The total roof area used by PLTS is 437 m^2 out of 702.7 m^2 as shown in Figure 1. This is due to the provision of distance for installation and maintenance lines

Table 1. Solar Radiation Potential

Parameter	kWh/m^2/ year
Global Horizontal Irradiation (GHI)	173
Direct Normal Irradiation (DNI)	1055
Diffuse Horizontal Irradiation (DIF)	909

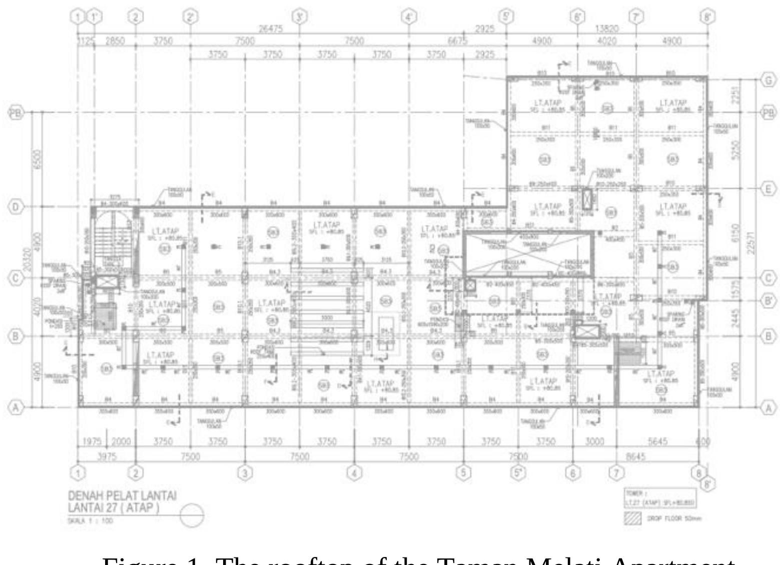


Figure 1. The rooftop of the Taman Melati Apartment

A. Engineering calculations for the PLTS system
   1. Solar Panels

PLTS depends on the intensity of solar radiation and temperature in the surrounding area. To calculate the average capacity of PLTS P watt peak (wp) it is necessary to use the roof area, the PSI is Peak Solar Insolation (W/m^2) and the module efficiency used (%) is in Table 1 below the equation (Dyah., 2022):

$$P_{watt\ peak} = PV\ area\ x\ PSI\ (Peak\ solar\ insolation)\ x\ \eta\ pv \quad (1)$$

After determining the capacity of the PLTS, then calculate the number of modules needed by $N_{modules}$, by dividing the $_{Pwatt\ peak}$ (Wp) PLTS capacity in Table 2 and the maximum output power of the P_{mpp} module (Wp). following is the equation (Dyah., 2022):

$$N_{modul} = \frac{Pwatt\ peak}{Pmpp} \quad (2)$$

Table 2. Solar Panel Module Specifications

Company	JinkoSolar
Type	JKM565M-7RL4-V
Power Capacity	565WP
Maximum Voltage (Vmp)	43.97 V
Maximum Current (Imp)	12.85 A
Efficiency	20.67%
Cell Type	P-type Monocrystalline
Dimensions	(2411x1134x 35)mm
Output Coefficient	-0.35%/ ^{0} c

2. Inverters

The inverter is the most important component for converting the DC electricity generated by solar panels into AC electricity for use on equipment. To determine the number of inverters used by N inverters, the power generated by PLTS Pmax pv (watts) is required and the maximum inverter power Pmax Inverter (watts) is shown in Table 3. The following is the equation (Dyah., 2022):

$$N\ inverter = \frac{P\ maks\ pv}{P\ maks\ inverter} \quad (3)$$

Table 3. Inverter Specifications

Company	Huawei Technologies
Model	Sun 2000-60 KTL-MO
Maximum Power	60,000W
starting voltage	30 A
MPPT operating voltage Range	200V – 1000V
Rated Input Voltage	600V@380V
Rated Output Current	91.2A @380V
Efficiency	98.7% @380V

B. Economic Analysis

The Economic analysis aims to determine the feasibility of PLTS planning. Here are the steps

1. Cost of Energy (COE)

The energy cost (cost of energy) is a comparison of the product of the multiplication of the life cycle cost (LCC) and the recovery factor (CRF) with the total energy produced by PLTS for one year, which can be formulated as follows (Asrori, 2022):

$$COE = \frac{LCC\ x\ CRF}{A\ kwh} \quad (4)$$

CRF is a capital recovery factor that is formulated as follows (Asrori, 2022):

$$CRF = \frac{i(1+i)^n}{(1+i)^n} - 1 \quad (5)$$

Where, A kwh = Total energy produced for one year (kWh/year); i = bank interest rate

Life Cycle Costs (LCC) or life cycle costs on PLTS are all costs incurred by PLTS during its operation which are determined by the present value of the total cost of the PLTS system which is formulated as follows (Ryan., 2022):

$$LCC = IA + M_{pw} \quad (6)$$

IA is the initial investment cost

M_{pw} is maintenance costs and operational costs for n years of project life, you can use the following equation (Yakobus & Joni., 2022):

$$M_{pw} = M\ \left(\frac{(1+i)^n - 1}{i(1+i)^n}\right) \quad (7)$$

Where, i = bank interest rate

M is the cost of maintenance and operational costs (O&M) per year in this PLTS system, it can be assumed to be worth 1% of the total initial investment value (Putranto, Widodo, Indrawan, Ali Imron, & Rosyadi, 2022).

$$M = 1\% \times IA \quad (8)$$

2. Net Present Value (NPV)

Calculating the Net Present Value (NPV) aims to make projections of future cash flows into present value or discounted at an interest rate which is used as the basis for comparison. To calculate the Net Present Value (NPV) following is the equation (Asrori, 2022):

$$NPV = (\sum PVNCF) - IA \quad (9)$$

where, PVNCF= net cash flow in period n

The project investment is considered feasible if the NPV> 0 or the NPV is positive

3. Profitability Index (PI)

The Profitability Index (PI) is a comparison between all net cash present value and the initial investment, following is the Profitability Index formula (Yakobus & Joni., 2022)

$$PI = \frac{\sum PVNCF}{IA} \quad (10)$$

Project investment is considered feasible if PI>1 or PI is positive

4. Discounted Payback Period (DPP)

Discounted Payback Period is a discounted payback period, and can be found by calculating how many years the net cash cumulative present value is estimated to be the same as the initial investment (I Kadek Hendy, Satya, Wayan., 2022)

$$DPP = year\ before\ recovery + \frac{investment\ cost}{PVNCF} \quad (11)$$

The investment is considered feasible if the DPP < the age of the project

5. Internal Rate of Return (IRR)

IRR is an interest rate that produces an NPV value equal to zero (because the present value of cash inflows is the same as the initial investment) (Ryan., 2022).

$$IRR = i1 \frac{NPV1}{(NPV1 - NPV2)} (i2 - i1) \quad (12)$$

Where, IRR = Internal Rate of Return ; i1= lowest discount rate; i2= highest discount rate; NPV1= NPV at i1; NPV2= NPV at i2

The investment is considered feasible if the IRR≥ the interest rate on the loan

C. The Steps of Study

This PLTS Planning Analysis was carried out with manual calculations and the help of the PVsyst software. Following The steps of this study are shown in the following figure

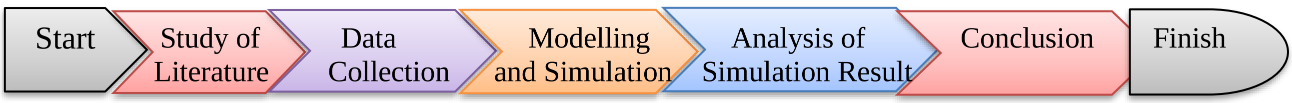


Figure. 2 Methodology Flowchart

1. Start: The first step to identify the problem
2. Study of Literature: This step is carried out to provide a theoretical basis for study in the form of scientific journals, government policies, regulations, and textbooks.
3. Data collection: This step is carried out to obtain the data needed in conducting the modeling and research analysis stages. The data needed is in the form of apartment roof area data, load profiles, solar radiation intensity data, and component cost data
4. PVsyst Software Modeling and Simulation: This step is carried out using the PVsyst software by setting the orientation to determine the tilt parameter of the module, setting the system to determine the parameters of the module and inverter to be used
5. Analysis of Simulation Results: The simulation results in step 4 are the large capacity of the PLTS, the amount of energy produced by the PLTS, the life of the project, and the carbon emissions stored during the life of the project. This step analyzes the simulation results in terms of economic feasibility and environmental sustainability.

6. Conclusion: This step is concluding the results of the analysis as well as providing suggestions and recommendations so that similar research in the future will be even better.

RESULT

This study uses an On-Grid system that is connected to the PLN network, based on the coordinates of the location, the amount of solar radiation exposure, the roof area used by the PLTS, and the generated capacity is 90.4 kWp. The following is a 3-Dimensional PLTS design using the PVSyst software

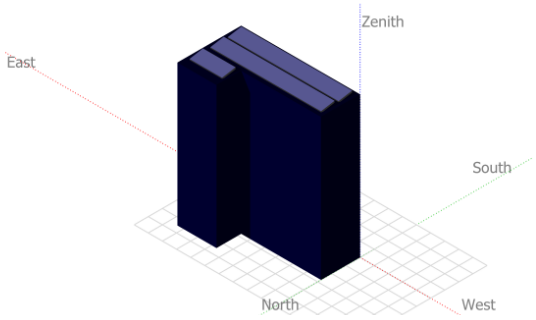
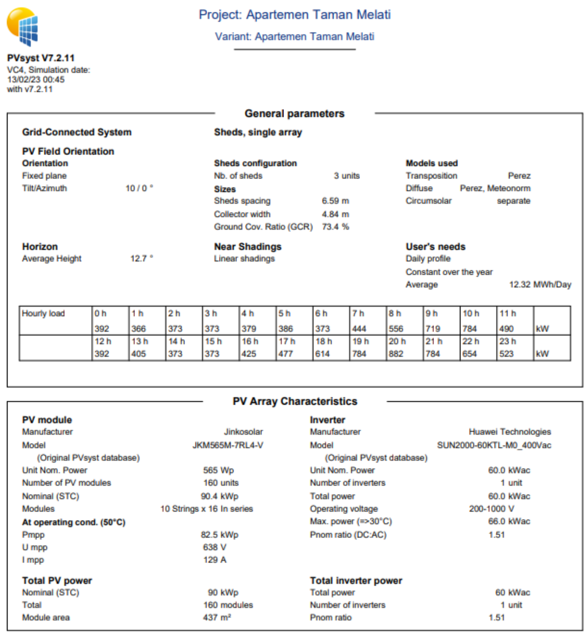


Figure 3. 3-Dimensional PLTS Simulation

In this PLTS planning, there will be 565 wp with 160 solar panels, the following are the calculation results for the PLTS system using PVSyst



Project: Apartemen Taman Melati
Variant: Apartemen Taman Melati

PVsyst V7.2.11
VC4, Simulation date:
13/02/23 00:45
with v7.2.11

General parameters

Grid-Connected System | **Sheds, single array**

PV Field Orientation
Orientation
Fixed plane
Tilt/Azimuth 10 / 0 °

Sheds configuration
Nb. of sheds 3 units
Sizes
Sheds spacing 6.59 m
Collector width 4.84 m
Ground Cov. Ratio (GCR) 73.4 %

Models used
Transposition Perez
Diffuse Perez, Meteonorm
Circumsolar separate

Horizon
Average Height 12.7 °

Near Shadings
Linear shadings

User's needs
Daily profile
Constant over the year
Average 12.32 MWh/Day

Hourly load	0 h	1 h	2 h	3 h	4 h	5 h	6 h	7 h	8 h	9 h	10 h	11 h	
	392	366	373	373	379	386	373	444	556	719	784	490	kW
	12 h	13 h	14 h	15 h	16 h	17 h	18 h	19 h	20 h	21 h	22 h	23 h	
	392	405	373	373	425	477	614	784	882	784	654	523	kW

PV Array Characteristics

PV module
Manufacturer Jinkosolar
Model JKM565M-7RL4-V
(Original PVsyst database)
Unit Nom. Power 565 Wp
Number of PV modules 160 units
Nominal (STC) 90.4 kWp
Modules 10 Strings x 16 In series
At operating cond. (50°C)
Pmpp 82.5 kWp
U mpp 638 V
I mpp 129 A

Inverter
Manufacturer Huawei Technologies
Model SUN2000-60KTL-M0_400Vac
(Original PVsyst database)
Unit Nom. Power 60.0 kWac
Number of inverters 1 unit
Total power 60.0 kWac
Operating voltage 200-1000 V
Max. power (=>30°C) 66.0 kWac
Pnom ratio (DC:AC) 1.51

Total PV power
Nominal (STC) 90 kWp
Total 160 modules
Module area 437 m²

Total inverter power
Total power 60 kWac
Number of inverters 1 unit
Pnom ratio 1.51

Figure 4. Calculation results for the PLTS system

Because the power plant capacity is 90400 wp, the total energy generated by the rooftop PLTS at the Taman Melati Apartment is 116.6 MWh/year, The following is a description for a year

Table 4. PLTS Energy Simulation

Energy (MWh)	January	February	March	April	May	June	July	August	September	October	November	December
Solar	7.64	6.35	9.89	9.7	10.5	10.21	11.01	11.35	11.27	10.77	9.11	8.8
Users	381.9	344.9	381.9	369.6	381.9	369.6	381.9	381.9	369.6	381.9	369.6	381.9

In this study, batteries were not used as excess PLTS energy storage, this is because the energy generated by PLTS is less than the user is needs. The following details the initial investment.

Table 5. Calculation of the Initial Investment Cost of PLTS

No.	Component	Unit Price	units	Total price
1.	PV Modules	Rp. 2,850,000.00	160	Rp. 456,000,000
2.	inverters	Rp. 39,000,000.00	1	Rp. 39,000,000
3.	MCCB	Rp. 280,000.00	1	Rp. 280,000
4.	Mounting Roof Racking	Rp. 1,500,000.00	90.4	Rp. 135,600,000
5.	Electrical Components	Rp. 2,500,000.00	90.4	Rp. 226,000,000
6.	Commissioning	Rp. 500,000.00	90.4	Rp. 45,200,000
7.	Contingency	4% of 1-6		Rp. 36,083,200
8.	taxes	11% of 1-6		Rp. 99,228,800
Total				Rp. 1,037,392,000

From Table 5, the initial investment cost of Rp. 1,037,392,000. The basis for operating costs refers to the National Renewable Energy Laboratory and a survey was also carried out from several buying and selling websites that provide components for PLTS (Ryan., 2022)

$$Biaya\ per\ kWp = \frac{\text{Rp.}1{,}037{,}392{,}000}{90.4\ kWp}$$

= Rp. 11,475,575.22/kWp

So the calculation of operating and maintenance costs based on equation (8) is obtained as follows

O&M Cost (M) = 1% x Rp. 1,037,392,000

= Rp. 10,373,920 per year

The next calculation parameter, assuming the age of the equipment used is 30 years, referring to equation (7) the total operational and maintenance costs for a lifetime are Rp.142,795,257.18, and by referring to equation (6) the life cycle cost of PLTS is Rp.1,180,187,257.18. The following is the calculation of NPV, IRR, and DPP

Table 6. Calculation of NPV, IRR, and DPP

Year	Period	Cost Initial Investment	Net cash flow	DF (i = 6%)	PVNCF	DF (i =12%)	PVNCF
2023	0	Rp. 1,037,392,000		1		1.00	
2024	1		Rp. 119,593,616.60	0.94	Rp. 112,824,166.60	0.89	Rp. 106,780,014.82
2025	2		Rp. 119,593,616.60	0.89	Rp. 106,437,893.02	0.80	Rp. 95,339,298.95
2026	3		Rp. 119,593,616.60	0.84	Rp. 100,413,106.62	0.71	Rp. 85,124,374.06
2027	4		Rp. 119,593,616.60	0.79	Rp. 94,729,345.87	0.64	Rp. 76,003,905.41
2028	5		Rp. 119,593,616.60	0.75	Rp. 89,367,307.43	0.57	Rp. 67,860,629.83
2029	6		Rp. 119,593,616.60	0.70	Rp. 84,308,780.59	0.51	Rp. 60,589,848.06
2030	7		Rp. 119,593,616.60	0.67	Rp. 79,536,585.46	0.45	Rp. 54,098,078.63
2031	8		Rp. 119,593,616.60	0.63	Rp. 75,034,514.59	0.40	Rp. 48,301,855.92
2032	9		Rp. 119,593,616.60	0.59	Rp. 70,787,277.91	0.36	Rp. 43,126,657.07
2033	10		Rp. 119,593,616.60	0.56	Rp. 66,780,450.86	0.32	Rp. 38,505,943.81
2034	11		Rp. 119,593,616.60	0.53	Rp. 63,000,425.34	0.29	Rp. 34,380,306.98
2035	12		Rp. 119,593,616.60	0.50	Rp. 59,434,363.53	0.26	Rp. 30,696,702.66
2036	13		Rp. 119,593,616.60	0.47	Rp. 56,070,154.27	0.23	Rp. 27,407,770.23
2037	14		Rp. 119,593,616.60	0.44	Rp. 52,896,371.96	0.20	Rp. 24,471,223.42
2038	15		Rp. 119,593,616.60	0.42	Rp. 49,902,237.69	0.18	Rp. 21,849,306.62
2039	16		Rp. 119,593,616.60	0.39	Rp. 47,077,582.73	0.16	Rp. 19,508,309.49
2040	17		Rp. 119,593,616.60	0.37	Rp. 44,412,813.90	0.15	Rp. 17,418,133.47
2041	18		Rp. 119,593,616.60	0.35	Rp. 41,898,881.03	0.13	Rp. 15,551,904.88
2042	19		Rp. 119,593,616.60	0.33	Rp. 39,527,246.26	0.12	Rp. 13,885,629.36
2043	20		Rp. 119,593,616.60	0.31	Rp. 37,289,854.96	0.10	Rp. 12,397,883.36
2044	21		Rp. 119,593,616.60	0.29	Rp. 35,179,108.45	0.09	Rp. 11,069,538.71
2045	22		Rp. 119,593,616.60	0.28	Rp. 33,187,838.16	0.08	Rp. 9,883,516.71
2046	23		Rp. 119,593,616.60	0.26	Rp. 31,309,281.29	0.07	Rp. 8,824,568.49
2047	24		Rp. 119,593,616.60	0.25	Rp. 29,537,057.82	0.07	Rp. 7,879,079.01
2048	25		Rp. 119,593,616.60	0.23	Rp. 27,865,148.88	0.06	Rp. 7,034,891.97
2049	26		Rp. 119,593,616.60	0.22	Rp. 26,287,876.31	0.05	Rp. 6,281,153.55
2050	27		Rp. 119,593,616.60	0.21	Rp. 24,799,883.31	0.05	Rp. 5,608,172.81
2051	28		Rp. 119,593,616.60	0.20	Rp. 23,396,116.33	0.04	Rp. 5,007,297.15
2052	29		Rp. 119,593,616.60	0.18	Rp. 22,071,807.86	0.04	Rp. 4,470,801.03
2053	30		Rp. 119,593,616.60	0.17	Rp. 20,822,460.24	0.03	Rp. 3,991,786.63
Total				-	**Rp. 1,646,185,939.29**	-	**Rp. 963,348,583.07**
Net Present Value					**608,793,939.30**		**-74,043,416.93**
IRR (Internal Rate of Return)				**11%**			
DPP (Discounted Payback Period)				**12 Years 9 Months**			

From Table 6, the value of net cash flow or Net Cash Flow is used to calculate the results of reducing cash inflows and cash outflows, so that according to equation (9) it is Rp. 119,593,616.60, the COE value is Rp. 735.39 cheaper when compared to the PLN rate of Rp. 1,114.74 per kWh (Regulation of the Minister of Energy and Mineral Resources., 2023), the NPV with an interest rate of 6% is positive, which is Rp. 608,793,939.29 while the NPV value is negative of Rp.-74,043,416.93 with an interest rate of 12% so that an IRR value of 11% is higher than the BI reference rate of 6% per year (Bank Indonesia Board of Governors Meeting, 2023), as well as the DPP value of 12 years 9 months means that the investment will return on investment in 12 years 9 months.

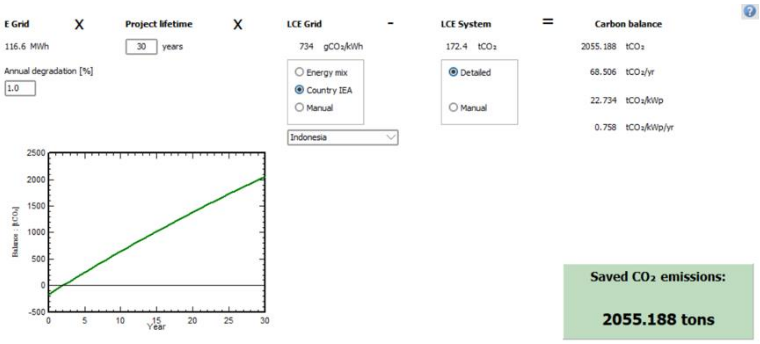


Figure 5. Simulation of Carbon Gas Emissions

In Figure 5, the total stored emissions for 30 years is 2055,188 tCO2, the total stored emissions per year are 68,506 tCO2, the total stored emissions per 1 kWp are 22,734 tCO2, while the total stored emissions per 1kWp and each year are 0,758 tCO2. Thus the longer the use of PLTS, the more total CO2 emissions will be stored, so this has a big impact on the environment.

DISCUSSION

The total energy produced by PLTS for a year is 116.6 MWh and the electrical energy needed for apartments for a year is 4,496.6 MWh with details as in Table 4, it needs electricity supply from PLN. This PLTS planning will provide benefits and attract investors if, in the future equipment prices are cheaper, so that later the initial investment cost of development is lower than the calculation in Table 5, and also the return on the capital process will be faster or the DPP value will be lower than the DPP value which has been calculated in Table 6. In Figure 5, the total emissions stored if this PLTS is used for 30 years is 2055,188 tCO2, it has a positive impact on the environment and supports government programs to reduce gas emissions, if more Apartments build on rooftops PLTS, the greater the stored gas emissions and the gas emission reduction target planned by the government through the ENDC report, namely in 2030 the targeted emission reduction of 31.89% can be achieved. In the calculation, the COE PLTS value using equation (4) is found to be cheaper than the PLN tariff, and in Table 6 the NPV value is positive, the IRR value is also worth more than the reference interest rate, which is 6% per year (Bank Indonesia Board of Governors Meeting., 2023), and the investment will return on investment in 12 years and 9 months, which is faster than the assumed age of the equipment which is 30 years. So that study on the rooftop PLTS investment project at the Taman Melati Margonda Apartment is feasible to continue.

CONCLUSION

This study was conducted to analyze the economic feasibility of planning the on-grid PLTS Rooftop system at the Taman Melati Apartment. The results show that the generated PLTS power is 90.4 kWp with a roof area of 437 m^2, so 160 solar panels and 1 inverter are needed, with a circuit configuration of 16 PV and 10 modules in series per series, so that the energy produced by PLTS is 116.6 MWh/ year and the COE value is Rp. 735.39. From economic analysis with a reference interest rate of 6%, the NPV value is Rp. 608,793,939.29 and a negative NPV of Rp.-74,043,416.93, so that an IRR value of 11.00% is obtained and with a service life of 30 years, a DPP value of 12 years and 9 months is obtained. It can be concluded that the planning investment for the On-grid rooftop PLTS system at the Taman Melati Apartment is feasible to continue.

REFERENCES

Asrori., Fajar, A,R., Pipit, W&Irwan,H,E. (2022). Kajian Kelayakan Solar Rooftop On Grid Untuk Kebutuhan Listrik Bengkel Mesin di Polinema. Jurnal Teknik Energi Listrik, Teknik Telekomunikasi &Teknik Elektronika. Vol.10,No.4. 830-845. http://dx.doi.org/10.26760/elkomika.v10i4.830

Bank Indonesia. (2023). Rapat Dewan Gubernur Bank Indonesia 2023 Tentang BI 7-Day Reverse Repo Rate.

Deputi Bidang Klimatologi BMKG. (2023). Peta Potensi Energi Matahari Indonesia.

Dyah, A,K,S.,Fransisco, D,W.,Husni,R,A.(2022).Optimasi Sistem Pembangkit Listrik Tenaga Hybrid di Pulau Enggano. Jurnal Nasional Teknik Elektro dan Teknologi Informasi. Vol.11, No. 2.

I Kadek, H,W., I Nyoman, S,K& Wayan, G,A.(2022). Analisa PLTS Atap 25 kWp On Grid Kantor DPRD Provinsi Bali. Jurnal Spektrum. Vol. 9, No. 2 Juni 2022.

Kementerian Lingkungan Hidup dan Kehutanan.(2022). Enhanced Nationally Determined Contribution (ENDC):Komitmen Indonesia Untuk Makin Berkontribusi Dalam Menjaga Suhu Global.

Nurlaila Amna, dkk Performa Konfigurasi Modul Surya Seri dan Seri dan Paralel pada Kondisi Mismatch Karakteristik Arus-Tegangan (I-V) Terhadap Daya Output. Jurnal Rekayasa Elektrika. Vol. 17, No.4. 204-211. https://doi.org/10.17529/jre.v17i4.22467.

Outlook Energi,B. (2022). Indonesia Energy Transition Outlook Tentang Upaya Pencapaian Target Pengembangan Energi Baru Terbarukan dan Percepatan Transisi Energi Menuju Net Zero Emission.

Pemerintah Indonesia.(2023). Peraturan Menteri ESDM No. 138 Tahun 2023 Tentang Tarif Tenaga Listrik Non Subsidi periode April-Juni 2023.

Putranto, L.,M.,Widodo,T., Indrawan H., Ali Imron, M.,&Rosyadi, S.A. (2022). Grid Parity analysis: The present state of PV rooftops in Indonesia. Renewable Energy Focus, 40, 23-38. http://doi.org/10.1016/j.ref.2021.11.002.

Qashtalani, H., Agus, S., Aloysius, D.,Chaizae, A.,&Eko, A. (2018). Economic Analysis of PV DistributedGeneration Investment Based on Optimum Capacity for Power Losses Reducing. Energy Procedia 156 (2019) 122-127.

Rafli.,Jumiati,I.,&Sardi,S.(2022).Perencanaan dan Studi Kelayakan PLTS Rooftop Pada Gedung Fakultas Teknik UNG. Jambura Journal of Electrical and Electronics Engineering. Vol.4, No.1.

Ryan, H,B., Budi, S., Fariz, M,R.,&Agus, R,U.(2022). Techno-economic Analysis of Solar Photovoltaic Power Plant for Mass Transportation Integrated Apartment. The 7th International Engineering Student Conference.

Selamat meliala. 2020. Implementasi Ongrid Inverter Pada Instalansi Rumah Tangga Untuk Masyarakat Pedesaan Dalam Rangka Antisipasi Krisis Energi Listrik. Jurnal Listrik Telekomunikasi Elektronika, Vol. 17, No.2. pp 47-56.

Yakobus Karingan.,&Joni. (2022). Perencanaan dan Analisa Ekonomi Pembangkit Listrik Tenaga Surya Rooftop dengan Sistem On Grid sebagai Catu daya Tambahan pada RSUD Kabupaten Mimika. Jurnal Pendidikan Tambusai. 3763-3773.