# ECONOMIC ANALYSIS OF ON-GRID SOLAR POWER PLANT SYSTEM DESIGN IN THE BUILDING OF POLITICS,LAW AND HUMAN RIGHTS MINISTRY AT NORTH PENAJAM PASER REGENCY,EAST KALIMANTAN

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#### ABSTRACT

PLTS is one of the renewable energy solutions that utilizes solar radiation as the main source of its generation, so it is considered environmentally friendly and has great potential in areas with high sunlight intensity. The research methods used include collecting solar radiation data, PLTS system design, and performance simulation and testing using HOMER Pro software. This research was conducted at the Ministry of Politics, Law and Human Rights Building in the Nusantara Capital development area in Penajam Paser Utara Regency, East Kalimantan. The tool used to help solve this research problem uses software, namely HOMER Pro. Based on the data obtained, the estimated load consumed in these 4 buildings is 4,222 kWh/day. The PLTS is planned to be built with a capacity of 550 Wp with a total of 376 units, while the inverter capacity is 15,000 Watts with 8 units and 11,000 Watts with 8 units. Based on the results of manual calculations and using HOMER Pro software, the payback period value can be obtained of around 8 to 9 years. and this PLTS will be planned to operate for 25 years.

Keywords : New Renewable Energy Solar Power Plant Energy Saving On-Grid HOMER Pro.

### **INTRODUCTION**

The President of the Republic of Indonesia Joko Widodo has given direction regarding the relocation of the Indonesian Capital City in a limited ministerial meeting on April 29, 2019. The President of the Republic of Indonesia reiterated the plan to relocate the Capital City in a state speech delivered at the DPR RI and DPD RI Session on August 16, 2019. At that time, the President of the Republic of Indonesia requested permission and support for the relocation of the Capital City (IKN) to Kalimantan Island..

In accordance with Presidential Regulation No. 22 of 2017 concerning the National Energy General Plan, government buildings are required to install solar panels on more than 30% of the roof area. The solar panel system that will be applied to this building is an On-Grid system to supply lighting panels for corridors and other public areas. 4 (four) criteria that need to be considered in selecting Solar Panels: Solar panel cost per square meter, Solar panel efficiency of all solar panel modules, Individual solar cell age. Aesthetics and design of solar panels.

Considering that the construction of the Ministry of Politics, Law and Human Rights Building requires the design of installing more than 30% solar panels in accordance with the provisions of Presidential Regulation Number 22 of 2017 above and taking into account the return on investment in designing solar power plants, the author is interested in conducting research related to the economic analysis of designing the installation of solar panels in the construction of the Ministry of Politics, Law and Human Rights Building.

#### METHOD

1. Location and Time of Research

The location of the research conducted this time is in the IKN (Indonesian Capital City) development area which is located in the construction of the Ministry of Politics,

Law and Human Rights (Politics, Law and Human Rights) building, Penajam Paser Utara Regency, East Kalimantan. The location of the Ministry of Politics, Law and Security Building and its location can be seen through the Maps application, and this research will be carried out within a period of 4 months (September-January).

2. Roof Area of the Ministry of Politics, Law and Human Rights Building

a. Roof Area of Building 1



As shown in the picture, the total roof area of Building 1 of the Ministry of Politics, Law and Human Rights has a length of about 48m while the width is about 14m so that the total roof area of building 1 is 672 m<sup>2</sup> where this is the last floor of building 1 and later a rooftop will be built for the installation of the ongrid PLTS system.

b. Roof Area of Building 2



As shown in the picture, the total roof area of Building 2 of the Ministry of Politics, Law and Human Rights has a length of about 46 m while the width is about 11 m so that the total roof area of building 2 is 506 m<sup>2</sup> where this is the last floor of building 2 and later a rooftop will be built for the installation of the ongrid PLTS system.

c. Roof Area of Building 3



As shown in the picture, the total roof area of Building 3 of the Ministry of Politics, Law and Human Rights has a length of about 46 m while the width is about 11 m so that the total roof area of building 3 is 506 m<sup>2</sup> where this is the last floor of building 3 and later a rooftop will be built for the installation of the ongrid PLTS system.

# d. Roof Area of Building 4



As shown in the picture, the total roof area of Building 4 of the Ministry of Politics, Law and Human Rights has a length of about 48m while the width is about 14 m so that the total roof area of building 4 is 672 m<sup>2</sup> where this is the last floor of building 4 and later a rooftop will be built for the installation of the ongrid PLTS system. 3. Solar Panels Used

In this study, the solar panel components used are monocrystalline types with 1 solar panel with a maximum power of 550 wp installed on the roof. The use of this monocrystalline type is due to the TKDN (Domestic Component Level) value of 40% and the output produced is greater because the efficiency produced is much better and the use of this panel is one way to maximize land and costs because the larger the panel, the cheaper the price.

Tuber I Dutu bileet of bolur I uners esed			
Cell Type	Monocrystalline		
<b>Rated Maximum Power</b>	550 W		
Module Efficiency	21,3%		
Nominal Operating Cell	45°C		
Temperatur			
alfaP	-0,350%/°C		

Tabel 1 Data Sheet of Solar Panels Used

4. Basic Electricity Tarif

The difference in performance limits also affects the difference in basic electricity tariff groups. For example, for electricity group R1/TR 900 VA, you must pay a basic electricity tariff of IDR 1,352/kWh. If you use the 1,300 VA to 2,200 VA group, the basic electricity price you pay is IDR 1,444/kWh. Understanding electricity tariff groups makes it easier for you to calculate your monthly electricity bill. The following are the basic electricity tariffs issued by PLN in November 2024:

No	Tariff Class	Power Limit	Usage Cost (Rp/kWh)
1	R-1/TR	900VA-RTM	Rp.1.352,00
2	R-1/TR	1.300 VA	Rp.1444,70
3	R-1/TR	3.500-5.500 VA	Rp.1444,70
4	R-2/TR	6.600 VA ke atas	Rp.1.699,53
5	R-3/TR	6.600 VA ke atas	Rp.1.699,53
6	S-2/TR	6.600 VA ke atas	Rp.1444,70
7	B-2/TR	6.600 VA-200 kVA	Rp.1444,70

Source: Electricity Tarif November 2024 PLN

## **RESULTS AND DISCUSSION**

1. Roof Area Calculation

According to Presidential Decree no. 22 of 2017 concerning the National Energy

General Plan, government buildings are required to install solar panels on at least 30% of the roof area. The solar panel system that will be applied to this building is the On-Grid system to supply lighting panels for corridors and other public areas. Calculations are needed to ensure the roof is sufficient to accommodate all solar panels that will later be installed at the Ministry of Politics, Law and Human Rights.

a. Calculation of Roof Area on Building 1

Based on Figure 4.7, it can be seen that the total roof area that will be used in the installation of PLTS in Building 1 is 279 m<sup>2</sup>. Then the percentage of the total building area with the area where the PLTS will be installed can be calculated. It is as follows

Given the area for PLTS (Rooftop) as	s follows:
Building I	
Production 1	$= \mathbf{P} \mathbf{x} \mathbf{L}$
	= 9m x 18m
	$= 162 \text{ m}^2$
Production 2	$= \mathbf{P} \mathbf{x} \mathbf{L}$
	= 9m x 13m
	$= 117m^{2}$
Total building area	= Production $1 +$ Production $2$
	$= 279 \text{ m}^2$

Based on Figure 4.10, it can be seen that the total roof area of Building 1 at the Ministry of Politics, Law and Human Rights is 672 m<sup>2</sup>. Then the percentage of the total building area with the area where the PLTS will be installed can be calculated. It is as follows:

 $\% = \frac{\text{roof area solar panel area}}{\text{total roof area}}$  $\% = \frac{\frac{279m^2}{672m^2}}{\%} = 41,5\%$ 

According to Presidential Decree No. 22 of 2017 concerning the National Energy General Plan, government buildings are required to install solar panels on at least 30% of the roof area.

b. Calculation of Roof Area on Building 2

Based on Figure 4.7, it can be seen that the total roof area that will be used in the installation of PLTS in Building 2 is 189 m<sup>2</sup>. Then the percentage of the total building area with the area where the PLTS will be installed can be calculated. It is as follows

Given the area for PLTS (Rooftop) as follows:

Building II

Production 1	$= P \times L$	
	= 7m x 13,5m	
	= 94,5 m^2	
Production 2	$= P \times L$	
	= 7m x 13,5m	
	= 94,5 m^2	
Total building area	= Production 1 + Production 2	
	= 189 m^2	

Based on Figure 4.10, it can be seen that the total roof area of Building 2 at the Ministry of Politics, Law and Human Rights is 506 m<sup>2</sup>. Then the percentage of the total building area with the area where the PLTS will be installed can be calculated. It is as follows:

04	_ <u>roof</u> area solar panel area
90	total roof area
	$0_{0} - \frac{189m^{2}}{1}$
	$506m^2$
	% = 37,3%

According to Presidential Decree No. 22 of 2017 concerning the National Energy General Plan, government buildings are required to install solar panels on at least 30% of the roof area.

c. Calculation of Roof Area on Building 3

Based on Figure 4.7, it can be seen that the total roof area that will be used in the installation of PLTS in Building 3 is 189 m<sup>2</sup>. Then the percentage of the total building area with the area where the PLTS will be installed can be calculated. It is as follows

Given the area for PLTS (Rooftop) as follows:

Building II	
Production 1	$= P \times L$
	= 7m x 13,5m
	= 94,5 m^2
Production 2	$= P \times L$
	= 7m x 13,5m
	= 94,5 m^2
Total building area	= Production 1 + Production 2
	= 189 m^2

Based on Figure 4.10, it can be seen that the total roof area of Building 3 at the Ministry of Politics, Law and Human Rights is 506 m<sup>2</sup>. Then the percentage of the total building area with the area where the PLTS will be installed can be calculated. It is as follows:

$$\% = \frac{\text{roof area solar panel area}}{\text{total roof area}}$$
$$\% = \frac{\frac{279m^2}{672m^2}}{\%} = 41,5\%$$

According to Presidential Decree No. 22 of 2017 concerning the National Energy General Plan, government buildings are required to install solar panels on at least 30% of the roof area.

d. Calculation of Roof Area on Building 4

Based on Figure 4.7, it can be seen that the total roof area that will be used in the installation of PLTS in Building 4 is 279 m<sup>2</sup>. Then the percentage of the total building area with the area where the PLTS will be installed can be calculated. It is as follows

Given the area for PLTS (Rooftop) as follows:

Building I	
Production 1	= P x L
	= 9m x 18m
	$= 162 \text{ m}^2$
Production 2	= P x L
	$=9m \times 13m$
	$= 117m^{2}$
Total building area	= Production 1 + Production 2
	$= 279 \text{ m}^2$

Based on Figure 4.10, it can be seen that the total roof area of Building 4 at the Ministry of Politics, Law and Human Rights is 672 m<sup>2</sup>. Then the percentage of the total building area with the area where the PLTS will be installed can be calculated. It is as

follows:

$$\% = \frac{\text{roof area solar panel area}}{\text{total roof area}}$$
$$\% = \frac{279m^2}{672m^2}$$
$$\% = 41,5\%$$

According to Presidential Decree No. 22 of 2017 concerning the National Energy General Plan, government buildings are required to install solar panels on at least 30% of the roof area.

e. Calculation of building loads

Table 3 Estimated Building Load Calculation for Weekdays (Monday-Friday)

No	Information	Power Connected (Watt)	Energy needed (Wh)	
Α	Building 1	232.783	1.607.735	
В	Building 2	171.604	1.236.833	
С	Building 3	171.604	1.236.833	
D	Building 4	232.783	1.607.735	
TOTAL		808.774	5.689.136	

Table 4 Estimated Building Load Calculation for Holidays (Saturday-Sunday)

No	Information	Power Connected (Watt)	Energy needed (Wh)
Α	Building 1	53.363	152.583
В	Building 2	47.248	124.443
С	Building 3	47.248	124.443
D	Building g 4	53.363	152.583
	TOTAL	201.222	554.052

We can see based on the table above every day, that on weekdays the total power installed in the Ministry of Political, Legal and Security Affairs building is 808,774 Watts with a total energy used of 5,689,136 Wh and on holidays the total power installed is 201,222 Watts and the total energy used is 554,052 Wh so that in a week the total energy used in the Ministry of Political, Legal and Security Affairs Building is 29,553,784 Wh. and if calculated per day the estimated total energy used in the Ministry of Political, Legal and Security Affairs Building is 4,221,969,143 Watts (4,222 kWh).

f. Solar Panel Energy Calculation

The electrical energy produced by solar panels can be calculated using the formula described in equations (1), (2), (3), (4), and (5), namely as follows:  $(T_{C}NOCT = T_{C}NOCT)$ 

$$\begin{aligned} f_{temp1} &= 1 + \alpha p[T_a + I_T \left(\frac{1 + NOCT - I_a NOCT}{I_T NOCT}\right) - T_{c,STC}] \\ f_{temp1} &= 1 + (-0,00350)[29,47 + 0,504 \left(\frac{45 - 20}{0,8}\right) - 25] \\ f_{temp1} &= 1 + (-0,00350)[29,47 + 15,75 - 25] \\ f_{temp1} &= 1 + (-0,00350)[20,22] \\ f_{temp1} &= 0,9292 \\ f_{temp2} &= 1 + \alpha pI_T \left(\frac{T_C NOCT - T_a NOCT}{I_T NOCT}\right) \frac{\eta_{mp}}{0,9} \\ f_{temp2} &= 1 + (-0,00350)0,504 \left(\frac{45 - 20}{0,8}\right) \frac{0,2130}{0,9} \\ f_{temp2} &= 1 + (-0,00350)0,504(31,25 x0,2366) \\ f_{temp2} &= 1 + (-0,00350)(15,75x0,2366) \end{aligned}$$

$$f_{temp2} = 0,9869$$

$$f_{temp} = \frac{f_{temp1}}{f_{temp2}} = \frac{0,9292}{0,9869} = 0,9415$$

$$P_{PV} = P_{PVSTC} \times f_{PV} \times f_{temp} \left(\frac{l_T}{l_{TSTC}}\right)$$

$$P_{PV} = 550 \times 0,85 \times 0,9415 \left(\frac{0,504}{1}\right)$$

$$P_{PV} = 0,2218 \text{ kW}.$$

Time	Ta(°C)	$IT(kW/m^2)$	$P_{pv}(kWh)$
07.00-08.00	27,35	0,347	0,1561
08.00-09.00	28,44	0,412	0,1836
09.00-10.00	29,23	0,493	0,2174
10.00-11.00	30,17	0,546	0,2388
11.00-12.00	30,35	0,691	0,2979
12.00-13.00	30,46	0,675	0,2913
13.00-14.00	31,74	0,593	0,2566
14.00-15.00	30,83	0,482	0,2115
15.00-16.00	28,73	0,437	0,1941
16.00-17.00	27,44	0,364	0,1635
Average	29,47	0,504	0,2218
Total Energy(kWh/day)		2,22	

Next we calculate in one day.

= Ppv x Number of Panels

= 2.22 kWh x 376 Panels

= 835 kWh/day

Based on the calculations that we do manually using the equation above, it can be seen that the energy produced by solar panels with a total of 376 panels is 835 kWh/day. And if we calculate it per month (30 days) then the energy produced by the panel is 25,050 kWh/month, the energy produced by solar panels can change (unstable) due to the influence of the IRM value and temperature at the research location.

## 2. Economic Aspects

a. Calculating Initial Investment Costs

Here will be explained how much each main component that will be used costs. This price information is obtained from the cost price details calculated by the related party. From here you can see how much initial investment must be spent[2][3].

No	Component	Volume	Unit price	Total price
1	Solar Panel Soltera 550 Wp	376	Rp.3.400.532	Rp.1.288.000.000
2	Inverter 15 kW	8	Rp.93.750.000	Rp.750.000.000
3	Inverter 11 kW	8	Rp.75.000.000	Rp.600.000.000
3	Box Panel	4	Rp.8.000.000	Rp.32.000.000
4	Grounding Fullset	4	Rp.3.000.000	Rp.12.000.000
5	Cables and Other	1	Rp.10.000.000	Rp.10.000.000
	Accessories			
6	Installation costs	1	Rp.365.000.000	Rp.365.000.000
7	Unforeseen expenses	1	Rp.552.661.440	Rp.552.661.440
	Initial	Rp. 3.609.661.440		

Table 6 Initial Investment Costs for Installing Ongrid PLTS

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#### b. Maintenance Cost Calculation

Operational & maintenance costs based on NREL's reference are 1%-2% of the initial investment cost. This PLTS will be planned to operate for 25 years, so the maintenance cost of this PLTS for each year is 1% of the initial investment, so the maintenance cost is IDR 36,096,614/year.

Operation & Maintenance Cost	= 1% x Initial Investment
	= 1% x Rp.3,609,661,440
	= Rp.36.096.614 / year

c. Maintenance Cost Calculation

In this study, the solar power plant used will operate for 25 years according to the service life of the solar panels. The discount rate used is i = 6% which is calculated using the following equation:

$$Aw = A \frac{(1+i)^n - 1}{i(1+i)^n} = 36.096.614 \frac{(1+0.06)^{25} - 1}{0.06(1+0.06)^{25}}$$
$$Aw = 36.096.614 \text{ x } 13 = 469.255.982$$

Description:

Aw = Present value cost for total maintenance and operational costs during n years of project life

A = Maintenance cost

n = Panel usage period

LCC = Life cycle cost

Fixed maintenance costs for a period of 25 years amount to Rp469,255,982, then the life cycle costs can be determined as follows:

LCC = Ct + Aw

LCC = 3,609,661,440+ 469,255,982= 4,078,917,422

Based on the calculations above, the life cycle costs for the Design of the On-Grid Grid System PLTS at the Ministry of Politics, Law and Security Building in Penajam Paser Utara Regency, East Kalimantan for 25 years are Rp..4.078.917.422.

d. Payback Period

Payback Period is when income can cover the initial investment value without thinking about further income. The shorter the period to return the initial investment, the better. By knowing the initial investment value, operating or maintenance costs and income turnover. To assume 0%. Initial investment according to the calculation of solar panel modules, inverters along with operating costs as follows:

Income / Annual

= 1 Year Solar Power x Tariff / kWh = 300,504 kWh x Rp. 1,444.70 / kWh

= Rp. 434,138,129 / Year

Then the Payback Period value is obtained as follows:



e. HOMER Pro Software Simulation

In the HOMER Pro software, simulations are carried out according to the same PLTS component specifications and using the same prices. The following are the results of the HOMER Pro software



Figure 3 Results of economic aspects

Based on the image above, the energy produced by solar panels on the Ministry of Political, Legal and Security Affairs Building is 307,061 kWh for one year or 19.7% and PLN's contribution is 80.3%, this result is obtained from the HOMER Pro software program. With a total of 376 panels with a power of 550 Wp per panel and a total of 8 inverters with a capacity of 15,000 Watts per unit and an inverter capacity of 11,000 Watts with a total of 8 units. with a COE value of Rp. 1,356 / kWh and will return on investment for 8.55 years.

## CONCLUSION

Based on the calculations, it can be seen that the planning of the PLTS with an ongrid system at the Ministry of Politics, Law and Security Building will use the roof area of building 1 and building 4 of around 41.5% and building 2 and building 3 of around

37.3%, which is in accordance with Presidential Regulation no. 22 of 2017 concerning the National Energy General Plan that government buildings are required to install solar panels on a minimum of 30% of the roof area. Based on the calculations, it can be seen that the planning of the PLTS in this building will support a load of 19.7% of the total daily energy use, while the contribution given by PLN is 80.3%. Based on manual calculations, it can be seen that the payback period, initial investment is IDR 3,609,661,440 with an average annual income of IDR 434,138,129 and operational and maintenance costs of IDR 36,096,614 and will return after 9.1 years, but based on simulations using HOMER Pro software, the payback period value is 8.55 years, this is not much different from the results of manual calculations because the price of PLTS components in the HOMER Pro software is the same as the price in manual calculations.

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