INDONESIAN JOURNAL OF MULTIDISCIPLINARY SCIENCE

P-ISSN: 2808-5957
E-ISSN: 2808-6724
ijoms.internationaljournallabs.com

EVALUATING AND ANALYZING THE SOLAR PUBLIC STREET LIGHTING UTILIZATION: A CASE STUDY IN MANOKWARI

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ARTICLE INFO

Published: May 26th, 2023

Keywords: *PSL, SPSL, NPV, IRR, B/C Ratio*

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ABSTRACT

Public Street Lighting (PSL) is one of the complementary road buildings used to illuminate the road. Solar Public Street Lighting (SPSL) is used in several places in Indonesia. Based on the background above, the objectives of this study are (1) to obtain the results of technical analysis of SPSL, (2) to obtain the results of economic analysis of SPSL development using investment schemes. The research was conducted in Manokwari Regency, West Papua. The research data were obtained from the results of measurements on solar panels to solar charge controllers and measurements from solar charge controllers to batteries in sunny, cloudy or rainy weather conditions from 08:00 WIT to 17:00 WIT. Economic analysis is carried out to obtain the parameters of Net Present Value (NPV), and Benefit Cost Ratio (B/C Ratio) with discount rates of 10% and 0%. The results showed that (1) based on technical analysis SPSL in Manokwari Regency has met public street lighting standards, in accordance with the Minister of Transportation Regulation No. 27 of 2018 concerning street lighting equipment. (2) An economic analysis shows that the development of SPSL with investment schemes is not feasible because the NPV value < 0 with an IRR of 10%, and a B/C Ratio of < 1. The construction of SPSL is economically feasible if the calculation of 0% IRR with the price of electricity per kWh reaches a value of IDR 14,411.32 or approximately ten times the price of Non-Subsidized PLN kWh electricity which is worth IDR 1,444.70.

INTRODUCTION

Roads are indispensable infrastructure in the transportation system to connect one place to another in order to meet economic, social and cultural needs. In the Law of the Republic of Indonesia Number 38 of 2004 concerning Roads, it is stated that roads as part of transportation infrastructure have an important role in the economic, socio-cultural, political, defense and security fields. To optimize road functions, one of the road complementary buildings is in the form of street lighting devices that are useful for realizing safety, security, order, and smooth traffic as well as convenience for road users in traffic (Falcitelli & Pagano, 2016; Gharaibeh et al., 2017; Oladimeji et al., 2023), which is also stated on the Regulation of the Minister of Transportation of the Republic of Indonesia from 2018. The use solar panels as public street lighting is an alternative to PSL that uses electrical energy sources from PLN because these solar panels are very energy-efficient, environmentally friendly and very easy to install and maintain (Allery, 2018).

Seeing the condition of the Utilization of Solar Public Street Lighting (SPSL) as Public Street Lighting in Manokwari Regency, to find out how much the feasibility of utilizing SPSL in Manokwari Regency needs to be carried out technical analysis and economic analysis.

The goal in this study is to obtain the results of the technical analysis of SPSL in Manokwari Regency and obtain the results of the economic analysis of SPSL development using an investment scheme.

METHOD

The research was carried out in Manokwari Regency, West Papua Province for 7 days from 25 to 31 August 2022, this research used tools in the form of voltage measuring devices and current measuring devices to determine the power generated on solar panels. The research flow diagram is shown in Figure 1. Starting from literature study, making observations, taking data, analyzing technically and economically, and concluding research results.

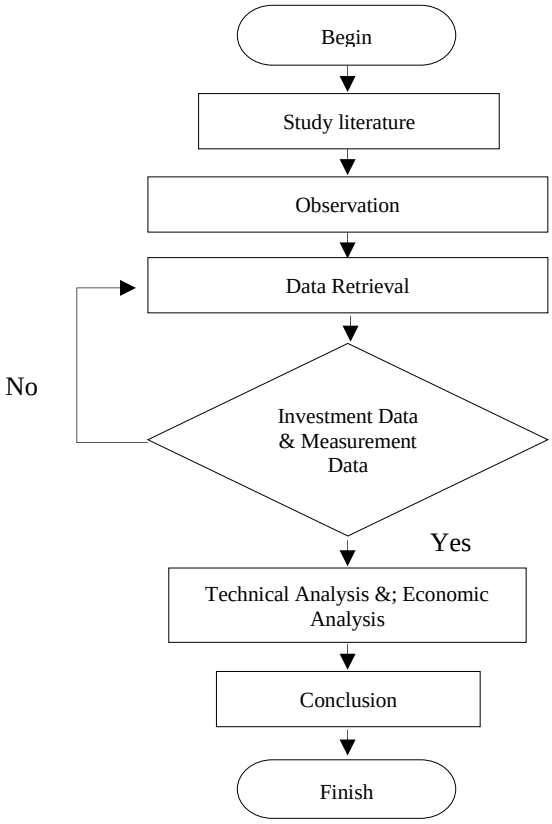

Figure 1. Research Methodology Flowchart

Solar Power Plant (SPP)

Solar Power Plant (SPP) is a power plant that utilizes solar energy sources by converting photon energy from sunlight into electrical energy using solar cells on solar panels (Wiguna et al., 2012). Pure silicon coatings and semiconductor materials are the main constituents of solar panels. Solar Power Plants generally consist of the following components: solar panels, charger controllers, batteries and inverters (Windarta et al., 2021).

SPP consists of on-grid SPP and off-grid SPP. On-grid SPP is a Solar Power Plant connected to the PLN electricity network, where the main component is an inverter, or Power Conditioning

Unit (PCU) which functions to convert direct current (DC) electricity produced by SPSL into alternating current (AC) electricity in accordance with the connected electricity network (Franklin, 2017). Off-grid solar is a stand-alone solar system that operates independently to produce ac or dc electricity as needed. Stand-alone solar power plants use batteries to store the electrical energy produced (Franklin, 2017).

Solar Public Street Lighting (SPSL)

Solar Public Street Lighting is public street lighting that utilizes solar power as a source of electrical energy (Akindipe et al., 2022; Hans & Tamhane, 2020). SPSL components consist of solar panels, charge controllers, batteries, and LED lights.

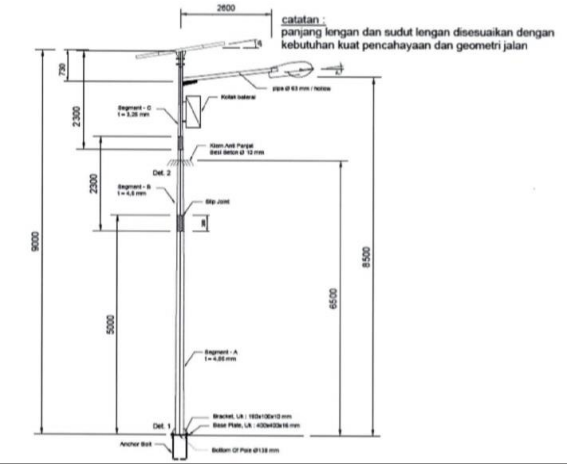

Figure 2. SPSL Scheme

Source: Minister of Transportation Regulation 2018 no 27 concerning street lighting equipment

Solar Panel

Solar research is a component that functions to convert solar energy into electrical energy (Quaschning, 2005). This panel is composed of several solar cells connected in series or parallel. Types of solar cells Polycrystalline Silicon, Monocrystalline Silicon, and Thin Film Solar Cell (TFSC).

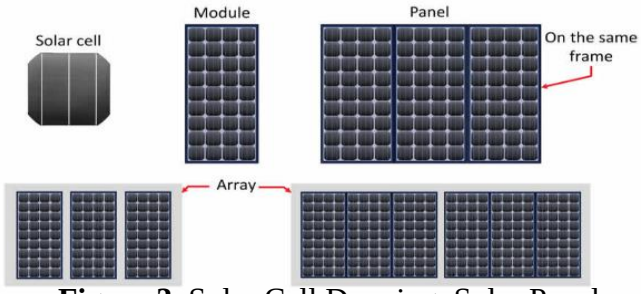

Figure 3. Solar Cell Drawing, Solar Panel

Source: netsolar.com

Solar Charger Controller

Solar Charge Controller is an electronic equipment used to regulate direct current charged to the battery and out from the battery to the load (Lokeshreddy et al., 2017). Solar charge controller prevents overcharging and protects the battery from overvoltage, as well as preventing the battery so that the electrical energy stored in it is not discharged until it runs out (Kencana et al., 2018)

Battery

Battery is a component of SPP that functions to store electrical energy produced by solar panels during the day, to be used at night. The batteries used in SPP are those that have Deep Discharge character types (Kencana et al., 2018)

LED Light

LED lamp (Light Emitting Diode) is a semiconductor component that has the main function as a source or producer of light (Borille et al., 2013).

Technical Analysis

Technical analysis is carried out based on the capacity of SPSL, as well as the power generated from SPSL. To determine the technical feasibility of SPSL using references from the Minister of Transportation Regulation No. 27 of 2018 concerning street lighting equipment.

Determining energy per day is calculated by the equation:

$$E_t = P_L \; x \; h \qquad (1)$$

Where E_t is the total compulsion of electrical energy per day (Watt/hour), P_L is the total power (Watt) and h is the usage time per day (hours).

Solar Panel

To determine the number of solar panels needed by SPSL, several calculations are carried out:

a) Knowing the nominal power of the module

$$P_n = V \; x \; I \qquad (2)$$

Where P_n is the nominal power of the module (Watts), V is the voltage (Volts), and I is the current (Amperes).

b) Knowing the amount of solar panel power to supply energy needs

$$\text{Total power} = \frac{(power \; x \; h \; x \; 1{,}3)}{5} \qquad (3)$$

c) Knowing the needs of solar panels

$$n = \frac{power\ consumption}{solar\ panel\ specifications} \qquad (4)$$

Where n is the number of solar panel requirements

Battery

To determine the battery capacity, calculations are made:

$$\text{Battery capacity} = \frac{E_t}{P_L}\ x\ \frac{1}{DOD} \qquad (5)$$

Where E_t is the total consumption of electrical energy per day (Watt/hour), P_L is the total power (Watt), and DOD is the Depth of Discharge.

Economic Analysis

Economic analysis is carried out to assess the investment feasibility of a project where this analysis uses NPV indicators, and B/C Racio with discount rates of 10% and 0%.

Net Present Value (NPV)

$$NPV = \sum_{t=1}^{n} \frac{NCF_t}{(1+i)^t} - II \qquad (6)$$

Where NCF_t is the Net Cash Flow period of the 1st year to the nth year, II is the initial investment, I is the discount rate, and N is the period of years (age of the investment). The feasibility indicators from the assessment of the calculation results of the Net Present Value (NPV) are:

1) If the Net Present Value (NPV) > 0, then the investment is worth implementing
2) If the Net Present Value (NPV) < 0, then the investment is not worth implementing

Internal Rate of Return (IRR)

$$IRR = i^1 + \frac{NPV^1}{NPV^1 - NPV^2}\ (i^1 - i^2) \qquad (7)$$

Where i^1 is the interest rate that produces a positive value of NPV (%), i^2 is the interest rate that produces a negative value of NPV (%), NPV^1 is a positive net present value and NPV^2 is a negative net present value. The decision-making criteria in IRR are if the IRR is > i (applicable

interest rate) then the investment is worth doing and if the IRR is < i (applicable interest rate) then the investment is not worth doing.

Benefit Cost Ratio

$$BCR = \frac{Benefit}{Cost} \qquad (8)$$

The reason used in this analysis is that if the ratio of B/C > 1 then the investment is worth doing, on the other hand, if B/C < 1, then the investment is not worth doing(Giatman. M, 2006). Investment data is obtained from e-catalog prices, and auction results on West Papua electronic procurement services, operational data is obtained from the results of wawancara in the field, and revenue data is obtained from solar panel power measurement data and prices generated from non-subsidized PLN kWh prices.

RESULT AND DISCUSSION

Technical Analysis

Seeing the Utilization of Solar Public Street Lighting (SPSL) as Public Street Lighting (PSL), to find out how much SPSL utilization needs to be done technical analysis to find out the specifications of SPSL that have been adjusted to needs.

The Need for Electrical Energy

From the time of turning on the SPSL in Manokwari Regency in the time span from 18.00 WIT to 06.00 WIT (12 hours) with the load (LED lights) used in this SPSL unit is an LED lamp with a power of 50 Watt. So to find out the amount of electrical energy needs or power consumption of 1 unit of SPSL lamps in the period of 18.00 – 06.00 is as follows:

Operating time = 12 Hours daily

Load = 50 Watts dc

Power requirements per day:

= 50 x 12 hours

= 600 Wh

= 600/1000 = 0.6 kWh

The annual power requirement is 219 kWh

Solar Panel

Solar panel data on SPSL is taken from the specifications of solar panels used at the research site. To determine the amount of generation (Power) produced by solar panels in sunny weather or during cloudy/rainy weather, measurements are made on solar panels without being given a load (Battery). Measurements are taken both in sunny and cloudy/rainy weather.

Measurements on solar panels are carried out from 08:00 WIT to 17:00 WIT every one hour per day. For sunny weather, measurements were taken for 4 days, namely August 25, 26, 27, and

29, 2022 and 3 days during cloudy/rainy weather, namely on August 28, 30, and 31, 2022. For measurement results in sunny weather, the average value of voltage, current and power output is obtained as shown in Table 1.

Table 1. Average Output of Solar Panel Voltage, Current, and Power When the Weather is Clear

No	Time	Voltage (Volt)	Current (Ampere)	Power (Watt dc)
1.	08:00	19,84	2,78	55,06
2.	09:00	19,62	4,73	92,77
3.	10:00	19,53	5,23	102,20
4.	11:00	19,53	6,41	125,15
5.	12:00	19,48	7,12	138,67
6.	13:00	19,51	5,41	105,44
7.	14:00	19,63	5,44	108,71
8.	15:00	19,56	3,91	76,43
9.	16:00	19,64	2,33	45,80
10.	17:00	19,13	0,83	15,92

Source: Research Measurement Results

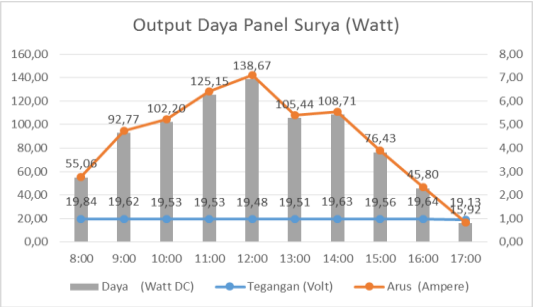

Figure 1. Daily Power Graph of Solar Panels in Sunny Weather

To determine the amount (power) produced by PV Panel during cloudy/rainy weather, measurements were taken for 3 days, namely on August 28, 30, and 31, 2022, the average measurement of voltage, current and power output as shown in Table 2.

Table 2. Average Output of Solar Panel Voltage and Current During Cloudy/Rainy Weather

No	Time	Voltage (Volt)	Current (Ampere)	Power (Watt dc)
1.	08:00	18,86	1,43	26,90
2.	09:00	19,36	2,56	49,63
3.	10:00	19,70	3,50	68,87
4.	11:00	19,68	4,68	92,17
5.	12:00	19,41	5,22	101,27
6.	13:00	19,74	3,12	61,67

7.	14:00	19,31	1,87	36,18
8.	15:00	19,67	2,46	48,31
9.	16:00	19,43	1,31	25,51
10.	17:00	18,88	0,70	13,22

Source: Research Measurement Results

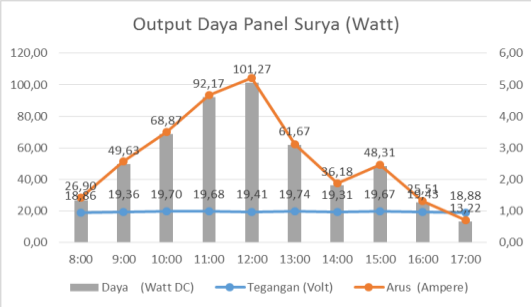

Figure 2. Daily Power Graph of Solar Panels in Cloudy/Rainy Weather

The measurement results show that solar irradiation at the optimum time to generate electricity on solar panels is 5 hours per day. Electrical energy produced by solar panels will experience power losses or power losses of 130% (Yuliarto, 2017). The requirements for a panel for SPSL with a power of 50 Watt and an operating time of 12 hours per day are:

= (50 x 12 x 1,3) / 5

= 156 Wp

If the capacity of solar panels is 155 Wp then the need for 1 unit of SPSL is:

= 156 / 155

= 1,006 units or 1 unit of solar panels, for 1 unit of SPSL

Battery Capacity and SPSL Lamp

The SPSL operating hour system operates for 12 hours per day from 18:00 to 06:00 WIT, so to find out the capacity of the battery and SPSL lamps, the calculation is carried out from the energy source to the load where the load used is a 50 W LED lamp according to the specifications of the components used. Lithium battery with a capacity of 20 Ah, 14.8 Volts, then the battery capacity to work to serve the load (LED lamp 50 W dc, 55 V) namely:

I_{dc} = (50 W x operating hours)/load voltage

= (50 W x 12 hours)/55 V

= 10.91 Ah.

Thus, in one day the battery operating hours needed to meet the need to turn on the 50 W dc lamp for 12 hours is 10.91 Ah, this means that the battery capacity decreases for 12 hours at night.

Based on the Regulation of the Minister of Transportation 2018 No. 27 about street lighting, that backing up solar energy for 3 days means that for 36 hours of use, the energy needs are:

E_t = P_L x h
= 50 x 36 hours
= 1800 Wh

Then the battery capacity used is:

I_{Ah} = 1800 / 55
= 32.73 Ah

By consideringthe depth of discharge (DOD) factor in accordance with the 2018 Minister of Transportation Regulation No. 27 at 80% then the required battery capacity is:

I_{Ah} total= I_{Ah} / *DOD*
= 32,73 / 80%
= 40.91 Ah

If using a battery with a capacity of 20 Ah, 14.8 V then the number of batteries needed is:

$\int_{battery}$ = 40.91 / 20
= 2.05 or 3 batteries

By using a type of lithium battery with a capacity of 20 Ah, 14.8 Volt @ 4 packs, and LED light loads with a capacity of 50 W, 55 V dc. Thus, SPSL can operate for three days even though the weather is cloudy/rainy without sunlight. However, this cannot guarantee that the battery can be fully charged again if cloudy/rainy weather conditions occur for a long time, especially if it enters the rainy season.

Looking at the measurement results on the solar panel for the output of voltage and current as shown in Table 1 and 2 it can be seen that the results of measurements in the field show that solar irradiation when the weather is sunny, the optimum time to generate electricity on solar panels is 5 hours per day, and the capacity of the battery in serving the load (LED lamp) is in accordance with solar public street lighting standards based on the Minister of Transportation Regulation 2018 No. 27 about street lighting devices.

Economic Analysis

Economic analysis is carried out by calculating based on the investment cost of SPSL where the investment life is 25 years, according to the age of solar panels. As well as operational and maintenance costs of SPSL, where investment costs come from the cost of installed SPSL components.

Cost of Investment

The cost of SPSL investment conducted at the research site in Manokwari Regency as shown in Table 3. where the initial investment cost for SPSL units.

Table 3. Investment Cost of 1 Unit of SPSL

No.	Description	Quantity	Unit Price (IDR)	Total Price (IDR)
I	***Mobilization Work***			
	Mobilization	Parcel	3.500.000	3.500.000
II	***Procurement and Installation***			

1	Solar Panel 155 WP	1	4.850.000	4.850.000
2	Street Light PLM 971	1	2.500.000	2.500.000
3	Lithium Battery x 4 Pack	1	7.500.000	7.500.000
4	LED Driver DH 100 Li + Solar Charging Controller Venus	1	1.532.800	1.532.800
5	Solar Mounting	1	1.250.000	1.250.000
6	Rotor RM 1762	1	1.250.000	1.250.000
7	Rotor Control D 132	1	1.000.000	1.000.000
8	7M Octagonal Mast	1	5.500.000	5.500.000
9	Installation and Installation	1	6.790.000	6.790.000
Total Price				**35.672.800**

The initial investment per unit of SPSL at the research location amounted to IDR 35,672,800.

Investment of LED Lights and Batteries

Investment of LED lights and Batteries for investment for 25 years. For LED lamps seen from the lamp operating hours (Permenhub No. 27 of 2018 on street lighting devices) is 36,000 hours. In one day the lamp is on for 12 hours so that the lamp is used for 36,000 : (12 x 365) = 8.22 years. Because the investment life is 25 years, it will be carried out with 25/8.22 = 3.04 or 4 times per SPSL unit.

For battery charging/changing can be seen from the battery cyclelife is 1500 cycles DOD means that the battery can be used for recharging for 1500 times, then one battery can be used for 1500/365 = 4.1 or 4 years. Because the investment life is 25 years, battery replacement will be carried out as much as 25/4 = 6.25 or 7 batteries per SPSL unit. Thus, the results of the calculation of investment costs for 25 years for 46 units, then the calculation results as shown in Table 4.

Table 4. The Result of the Calculation of Investment Costs of 25 Years

No.	Description	Quantity	Unit Price (IDR)	Total Price (IDR)
I	***Mobilization Work***			
	Mobilization	Parcel	3.500.000	3.500.000
II	***Pawning and Installation***			
1	Solar Panel 155 WP	1	4.850.000	4.850.000
2	Street Light PLM 971	4	2.500.000	10.000.000
3	Litium Battery x 4 Pack	7	7.500.000	52.500.000
4	LED Driver DH 100 Li + Solar Charging Controller Venus	1	1.532.800	1.532.800
5	Solar Mounting	1	1.250.000	1.250.000
6	Rotor RM 1762	1	1.250.000	1.250.000
7	Rotor Control D 132	1	1.000.000	1.000.000
8	7M Octagonal Mast	1	5.500.000	5.500.000
9	Installation and Installation	1	6.790.000	6.790.000

Total Price	**88.172.800**
Total 46 Units of SPSL	**4.055.948.800**

From Table 7, by the 25th year, LED lights and batteries have residual value to the investment. The calculation for the residual investment value of LED lamps seen from the ability of the operating life of LED lamps is 36,000 hours. The use of lights for 1 unit as much as 4 times so as to produce 36,000 hours x 4 = 144,000 hours. The use of lights for 25 years where every day the lights are on for 12 hours so that 25 x 365 x 12 hours = 109,500 hours. LED lamp capacity is 144,000 hours – 109,500 hours = 34,500 hours, then the remaining value of the lamp is 34,500/36,000 x IDR 2,500,000 x 46 units = IDR 110,208,333.33. Taking into account the 10% discount rate, the remaining value of LED lights in the 25th year is IDR 10,171,788

From the battery specification data of 1500 cycles DOD, so that for 7 batteries produce 7 x 1500 cycles = 10,500 cycles. The battery usage for recharging for 25 years is 25 x 365 days = 9,125 days or 9,125 recharges. Then the remaining capacity of the battery is 10,500 cycles – 9,125 cyles = 1,375 cycles. The calculation of the remaining value of the battery is 1,375/1500 x IDR 7,500,000x46 units = IDR 316,250,000. Taking into account the 10% discount rate, the remaining value of the battery in the 25th year is IDR 29,188,609

kWh SPSL Production

SPSL used operates for 25 years based on the life of solar panels recommended by distributors. By calculating the discount rate of 10%, itis possible to obtain a calculation of income from electricity generated from 1 unit of SPSL by multiplying the price per kWh of non-subsidized electricity. A 50 W lamp load per SPSL unit that lights up for 12 hours per day in one year will produce energy as:

= (50 W x 12 hours x 365 days) / 1000

= 219 kWh

Production kWh 46 points = 219 x 46

= 10,074 kWh

The price of PLN's non-subsidized is IDR 1,444.70 per kWh, then income per year is = IDR 1,444.70 x 10,074 kWh

= IDR 14,553,908

By taking into account the 10% discount rate, the NPV of kWh income is obtained as shown in Table 5.

Table 5. NPV calculation result with 10% discount rate for kWh income for 25 years

No	Period Year to n	Cash Flow (NCF)	NCF/(1+i)^t
1.	Year 1 revenue	14.553.908	13.230.825
2.	Year 2 revenue	14.553.908	12.028.023
3.	Year 3 revenue	14.553.908	10.934.566
...	Year's income ...	...	...

24.	24 year revenue	14.553.908	1.477.594
25.	25 year revenue	14.553.908	1.343.267
	Total Revenue kWh for 25 years		132.106.405

NPV = Total Revenue – Investment Cost

Total of Revenue = kWh revenue + lamp residual value + Battery residual value

= IDR 132,106,405 + IDR 10,171,788 + IDR 29,188,609

= IDR 171,466,802

Investment Cost = IDR 4.055.948.800

NPV = IDR 171.466.802–IDR 4.055.948.800

= - IDR 3,884,481,998

Net B/C Ratio = 0,042

If the discount rate (i) is determined at 0%, then the NPV of kWh revenue is obtained as shown in Table 6.

Table 6. NPV Calculation Result with 0% Discount Rate for kWh Revenue for 25 Years

No	Period Year to n	Cash Flow (NCF)	$NCF/(1+i)^t$
1.	Year 1 revenue	14.553.908	14.553.908
2.	Year 2 revenue	14.553.908	14.553.908
3.	Year 3 revenue	14.553.908	14.553.908
...	Year's income ...	...	...
24.	24 year revenue	14.553.908	14.553.908
25.	25 year revenue	14.553.908	14.553.908
	Total Revenue kWh for 25 Years		363.847.700

NPV = Total Revenue – Investment Cost

Total of Revenue= kWh revenue + Lamp residual value + Battery residual value

= IDR 363,847,700 + IDR 110,208,333 + IDR 316,250,000

= IDR 790,306,033

Investment Cost = IDR 4.055.948.800

NPV = IDR 790.306.033–IDR 4.055.948.800

= - IDR 3,265,642,767

Net B/C Ratio = 0,195

The economic feasibility of SPP as Public Street Lighting (PSL) by calculating the kWh produced, where the discount rate is determined at 0%, so that the calculation of the kWh price is:

NPV = 0

Total Income – Investment Cost = 0

Total Revenue = Cost of investment

Total Revenue = kWh revenue + Lamp residual value + Battery residual value

Thus,

kWh revenue = Cost Invest - Lamp residual value - Battery residual value
= IDR 4,055,948,800 - IDR 110,208,333 - IDR 316,250,000
kWh Revenue = IDR 3.629.490.467

Investment age of 25 years with discount rate (i) 0%, then Kwh income per year is IDR 3,629,490,467/25 = IDR 145,179,619.68 with annual electricity production of 10,074 kWh. The economic price of Solar PSL per kWh is IDR 145,179,619.68/10,074 kWh = IDR 14,411.32. The use of SPSL as public street lighting in Manokwari is economically not an investment project worth doing. Economic feasibility can be done if the price per kWh is IDR 14,411.32.

Cost Comparison of PSL and SPSL

In addition to calculating economic analysis, calculations are also carried out related to the cost comparison between public street lighting and solar public street lighting. For the cost of PSL 22 points as shown in Table 7.

Table 7. PSL Installation Fee for 22 Units

No	Description	Vol	Unit Price (IDR)	Total Price (IDR)
	Material			
	PSL Pole 9 Mtr	22	6.000.000	132.000.000
	Cable Twistic 2 x 10 mm	2000	25.000	50.000.000
	Cable NYM 3 x 2.5 mm	300	20.000	6.000.000
I	Complete panel box with timer	3	4.500.000	13.500.000
	Unibel Isolation	15	35.000	525.000
	Stainlees steel	3	850.000	2.550.000
	Insulation 3 M	5	90.000	450.000
	Single lamp + Ornaments@ 90 W	22	4.000.000	88.000.000
	Stopping	100	15.000	1.500.000
	Calm Pull	46	30.000	1.380.000
	Connector	46	30.000	1.380.000
	Cement	15	80.000	1.200.000
	Sand	2	700.000	1.400.000
	Sum			**299.885.000**
II	***Freight Costs***			
	Port transportation costs Jakarta/other provinces - Manokwari	1	63.000.000	63.000.000
	Loading and unloading costs Jakarta/other provinces	1	7.500.000	7.500.000
	Manokwari loading and unloading cost	1	8.000.000	8.000.000
	Local material mobility	1	10.000.000	10.000.000
	Sum			**88.500.000**

III	***Rental Cost***			
	Warehouse rental cost in Manokwari	14	350.000	4.900.000
	Sum			**4.900.000**
IV	***Installation Cost***			
	PSL pole installation	22	5.000.000	110.000.000
	Panel assembly and installation	3	2.500.000	7.500.000
	Twistic cabling	2.000	25.000	50.000.000
	Installation of lamp ornaments	22	2.700.000	59.400.000
	The cost of the new power meter 2200 Va 0.2	3	4.500.000	13.500.000
	Grounding panel	3	850.000	2.550.000
	Sum			**242.950.000**
	Total			**636.235.000**

The results of field data related to operating costs and maintenance are IDR 50,000,000 for 22 PSL units, where operational costs are pulse costs which are routine costs of public street lighting and maintenance costs are replacement of damaged PSL components. For the cost of public street lighting expenditures are:

kWh PSL per year:

= (90 W x 12 hours x 365 days)/1000 kWh

= 394.2 kWh

Use of kWh 22 units = 394.2 kWh x 22

= 8,672.4 kWh

The cost of spending kWh PSL per year is 8,672.4 kWh x IDR 1,444.70 = IDR 12,529,016. PSL operational costs are needed every year IDR 12,529,016 and maintenance costs are IDR 37,470,984. For 22 PSL units, operational and maintenance costs of IDR 50,000,000 per year are required.

If the projected investment for 25 years such as SPSL then the amount of operational and maintenance costs is IDR 50,000,000 x 25 years = IDR 1,250,000,000. So to calculate the total costs that will be incurred for PSL for 25 years are as follows:

Total cost = cost of investment + cost of O&P

= IDR 636,235,000 + IDR 1,250,000,000

= IDR 1,886,235,000

Further more, the projected cost of SPSL for 25 years per unit as shown in Tabel 4, if assuming the number of lamps equal to the number of PSL lamps is 22 units, then the cost for 25 years is 22 units x IDR 88,172,800 = IDR 1,939,801,600. Based on the calculation results between SPSL and PSL, it can be concluded that the cost of PSL is still cheaper than the cost of SPSL.

CONCLUSION

From the technical analysis of the performance of SPSL components where SPSL lamps used with a power of 50 W, voltage 55 V dc, a current of 0.9 A and a lithium battery with a capacity of 14.8 V, 20 Ah @ 4 packs and polycrystalline solar panels with a capacity of 155 W work according to their technical specifications and meet the standards of the Minister of Transportation Regulation No. 27 of 2018 about street lighting equipment.

From the investment feasibility analysis that the construction of SPSL with an investment scheme is not feasible because the NPV value < 0 with an IRR of 10%, and a B/C Ratio of < 1. The construction of SPSL is economically feasible if the calculation of 0% IRR with the price of electricity per kWh reaches a value of IDR 14,411.32 or approximately ten times the price of Non-Subsidized PLN kWh electricity which is worth IDR 1,444.70.

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