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Feasibility Study of Solar Power Generation System for Public Street Lighting

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Abstract. One of the uses of electricity that is widely used by society today is as a source of lighting. The increasing level of community mobility makes all activities require lighting. One part that is important and requires lighting is a highway or public road. PJU is a lighting lamp that is public (for the common good) and is usually installed on roads and certain places such as parks and other public places. PJU (street lighting) or road lighting is a light source that is installed as street lighting at night. Public street lighting using solar power is a cheap and economical alternative to be used as a source of lighting electricity because it uses a new and unlimited renewable energy source that comes from nature, namely solar energy. This study aims to determine the feasibility of solar street lighting in the future as a substitute for conventional public street lighting in the future by looking at the Net present cost, and Break even point assisted by HOMER software version 3.10.3. And the results obtained from the calculation of the Net present cost of conventional street lighting costs less, which is only Rp. 30,245,473 and the Net present cost of solar street lighting costs an initial investment of Rp. 128,341,312 and the BEP (Break even point) graph that has not been found to break even.

Keywords: Break Even Point, Lamp, Net Present Cost, Public Street Lighting, Software, Solar Power

1. Introduction

One of the uses of electricity that is widely used by society today is as a source of lighting. The increasing level of community mobility makes all activities require lighting. One part that is important and requires lighting is a highway or public road. PJU is a lighting lamp that is public (for the common good) and is usually installed on roads and certain places such as parks and other public places. PJU (street lighting) or road lighting is a light source that is installed as street lighting at night. Public street lighting using solar power is a cheap and economical alternative to be used as a source of lighting electricity because it uses a new and unlimited renewable energy source that comes from nature, namely solar energy. The purpose of this study is to determine whether or not it is appropriate for solar street lighting to replace conventional street lighting on the Bumiayu wage market street with the help of Homer software and calculations outside of Homer software and a comparison of NPC, COE and BEP within a period of 25 years.

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2. Methods

This research was conducted to plan a solar street lighting lamp (Solar Cell) for a feasibility study to replace conventional street lighting lamps. The research procedure in this research is assisted by Homer software which is used as a simulation tool for planning solar street lighting (Solar cell) as well as calculations outside the Homer software. The simulation process on Homer is carried out to determine the characteristics or performance of a generating system. And the process carried out outside the Homer software is merging the results of the Homer software with components that are not included in the software. The parameters are total production (kWh/year), energy consumption (kWh/year), Net present cost (NPC), Cost of energy (COE), and Break event point (BEP). The design of this study was carried out based on an analysis to determine the optimal system configuration based on costs in Figure 1 and Figure 2 shows the implementation flowchart.

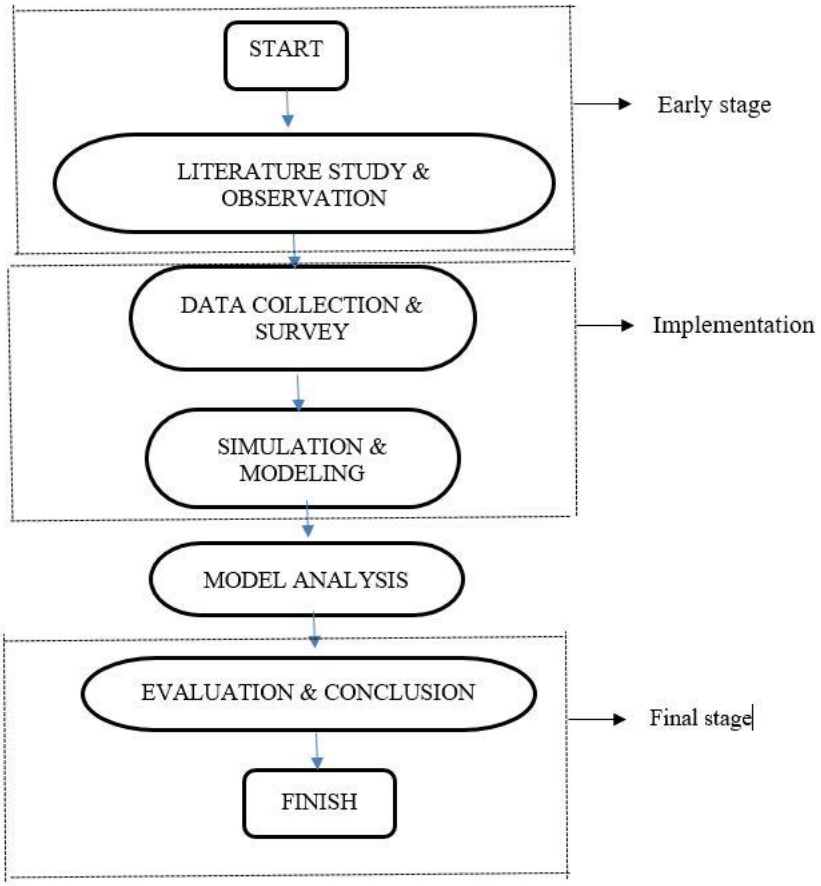

Figure 1. Research Design Flowchart

2.1 Figure 1 explains how the research process is carried out starting from literature studies, simulations and modeling to getting results.

2.1.1 Early stage

In the early stages, literature studies and observations are carried out to find relevant information about the research.

2.1.2 Implementation

In this section, data collection and surveys as well as simulation and modeling are carried out.

2.1.3 Final Stage

and in the last stage, evaluation and conclusion from the data and simulation are carried out

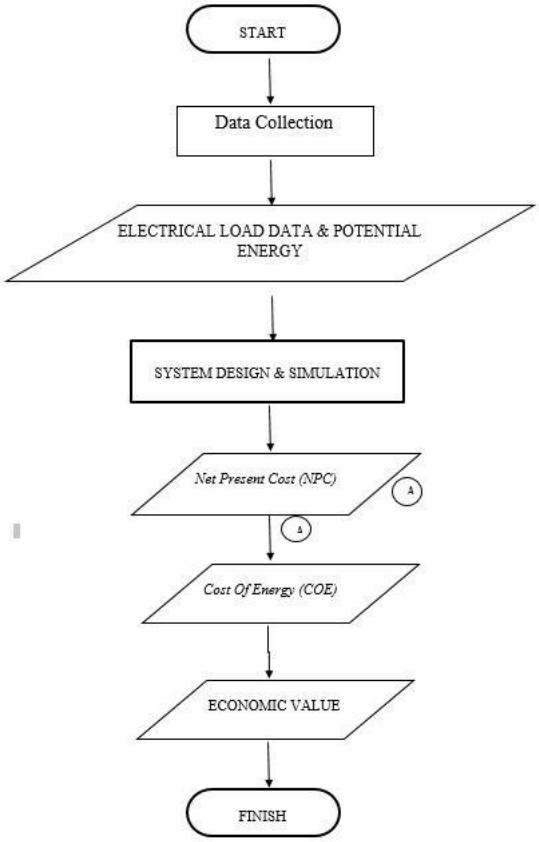

Figure 2. Implementation Flowchart

2.2 Figure 2 shows a flowchart of the implementation carried out by researchers to get the results along with the stages :

2.2.1 Data collection

The data collection carried out by the study was data collection from PLN UPJ Bumiayu and the Brebes Regency Transportation Service and data obtained from the NASA website. The data taken are electrical load data, specifications for lamps and public street lighting poles and solar radiation data.

2.2.2 Design and simulation

In design and simulation, the data taken is designed and will be simulated by Homer software, the Homer software will simulate several data components that have been obtained then will be combined with data that cannot be entered into Homer software and will produce the Net present cost and cost of energy.

2.2.3 Economic value

The economic value in this study is BEP (Break even point), after getting the results from planning and simulation, a comparison of the accumulation between conventional public street lighting and solar street lighting is carried out and a BEP graph is made.

3 Results and Discussion

3.1 Specifications of Solar Street Lights

In doing the calculations, the writer needs to know the specifications of the components of public street lighting that will be used in this study. Below are the components that will be used in planning a feasibility study for solar street lighting that will be installed at 10 points. Can be seen in Table 1.

Table 1. Specifications of solar street lighting components

Num	Component	Unit
1	LAMP PJU OSRAM LED 12V 60 Watt	10
2	BATTERY CHARGE REGULATOR CMTP02 PWM 15A	10
3	SMT 1265 LEAD ACID BATTERY 12V 65AH	10
4	SOLAR PANEL SUNLITE 200Wp	10
5	SOLAR POWER KNVERTTER 1500 W	10
6	POLE PJU OCTAGONAL	10
7	INSTALLATION & ACCESSSORIES	10

3.2 System Design

In carrying out the calculations, the researcher was assisted by the HOMER software, where this software helped researchers to design a schematic of solar street lighting to generate Net Present Cost (NPC), and others. here is the link or web to access the HOMER software: https://www.homerenergy.com/products/pro/index.html.However, in using the HOMER software, the researcher did not include all the components that would be used, because the HOMER software contained several components that the researcher could not input such as PJU lamps, battery charge control, lamp posts and other installations and accessories. in Table 2 components that exist in the Homer software and components outside the Homer software.

Table 2. Components in Homer and outside Homer

Component on HOMER			
Component	**Value**	**Unit**	**Size**
PV SUNLITE 200Wp	Rp.1.325.000	10	200 Wp
CONVERTER	Rp.450.000	10	1.500 Watt
BATTERY LEAD ACID SMT1265	Rp.1.585.000	10	12v 65AH
Component outside HOMER			
LAMP PJU OSRAM	Rp.1.700.000	10	60 watt 12v
BCR PWM	Rp.220.000	10	15 A
POLE OCTAGONAL	Rp.1.500.000	10	8 Meter
INSTALLATION & ACC	Rp.1.000.000	-	-

There are 7 components or tools that will be used for solar street lighting on Jalan Pasar Wage Bumiayu. There are two separate component parts between components that can be included in the software and those that are not included in the software. The HOMER software can only include a few components, such as Photovoltaic (solar cell), converter, and battery. And other components that cannot be included in the HOMER software are PJU lamps (public street lighting), battery charge control, octagonal light poles, as well as necessary installations and accessories.

3.3 Load Data

The load data used in this study were obtained from PLN UPJ Bumiayu. The load data used, namely the consumption of electrical energy (kWh) of conventional public street lighting per month during 2021 can be seen in Table 3.

Table 3. Monthly data on conventional 2021 PJU electricity bills

Month	Power	kWh	Bills
January	1300	196	Rp.283.161
February	1300	196	Rp.283.161
March	1300	178	Rp.257.157
April	1300	196	Rp.283.161
May	1300	187	Rp.270.159
June	1300	193	Rp.278.827
July	1300	173	Rp.248.488
August	1300	213	Rp.307.721
September	1300	191	Rp.275.938
October	1300	188	Rp.271.604
November	1300	189	Rp.273.048
December	1300	189	Rp.273.048
Total		2.288kWh	Rp.3.305.473

The data obtained from PLN UPJ Bumiayu shows energy consumption in a year and electricity bills in a year. The energy consumption of conventional PJU in 2021 is 2,288 kWh and the electricity bill is Rp. 3,305,473.

Table 4. Component data of conventional public street lighting

Component	Cost	Unit
Lamp HPS 250w	Rp.1.370.000	10
Lampshade E27	Rp.3.000.000	10
Pole Lamp	Rp.4.500.000	3
Installation & Acc	Rp.10.000.000	10

Table 4 shows some of the components used in conventional public street lighting lamps on Jalan Pasar Wage Bumiayu, it appears that there are only 3 lamp pole units because, after a field survey, 7 other lamps are attached to the electricity pole and there are only 3 which uses a standalone lamppost.

3.4 Economic analysis of conventional PJU techniques

3.4.1 *Net present cost (NPC)*

The net present cost (or life-cycle cost) of a Component is the present value of all the costs of installing and operating the Component over the project lifetime, minus the present value of all the revenues that it earns over the project lifetime. HOMER calculates the net present cost of each Component in the system, and of the system as a whole. The *net present cost* is used to determine the total costs incurred. The division of component costs for calculating the results of the Net present cost can be seen in the following equation:

NPC = Capital costs + Replacement costs + O&M costs + Fuel costs – salvage
= Rp.22.175.473 + Rp.7.850.000 + Rp.220.000 + Rp.0 – Rp.0
= Rp.30.245.473

From the following equation, the results of the net present cost of conventional public street lighting can also be seen in more detail in Table 5.

Table 5. *Net present cost* of conventional public street lighting

Component	Value	Raplacement	O&M	Fuel	Salvage
Lamp HPS 250w	Rp.1.370.000	Rp.6.850.000	Rp.0	Rp.0	Rp.0
Lampshade E27	Rp.3.000.000	Rp.0	Rp.0	Rp.0	Rp.0
Pole Lamp	Rp.4.500.000	Rp.0	Rp.0	Rp.0	Rp.0
Installation & Acc	Rp.10.000.000	Rp.1.000.000	Rp.220.000	Rp.0	Rp.0
Grid (PLN)	Rp.3.305.473	Rp.0	Rp.0	Rp.0	Rp.0
Total	Rp.22.175.473	Rp.7.850.000	Rp.220.000	Rp.0	Rp.0
Total				Rp.30.245.473	

3.4.2 *Annualized cost* (AC)

The total annualized cost is the annualized value of the total net present cost ,Annualized cost is used to find out the total annual costs incurred. The annual cost of conventional public street lighting is Rp. 1,835,900.

AC = capital costs + Replacement cost + O&M costs + Fuel costs – salvage
= Rp.1.346.051+ Rp.476.495 + Rp.13.354 +Rp.0 – Rp.0
= Rp.1.835.900

3.4.3 *Cost of energy* (COE)

COE as the average cost per kWh of useful electrical energy produced by the system.,The cost of energy produced is Rp.802.4/kWh.

3.5 *Economic analysis of solar power PJU engineering with Homer*

3.5.1 *Net Present Cost* (NPC)

As for the costs that will be incurred to buy components in the solar street lighting project, which costs have been combined with components that are not included in the HOMER software system, the cost is Rp. 112,663,064 and can be seen in Table 6

NPC = *Capital costs* + *Replacement costs* + *O&M costs* + *Fuel costs* – *salvage*
= Rp.78.300.000 + Rp.122.100.000 + Rp.1.253.386 + Rp.0 – Rp.88.990.332
= Rp.112.663.064

Table 6. Combined cost results (NPC)

Component	Value	Raplacement	O&M	Fuel	Salvage	
PV 200Wp Sunlite	Rp.13.250.000	Rp.0	Rp.0	Rp.0	Rp.0	
Converter	Rp.4.500.000	Rp.0	Rp.1.253.386	Rp.0	Rp.1.840.322	
Battery 65 Ah 12v	Rp.15.850.000	Rp.31.700.000	Rp.0	Rp.0	Rp.15.850.000	
Lamp PJU OSRAM 60W	Rp.17.000.000	Rp.85.000.000	Rp.0	Rp.0	Rp.68.000.000	
BCR PWM	Rp.2.200.000	Rp.4.400.000	Rp.0	Rp.0	Rp.3.300.000	
Pole PJU Ocragonal	Rp.15.000.000	Rp.0	Rp.0	Rp.0	Rp.0	
Installation & Acc	Rp.10.500.000	Rp.1.000.000	Rp.0	Rp.0	Rp.0	
Total	Rp.78.300.000	Rp.122.100.000	Rp.1.253.386	Rp.0	Rp.88.990.332	Rp.112.663.064

3.5.2 *Annualized cost* (AC)

AC = *capital costs* + *Replacement cost* + *O&M costs* + *Fuel costs* – *salvage*
= Rp.4.752.810 + Rp. 7.411.470 + Rp. 76.080 + Rp.0 – Rp.5.401.712
= Rp.6.840.648

the total annual cost incurred is Rp. Rp.6.840,648

3.5.3 *Cost Of Energy* (COE)

The cost of energy is calculated to determine the costs incurred 1 kWh of the system design. The cost of energy produced is Rp.2,300 kWh.

3.5.4 *Break even point*

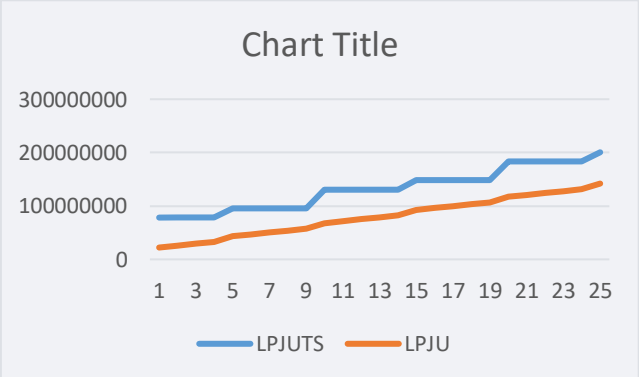

Figure 4. BEP Grap with PV 200 Wp

It can be seen in Figure 4 the researcher uses the 200 Wp which is in accordance with the load requirements and in Figure 4 the break-even point or (BEP) within a period of 25 years has not occurred. the break-even point (BEP), shown in Figure 4, the blue line shows the graph of solar street lighting and the orange line shows the graph of conventional public street lighting, the graphic form of the solar street lighting continues to climb, which means the public street lighting lamp Solar power for the Pasar Wage road has not been able to replace conventional public street lighting at this time.

3.6 Analysis Results

The electrical energy produced is used for the needs of public street lighting on Jalan Pasar Wage Bumiayu, to illuminate public roads at night. As many as 10 solar street lightings have been installed along Pasar Wage Bumiayu Street. In the results of this analysis, the results of the comparison between solar street lighting lamps and lighting lamps. The electrical energy produced is used for the needs of public street lighting on Jalan Pasar Wage Bumiayu, to illuminate public roads at night. As many as 10 solar street lightings have been installed along Pasar Wage Bumiayu Street. In the results of this analysis, the results of the comparison between solar street lighting lamps and conventional public street lighting lamps are obtained. And the comparison can be seen in Figure 16, the comparison table for conventional public street lighting with solar street lighting.

Table 7. LPJUTS comparison table with conventional LPJU

Parameter	Solar LPJU	Convensional LPJU
Energy total (kWh)	2.974 kWh	2.288kWh
Net Present Cost (Rp.)	Rp.112.663.064	Rp.30.245.473
Annualized Cost (Rp.)	Rp.6.840.648	Rp.1.835.900
Cost Of Energy	Rp.2.300 per kWh	Rp.802 Per kWh
Renewable Penetration	95,3%	-

4 Conclusion

From the results of the research that has been carried out, it can be concluded several things as follows:

From this study, obtained by using PV 160 Wp is still not able to meet the needs of the load which only produces 0.411 kW, therefore in this study using PV 200 Wp which is able to meet the needs of the load by producing 0.77kW where the load requirement is 0.72 kW. And the results of these calculations come from simulations in the Homer application where pV 160 Wp in simulations and calculations in Homer produces 114 kW, while PV 200Wp produces 0.72kW in simulations and calculations in Homer software.

When viewed from the calculation of the Net present cost, conventional street lighting costs less, which is only Rp. 30,245,473 and Net presnt cost of solar street lighting, the initial investment cost is Rp. 112,663,064 difference Rp.82,417,591

And if you look at the BEP (Break even point) in the graph, the break even point has not been found where this BEP comes from the accumulation of Capital (price), Placement (replacement) and Operations, which means solar street lighting planned by researchers As an energy saving, public street

lighting is currently not feasible to replace conventional public street lighting on Jalan Pasar Wage Bumiayu in terms of economic value.

For further research, further studies need to be carried out by covering more data and getting better results regarding the comparison of energy savings in solar street lighting on Pasar Wage Bumiayu Street.

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