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Cost Benefit Analysis Solar Cell for the Defense Industry to Support the Implementation of Protected War

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ABSTRACT : *The defense industry is important in national defense, therefore energy security is needed. The purpose of this research is to analyze the cost benefit of PT Pindad's solar energy development in order to face the threat of energy security when the war drags on. The method used in this research is Cost Benefit by calculating NPV (Net Present Value), PI (Profitability Index), DPP (Discounted Payback Period) and IRR (Internal rate of Return). . Based on the cost benefit analysis, for an NPV of 15 years, the investment is considered unfit for investment with a project age of less than 15 years with a discount of 11%. The results of the PI calculation with a value of 0.9988 (<1), indicate that the PLTS investment to be developed is not feasible to implement. The DPP of this PLTS system is more than 15 years. The IRR of PLTS planning within 15 years at PT Pindad can be said to be feasible if the discount factor is less than 9.5879%.*

KEYWORDS -*Defense Industry, Renewable Energy, Protracted War, Cost Benefit*

I. INTRODUCTION

Minister of Defense Regulation No. 20 of 2011 states that national defense is essentially all defense efforts that are universal in nature, which involve all citizens, territories and other national resources and are prepared early by the government and carried out in a total, integrated, directed, and effective manner. Continue to uphold state sovereignty, territorial integrity, and the safety of all nations from all threats. The elaboration of the constitution on the defense aspect, the Indonesian people have compiled the defense. The construction of a strong defense requires the fulfillment of the needs of the alustista. Since the issuance of Law Number 16 of 2012 concerning the Defense Industry, the government has shown its commitment to building a strong, independent and competitive Defense Industry (Indhan). TNI base and anticipate a protracted war. (2015 Defense White Paper)

One of the defense industries in Indonesia is PT Pindad. PT Pindad as a state-owned limited liability company was formed in 1983. PT Pindad is the Lead integrator of the defense industry cluster, combat vehicles and weapons sub-cluster. In meeting the demand for electricity to keep producing and overcoming the threat of a protracted war, energy security is needed. With the development of renewable energy in the PT Pindad area. With the above conditions, the researcher intends to analyze the *cost benefits* of PT Pindad's solar energy development in order to face the threat of energy security when the war drags on

II. HEADING S

2.1 National Defense and Protracted War

According to the Indonesian Defense White Paper (2015) the Indonesian Defense System is stated as a universal defense that involves all citizens, territories and other national resources, which are prepared early by the government in a total, integrated, directed and continuous manner to uphold state sovereignty, territorial integrity and safety of the entire nation from all threats. War is the highest form of conflict that occurs between humans. In the study of International Relations, war is traditionally the organization of the use of force by political units in the international system. In a broader sense, war is related to concepts in the form of crises, guerrilla action accompanied by violence, occupation, threats, conquest, and terror. A strong defense industry has two main effects, namely a direct effect on the development of defense capabilities, and an effect on national economic and technological development. The defense industry is part of the national industry determined by the Government to partially or wholly produce defense equipment and maintenance services to fulfill strategic interests in the defense and security sector within the territory of the Unitary State of the Republic of Indonesia. Defense Industry is a national industry consisting of state-owned enterprises and private-owned enterprises, both individuals and groups determined by the government to partially or wholly produce defense equipment, maintenance services. fulfill strategic interests in the field of defense and security within the territory of the State

2.2 Defense Industry

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III. INDENTATIONS AND EQUATIONS

3.1 Renewable Energy and Solar Energy

Indonesia has a high potential for clean and renewable energy. Solar Power Plant is a power generation system whose energy is sourced from solar radiation, through the conversion of photovoltaic cells. Photovoltaic systems convert solar radiation into electricity. The higher the intensity of solar radiation (irradiation) hitting the photovoltaic cell, the higher the electrical power it produces.

Array area (PV Area) is calculated by

using the following formula:

$$PV\ Area = \frac{FL}{Gav\ x\ \eta PV\ x\ TCF\ x\ \eta\ out}$$

Where :

EL is energy consumption (kWh/day).

Gav is the average daily solar insolation (kWh/m2/day).

PV is the efficiency of the solar panels.

TCF is the temperature correction factor.

out is the efficiency of the inverter.

3.2 Cost Benefits

Economic cost-benefit analysis is a method developed specifically as a medium for evaluating a project by using the profit and cost factors obtained or projected to be obtained from the project or policy. Furthermore, all potential benefits and costs are identified, then quantified into monetary units, and each result is compared to facilitate evaluation of the feasibility of a project or policy from the community's point of view (Nas, 2016).

3.2.1.Net Present Value (NPV)

This NPV method also known as Present Worth is used to determine whether a plan is profitable in the analysis period, by determining the market value of the base year of the project. The net worth of the project is the present value of the benefits compared to the costs. NPV is also the value of the project in question obtained based on the difference between the cash flow generated and the investment issued. If the NPV is greater (>) by 0 (zero), then the business or project is feasible to implement. Likewise, when the NPV is smaller (<) than 0 (zero), then the business or project is not feasible to implement. When the NPV value is equal to (=) 0 (zero), then the value of the business or project is in a BEP state. Then, the following formula is obtained:

$$NPV = \sum_{t-1}^{r} \frac{Ct}{(1+r)^t}$$

NPV = Net Present Value (Rupiah)

Ct = Cas Flow per year in period

R = Interest rate or discount rate (%)

3.2.2Internal Rate of Return (IRR)

IRR is used to determine whether an investment is implemented or not, usually a reference is used if the investment must be higher than the Minimum acceptable rate of return or Minimum attractive rate of return . At the IRR interest rate, NPV = 0, or commonly referred to as IRR implies the interest rate that can be given an investment, which gives NPV = 0

To be able to get the final result of the IRR, we have to find a discount rate that produces a positive NPV, then after that look for a discount rate that produces a negative NPV. IRR when NPV = 0 using the interpolation method between the interest rate that produces a positive NPV and the interest rate that produces a negative NPV. The following equation is used:

$$IRR = i1 + \frac{NPV1}{NPV1 - NPV2}\, x\, (i1 - i2)$$

IV. FIGURES AND TABLES

PT Pindad's electricity demand data in one year from this table shows that the average monthly demand is 1,107,321 kwh/month. It is calculated that the average working hours of PT Pindad is 8 hours one day and 5 days working hours in one week or 168 working hours in one month. So PT Pindad's one hour electricity requirement is 6,591 kWh/m 2 .

Based on the results of observations using the PSVsyst program, data were obtained for the coordinates of PT Pindad. PT Pindad has a very good building for installing solar cells, namely unit 42 which is the production site for heavy equipment and its infrastructure. Unit 42 has a length of 140 meters by 95 meters, so the area that can be used for solar cell installation is 13,775 m 2 . Units 22 and 23 are infrastructure areas with an area of 14,600 m 2 . Unit 84 which is a special vehicle production site with an area of 5,400 m 2 . So the total area that can be used for solar cell roof area is 33,775 m 2 .

4.1 Cost Analysis of solar sell

Construction costs are set for construction costs of 15% of the main components. So it can be concluded that the investment costs for PV mini-grid planning in the PT Pindad area are as follows:

Table Investment Costs of PT Pindad Persero

Unit	Price	Qty	Total
Solar Cell 400WP	5,005,000	14976	74,954,880,000
Battery 500 Ah	3,500,000	10985	38,447,500,000
Inverter	7,645,000	3	22,935,000
Solar Charge Controller		3	1,150,000
Construction Cost	15%	1	17,013,969,750
Total			130,440,434,750

By using PSVsyst simulation, it is known that with the area owned by PT, it can meet electricity needs with a solar cell renewable energy system, so that in the event of a protracted war, PT Pindad can still produce alusita.

4.1.1 Maintenance and operational costs (M)

After knowing the amount of investment costs needed, then calculated the amount of maintenance costs and operational costs. PLTS maintenance and operational costs are determined at 1-2% of the total initial investment cost. Based on this reference, the maintenance fee is set at 2%. So to calculate the annual election and operational costs, it can be calculated:

M = 2% x investment value

M = 2% x130.440.434.750

= 2,608,808,695

4.1.2 Life cycle cost (PLTS)

The PLTS life cycle cost can be calculated by adding up the required investment costs with the maintenance and operational costs.

LCC = C + Mpw

PLTS is estimated to be able to operate for 15-20 years, so PLTS is set to operate for 15 years . Based on data from the Central Statistics Agency in 2021, the interest rate of government banks for investment costs is 9 to 11 percent, then the interest is set at 11%, so that the present value of PLTS during operation within 15 years is:

$$Mpw = 2.608.808.695\ \frac{(1+0.11)^{15}-1}{0.11(1+0.11)^{15}}$$

$Mpw =$18,759,943,326

So that the life cycle (LCC) for PV mini-grid which will be developed for 15 years is obtained as follows:

LCC = C + Mpw

LCC = 130,440,434,750 + 18,759,943,326

= 149,200,378.076

4.1.3 Calculating the energy costs of PV mini-grid (Levelized Cost of Energy)

Energy costs (Levelized Cost Control) of a PV mini-grid, determined by the life cycle cost (LCC). Capital recovery factor (CRF) and annual production kWh. The capital recovery factor for converting all of the current life cycle costs into a series of annual costs is calculated by the following equation:

$$CRF = \frac{0.11(1+0.11)^{15}}{(1+0.11)^{15}-1} = 0.139$$

While the annual kWh production value is:

Annual production kwh = daily production kwh x 365

= 52,728 kWh x 365 = 19,245,720 kWh

After obtaining the LCC, CR and kWh values of annual production, the energy costs (LCoE) for planning this PV mini-grid system are as follows:

$$LCoE = \frac{\text{LCCx CRF}}{Produksi\ KWh\ Tahunan}$$

$$= \frac{149{,}200{,}378{,}076 \text{ x } 0.139}{19.245.270}$$

= 1.077 /kWh

4.1.4 Investment feasibility analysis

PLTS investment eligibility is determined based on the results of the NPV, Profitability Index (PI) and Discount Payback Period (DPP).

To calculate the feasibility of PLTS investment, energy costs are used, which is Rp. 1.077/kWh. With these energy costs and an annual production kWH of 19,245,270 kWh, the annual cash inflow is IDR 20,727,155,790. Meanwhile, the annual cash outflow or expenditure is IDR 2,608,808,695 which is determined based on the annual maintenance and operational costs. The discount factor is 11%, then you can calculate the net cash flow value of the discounted factor (FD), as follows :

$$DF = \frac{1}{(1+i)^n}$$

$$DF = \frac{1}{(1+0.11)^1} = 0.9009$$

The following is a table for calculating NFC, DF and PVNCF with a discount factor of 11% table for calculating NFC, DF and PVNCF with a discount factor of 11%

Table .Calculating NFC, DF and PVNCF with a discount factor of 11%

Yr	Capital (Rp)	Input Cost (Rp)	Maintenance Cost (Rp)	(NCF) (Rp)	Discount Factor (DF) 11% (Rp)	Present Value NCF x DF (Rp)	Kumulatif PVNCF (NCF+PV NCF) (Rp)
					1		
1	130,440,434,750	20,727,155,790	2,608,808,695	18,118,347,095	0.901	16,322,835,221	16,322,835,221
2		20,727,155,790	2,608,808,695	18,118,347,095	0.812	14,705,256,956	31,028,092,176
3		20,727,155,790	2,608,808,695	18,118,347,095	0.731	13,247,979,239	44,276,071,416
4		20,727,155,790	2,608,808,695	18,118,347,095	0.659	11,935,116,432	56,211,187,847
5		20,727,155,790	2,608,808,695	18,118,347,095	0.593	10,752,357,146	66,963,544,993
6		20,727,155,790	2,608,808,695	18,118,347,095	0.535	9,686,808,239	76,650,353,233
7		20,727,155,790	2,608,808,695	18,118,347,095	0.482	8,726,854,270	85,377,207,502
8		20,727,155,790	2,608,808,695	18,118,347,095	0.434	7,862,030,874	93,239,238,376
9		20,727,155,790	2,608,808,695	18,118,347,095	0.391	7,082,910,697	100,322,149,073
10		20,727,155,790	2,608,808,695	18,118,347,095	0.352	6,381,000,628	106,703,149,701
11		20,727,155,790	2,608,808,695	18,118,347,095	0.317	5,748,649,214	112,451,798,915
12		20,727,155,790	2,608,808,695	18,118,347,095	0.286	5,178,963,256	117,630,762,171
13		20,727,155,790	2,608,808,695	18,118,347,095	0.258	4,665,732,663	122,296,494,835
14		20,727,155,790	2,608,808,695	18,118,347,095	0.232	4,203,362,760	126,499,857,594
15		20,727,155,790	2,608,808,695	18,118,347,095	0.209	3,786,813,297	130,286,670,891

Net Present Value (NPV)

Net Present Value (NPV) is a parameter that describes an income earned in the future whose interest has been paid in advance or at a discount. The purpose of calculating the NPV is used to calculate the capital allocation to analyze the profits in a project implemented in order to build the same project in the future. The Net Present Value technique is calculated using the following equation:

$$NPV = \sum_{t=1}^{n} \left(\frac{NFCt}{(1+0.11)^{1}} \right) - 1A$$

The table ….. shows that the total net cash value (PV NCF) for 15 years is Rp 130,286,670,891 with an initial cost of Rp 130,440,434,750, the NPV value is:

NPV = 130,286,670,891 -130,440,434,750

= - 153.763,859

From the above calculation, it can be concluded that, for the negative investment value of IDR - 153,763,859 (<1) indicates that the PLTS to be developed is not feasible to invest.

4.1.6 Profitability Index (PI)

Profitability Index (PI) is an approach method that is almost the same as NPV. Profitability index, also known as profit investment ratio and value investment ratio. Profitability Index technique is calculated using the following equation:

$$PI = \frac{\sum_{t=1}^{n} NCFt\ (1+i)^{-t}}{1A}$$

The total net cash flow for 15 years is Rp 130,286,670,891 and the initial investment cost is Rp 130,440,434,750, the PI value is:

$$PI = \frac{130{,}286{,}670{,}891}{130{,}440{,}434{,}750}$$

$$PI = \frac{130{,}286{,}670{,}891}{130{,}440{,}434{,}750} = 0.998$$

4.1.7 Discounted Payback Period (DPP)

Discounted Payback Period (DPP) is obtained by calculating the number of years the present value of the cumulative net cash flows (Cumulative PV NCF) will be equal to the investment value. From the investment feasibility calculation table, information is obtained that the investment will return when the PVNCF value is greater than the initial investment value. So the payback period of the PLTS system is more than 15 years.

4.1.8 Internal Rate of Return (IRR)

IRR is used to determine whether an investment is implemented or not, usually a reference is used if the investment must be higher than the Minimum acceptable rate of return or Minimum attractive rate of return . At the IRR interest rate, NPV = 0, or commonly referred to as IRR implies the interest rate that can be given an investment, which gives NPV = 0.

By looking at the data from the Central Statistics Agency that the lowest discount factor in 2021 is 9.5%, we can compare the NPV1 value with the discount factor of 11% and 9.5% as follows:

$$IRR = i1 + \frac{NPV1}{NPV1 - NPV2}\ x\ (i1 - i2)$$

Table Internal Rate of Return

Yr	Cash Flow (Rp)	DF 11%	PV 11%	DF 9,5%	PV 9,5%
1	18,118,347,095	0.901	16,322,835,221	0.913	16,546,435,703
2	18,118,347,095	0.812	14,705,256,956	0.834	15,110,900,186
3	18,118,347,095	0.731	13,247,979,239	0.762	13,799,908,845
4	18,118,347,095	0.659	11,935,116,432	0.696	12,602,656,480
5	18,118,347,095	0.593	10,752,357,146	0.635	11,509,275,324
6	18,118,347,095	0.535	9,686,808,239	0.580	10,510,753,720
7	18,118,347,095	0.482	8,726,854,270	0.530	9,598,861,845
8	18,118,347,095	0.434	7,862,030,874	0.484	8,766,083,877
9	18,118,347,095	0.391	7,082,910,697	0.442	8,005,556,052
10	18,118,347,095	0.352	6,381,000,628	0.404	7,311,010,093
11	18,118,347,095	0.317	5,748,649,214	0.369	6,676,721,546
12	18,118,347,095	0.286	5,178,963,256	0.337	6,097,462,599
13	18,118,347,095	0.258	4,665,732,663	0.307	5,568,458,995
14	18,118,347,095	0.232	4,203,362,760	0.281	5,085,350,680
15	18,118,347,095	0.209	3,786,813,297	0.256	4,644,155,872
Total			130,286,670,891		141,833,591,818

V. CONCLUSION

Energy security at PT Pindad only comes from PLN, namely 5,540 kVA and 3,465 kVA, Then for emergencies, PT Pindad has 2 Genset Units with a maximum capacity of 1.8 MW. With this situation, there is a threat of energy security in the event of a protracted war, namely the decision to supply electricity from PLN. Therefore, energy security is needed with the construction of PLTS in the PT Pindad area. From the data one hour PT Pindad electricity demand is 6,591 kWh/m2 and the building area that can be used for solar cell roof area is 33,775 m2 at PT Pindad.. Based on the analysis cost benefit, for an investment period of 15 years, the investment is considered not worth investing in project life is less than 15 years with a discount of 11%. The results of the PI calculation with a value of 0.9988 (<1), indicate that the PLTS investment to be developed is not feasible to implement. The payback period of this PLTS system is more than 15 years. PLTS planning at PT Pindad can be said to be feasible if the discount factor is less than 9.5879%

VI. Acknowledgements

Further data or field data is needed regarding the values that affect the calculation of the cost benefit ratio factor, so that an interest rate value can be obtained that can be applied in the construction of PLTS.

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