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Feasibility Study of 10 MW Photovoltaic Power Plant in West Nusa Tenggara, Indonesia

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Abstract: This study aims to provide an overview of renewable energy sources' potential development as a solution to meeting electricity needs in the West Nusa Tenggara, Indonesia by analyzing the feasibility of 10 MW Photovoltaic power plant. The performance simulations and calculations based on renewable energy manufacturing data with RETScreen International software. The findings show that West Nusa Tenggara has good potential for Photovoltaic power plant development. It also indicates the feasibility of renewable energy investment in this region.

Keywords: Photovoltaic; Power Plant; RETScreen; West Nusa Tenggara

Introduction

It has been said that the increment in vitality utilization has driven to worldwide natural issues counting climate alter (Scheffran & Battaglini, 2011; Strawa et al., 2020). The significance of move to a moo carbon society has been broadly recognized universally. The worldwide activities are fundamental to nations on those issues have been expanding in an exceptional way. The significance of move to a moo carbon society has been broadly recognized globally (Baccay Sy et al., 2020; Ichsan et al., 2023). Renewable vitality can supply two-thirds of the overall worldwide vitality request, and contribute to the bulk of the nursery gas outflows diminishment that's required between presently and 2050 for constraining normal worldwide surface temperature increment underneath 2°C (Gielen et al., 2019). The utilize of renewable vitality is additionally basic for the utilize of ecologically neighborly vitality as relief of CO2 emanations (Mert; & Bölük, 2016).

Within the 21st century, the utilize of renewable asset s like sun based has been proliferated by the specter of climate alter and its related affect like dry spell (Imasiku, 2021). The development of renewable low-emission energy would be beneficial for both the national economy and the global environment (Heryadi & Hartono, 2016; Yana et al., 2022; Pratiwi, 2021; Setyono et al., 2019). As a potential commitment to climate change reaction, sun powered geoengineering presents tall stakes, worldwide scale, long time horizons, and profound instabilities. It hence postures different administration challenges that are well suited to examination through situation strategies (Parson & Reynolds, 2021). Among all renewable vitality advances, sun oriented photovoltaic (SPV) innovation is the one which has been broadly received over the world, indeed for little applications, due its basic plan and clean operation at an reasonable taken a toll (Janamala, 2021). On the off chance that compared to wind vitality, photovoltaic sun powered vitality is quiet and can be created in urban regions since boards can be introduced on the roof (Sampaio & González, 2017).

Essentially most of Indonesian range get sufficient escalated of sun-oriented radiation with the normal day

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by day radiation around 4 kWh/m2 (Handayani & Ariyanti, 2012; Hasan et al., 2012; Setiawan et al., 2011; Siswiyanti & Jahi, 2006). The equator crosses through Indonesia giving them plenitude sun-oriented illumination essential for creating and misusing sun-based vitality (Dang, 2020; Panjaitan & Pangestu, 2018). In Indonesia, eastern of Java, Bali, West Nusa Tenggara up to Timor Island, most of several areas over North and Central Celebes, most of Moluccas islands and some area of western Papua (local rainfall type) as the good area to be exploited the solar energy for solar energy power (PA, 2017; .Langer et al., 2021; Straatman & Van Sark, 2008).

West Nusa Tenggara has copious and assorted renewable vitality potential. Sun oriented radiation within the locale is among the most elevated in Indonesia (Islami & Aditya, 2020). As for the sun-oriented PV ventures generally found in West Nusa Tenggara, where the potential of sun-oriented irradiance is among the most noteworthy for the domain of Indonesia, taken after by Maluku, and East Nusa Tenggara (Halimatussadiah et al., 2020)..

Method

Climate Data and Location of The Power Plant

The research began with the documentation method. This method is used to obtain specific and accurate data on the light intensity, wind, air temperature, relative humidity, and climate data location. The documentation method is also used to collect supporting data in the form of electricity tariff provisions, solar radiation, subsidy policies, electricity demand planning, and power plant construction planning at the research location. Then perform simulations and calculations based on renewable energy manufacturing data with RETScreen International software.

The research will be conducted at three location points in West Nusa Tenggara, namely West Lombok , Sumbawa with, and Bima. The climate data from these three locations is extrapolated to perform the calculations of the feasibility study and the extrapolated data are given by table 1, table 2, and table 3.

Project Parameter

To specify the research, parameters need to be determined. So, the simulation variables at the three locations are not different. The parameter is adjusted to the research needs, the geographic location of the research location, and refers to the use of technology that may be done in the real world. Table 1 provides a summary of some of the basic design parameters used in this project.

Result and Discussion

After the data is simulated using software, the result shows more information regarding the revenue, cost, and economic viability of the three facility locations. The data generated from the project simulation are shown in detail in the table 5.

The West Lombok region has an average daily solar radiation of 5.40 kWh/m²/d, with the most elevated 6.27 kWh/m²/d esteem recorded in October and the least daily solar radiation in January with an estimation of 4.91 kWh/m²/d. Despite having a smaller value than Sumbawa and Bima, West Lombok has solar radiation above the average solar radiation within the Indonesian locale, 4.8 kWh/m²/d. West Lombok can be categorized as a really hot climate zone and can potentially improve solar power.

From the results of computer simulations, data shows that electricity exported to the system is 17.029 MWh with an annual electricity revenue of IDR 18,776,130,437. This project requires annual costs, namely operation and maintenance (O&M) and debt payments. The total initial cost is IDR 159.87 billion. Furthermore, the O&M cost for the photovoltaic power plant project in this first location IDR 1,433,363,100. Meanwhile, the annual debt payment is IDR 159,875,115,000.

Sumbawa is located at the western tip of Sumbawa Island, West Nusa Tenggara. The normal yearly solar radiation in this locale is 5.59 kWh/m²/d, with the most elevated 6.51 kWh/m²/d esteem recorded in September and the least daily solar radiation in February with an esteem of 4.84 kWh/m²/d. In common, all through the year, Sumbawa has solar radiation over the normal solar radiation within the Indonesian locale, 4.8 kWh/m²/d. With this condition, the Sumbawa locale can be categorized as a really hot climate zone and can improve.

The Photovoltaic power plant project in Sumbawa is able to produce 17.029 MWh electricity exported to the system with an annual electricity revenue of IDR 18,776,130,437. In this location, the total initial cost is IDR 159.87 billion. Meanwhile, the O&M cost for the photovoltaic power plant project in this location is IDR 1,433,363,100. And the annual debt payment is IDR 159,875,115,000.

Bima has an average daily solar radiation of 5.42 kWh/m²/d, with the most elevated 6.39 kWh/m²/d esteem recorded in October and the least daily solar radiation in June esteem of 4.81 kWh/m²/d. With this condition, the Bima locale can be categorized as a really hot climate zone and has the potential for improvement.

In this facility, electricity exported to the system is 16.477 MWh with an annual electricity revenue is IDR 18,167,656,775. The total cost required for constructing a 10 MW photovoltaic power plant project IDR 159.87

billion. Furthermore, the O&M cost for the photovoltaic power plant project in this location is IDR 1,433,363,100. Meanwhile, the annual debt payment is IDR 159,875,115,000.

Sumbawa is located at the western tip of Sumbawa Island, West Nusa Tenggara. The normal yearly solar radiation in this locale is 5.59 kWh/m²/d, with the most elevated 6.51 kWh/m²/d esteem recorded in September and the least daily solar radiation in February with an esteem of 4.84 kWh/m²/d. In common, all through the year, Sumbawa has solar radiation over the normal solar radiation within the Indonesian locale, 4.8 kWh/m²/d. With this condition, the Sumbawa locale can be categorized as a really hot climate zone and can improve.

The Photovoltaic power plant project in Sumbawa is able to produce 17.029 MWh electricity exported to the system with an annual electricity revenue of IDR 18,776,130,437. In this location, the total initial cost is IDR 159.87 billion. Meanwhile, the O&M cost for the photovoltaic power plant project in this location is IDR 1,433,363,100. And the annual debt payment is IDR 159,875,115,000

Table 1. Climate Data of Facility Location in West Lombok

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind Speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	26.70	83.40	261.95	4.91	99.60	2.90	27.60	0.00	518.00
February	26.60	84.60	252.28	4.92	99.60	2.90	27.40	0.00	465.00
March	26.80	83.10	199.33	5.34	99.66	2.50	27.60	0.00	521.00
April	27.00	81.80	126.00	5.52	99.70	2.70	27.80	0.00	510.00
May	26.50	81.00	79.05	5.35	99.70	3.30	27.30	0.00	512.00
June	25.80	80.40	42.30	4.92	99.80	3.60	26.70	0.00	474.00
July	25.10	78.90	30.69	4.96	99.90	3.90	26.00	0.00	468.00
August	25.20	76.60	14.88	5.47	99.90	3.90	26.10	0.00	471.00
September	26.00	76.00	33.00	6.06	99.90	3.70	26.80	0.00	480.00
October	27.00	76.20	87.73	6.27	99.80	3.30	27.80	0.00	527.00
November	27.40	78.90	183.90	5.76	99.60	2.80	28.20	0.00	522.00
December	27.00	81.30	247.69	5.33	99.60	2.70	28.00	0.00	527.00

Table 2. Climate Data of Facility Location in Sumbawa

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind Speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	26.70	83.40	261.64	5.01	99.40	2.90	27.50	0.00	518.00
February	26.50	85.00	248.92	4.84	99.40	3.00	27.20	0.00	462.00
March	26.80	82.60	188.48	5.50	99.40	2.30	27.60	0.00	521.00
April	27.10	80.30	115.80	5.65	99.50	2.20	27.90	0.00	513.00
May	26.80	78.60	53.94	5.55	99.50	2.60	27.60	0.00	521.00
June	26.10	77.30	29.40	5.17	99.60	2.90	26.90	0.00	483.00
July	25.60	75.20	19.84	5.27	99.60	3.00	26.40	0.00	484.00
August	25.90	72.60	10.23	5.86	99.70	2.90	26.50	0.00	493.00
September	26.90	71.10	20.10	6.51	99.60	2.60	27.30	0.00	507.00
October	27.90	70.60	48.67	6.42	99.50	2.30	28.40	0.00	555.00
November	28.00	74.30	130.80	5.93	99.40	1.90	28.70	0.00	540.00
December	27.20	80.10	238.08	5.38	99.40	2.30	28.10	0.00	533.00

Table 3. Climate Data of Facility Location in Bima

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind Speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	27.00	82.20	245.52	5.03	99.60	3.80	28.40	0.00	527.00
February	26.80	83.70	217.84	4.98	99.60	4.10	28.00	0.00	470.00
March	27.10	81.00	170.81	5.36	99.70	3.00	28.40	0.00	530.00
April	27.60	78.20	105.00	5.45	99.70	3.00	28.90	0.00	528.00
May	27.40	75.90	51.15	5.16	99.80	3.80	28.80	0.00	539.00
June	26.90	73.90	28.50	4.81	99.90	4.40	28.60	0.00	507.00
July	26.50	71.20	21.08	4.86	99.90	4.70	28.40	0.00	512.00
August	26.70	68.30	14.26	5.51	99.90	4.40	28.90	0.00	518.00
September	27.60	67.40	22.80	6.10	99.90	4.00	30.10	0.00	528.00
October	28.50	67.40	40.30	6.39	99.80	3.40	31.10	0.00	574.00
November	28.60	71.20	109.80	5.88	99.70	2.60	30.90	0.00	558.00
December	27.60	78.20	220.41	5.43	99.60	3.00	29.30	0.00	546.00

Bima has an average daily solar radiation of 5.42 kWh/m²/d, with the most elevated 6.39 kWh/m²/d esteem recorded in October and the least daily solar radiation in June esteem of 4.81 kWh/m²/d. With this condition, the Bima locale can be categorized as a really hot climate zone and has the potential for improvement.

In this facility, electricity exported to the system is 16.477 MWh with an annual electricity revenue is IDR 18,167,656,775. The total cost required for constructing a 10 MW photovoltaic power plant project IDR 159.87 billion. Furthermore, the O&M cost for the photovoltaic power plant project in this location is IDR 1,433,363,100. Meanwhile, the annual debt payment is IDR 159,875,115,000.

Emission Analysis

One of the main goals of developing renewable energy is to reduce greenhouse gas (GHG) emissions. This study also analyzes the amount of GHG that can be reduced in a scenario where the location only relies on the use of solar power per year. The reduction in gross annual GHG emissions reached 93%. Furthermore, the installation of a 10 MW photovoltaic power plant can reduce GHG emissions in a significant amount. GHG emission reductions in West Lombok were 12,459.2 tCO_2, GHG emission reductions reached 12,849.7 tCO_2 for the Sumbawa location, and GHG emission reductions in Bima Jurnal Penelitian Pendidikan IPA (JPPIPA) Date, Volume, Issue, Page 5 city reached 12,433.3 tCO and this is presented in Table 6.

Economic Viability

The potential for developing a photovoltaic power plant in West Lombok is very good. Figure 1 shows a positive trend from year 0 to year 25, it is indicated by the pre-tax value, which continues to increase every year—starting from year 0 with a CAD value of -7,250,000 to a value of CAD 3,264,328 or equivalent to IDR 35,992,056,165 in the 25th year. With an average addition of pre-tax of CAD 113,015.5 starting from year 1.

Table 4. Project Parameter

Parameter	Unit	Detail
Capacity	MW	10
Benchmark	CAD/kwh	0.074
Photovoltaic Efficiency	%	16
Number of units	-	40000
Type of Photovoltaic	-	Mono-Si
Inverter Efficiency	%	97.5
Solar Tracking Mode	-	Fixed
Azimuth	°	170
Inflation Rate	%	1.59
Debt Ratio	%	50
Debt Term	Year	10
Project Life	Year	25

Table 5. Annual Electricity Revenue and Cost

Location	Item	Unit	Total
West Lombok	Electricity Exported to The System	MWh	16,512
	Annual Electricity Revenue	IDR	18,205,552,690
	Operation and Maintenance	IDR	1,433,363,100
	Debt Payments	IDR	12,455,881,236
	Initial Cost	IDR	159,875,115,000
Sumbawa	Electricity Exported to The System	MWh	17,029
	Annual Electricity Revenue	IDR	18,776,130,437
	Operation and Maintenance	IDR	1,433,363,100
	Debt Payments	IDR	12,455,881,236
	Initial Cost	IDR	159,875,115,000
Bima	Electricity Exported to The System	MWh	16,477
	Annual Electricity Revenue	IDR	18,167,656,775
	Operation and Maintenance	IDR	1,433,363,100
	Debt Payments	IDR	12,455,881,236
	Initial Cost	IDR	159,875,115,000

Table 6. Gross Annual GHG Emission Reduction

Location	GHG Emission	Unit	Total
West Lombok	Base Case	tCO_2	13,397.0
	Proposed Case	tCO_2	937.8
	Gross Annual GHG Emission Reduction	tCO_2	12,459.2
Sumbawa	Base Case	tCO_2	13,816.9
	Proposed Case	tCO_2	967.2
	Gross Annual GHG Emission Reduction	tCO_2	12,849.7
Bima	Base Case	tCO_2	13,816.9
	Proposed Case	tCO_2	967.2
v	Gross Annual GHG Emission Reduction	tCO_2	12,849.7

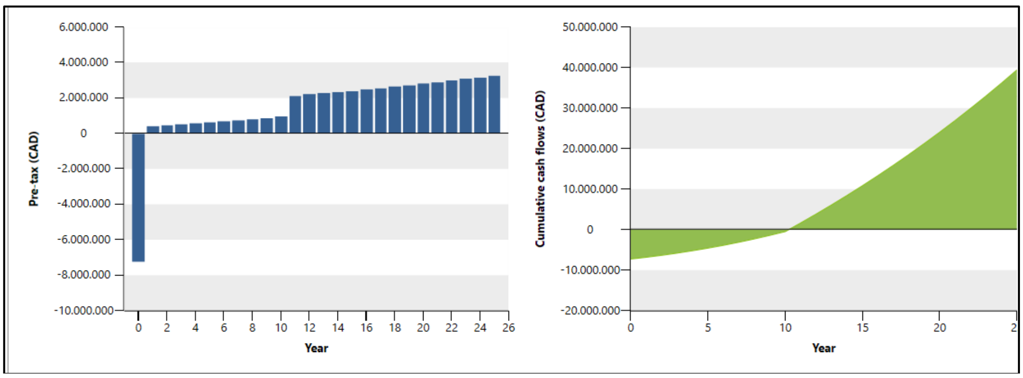

Figure 1. Pre-Tax and Cumulative Cash Flow of Photovoltaic Power Plant in West Lombok

In a vulnerable period of 25 years, the cumulative cash flow of the photovoltaic power plant project in West Lombok has a positive trend, which continues to increase every year. In the 0 year, the cumulative cash flow value was at CAD - 7,250,000 or the equivalent of IDR -79,937,557,500 and became CAD 3,372,679 in the 25th year or equivalent to IDR 37,186,720,206. With an average addition of cumulative cash flow of CAD 1,867,751.12 starting from the first annual.

From an economic point of view, the potential for photovoltaic power plant development in Sumbawa is excellent. The Figure 2 shows a positive trend from year 0 to year 25, which is indicated by the pre-tax value, which continues to increase every year—starting from year-0 with a CAD value of -7,250,000 to a value of CAD 3,372,679 in the 25th year or equivalent to IDR 37,186,720,206. With an annual average addition of pre-tax of CAD 115,217.5 starting from year 1. If you look closely, there was a spike in the addition of the pre-tax value in the 11th year to reach CAD 1,195,933.

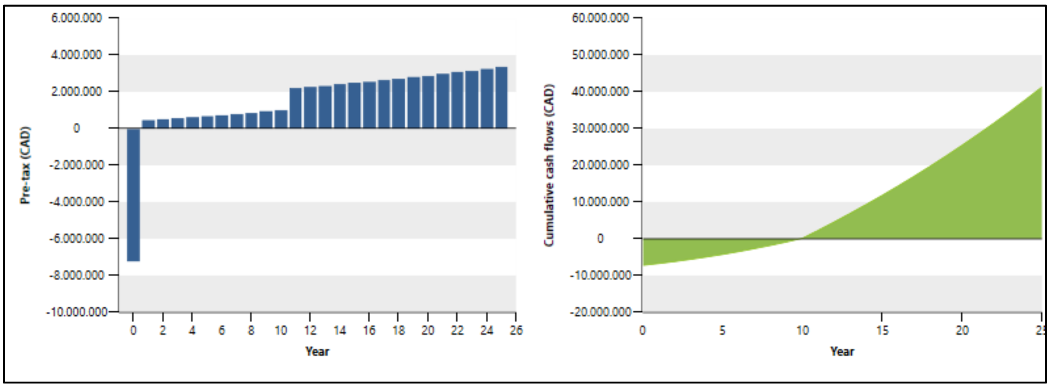

Figure 2. Pre-Tax and Cumulative Cash Flow of Photovoltaic Power Plant in West Lombok

Presented in Figure 2., in a vulnerable time of 25 years, the cumulative cash flow of the photovoltaic power plant project in Bima has a positive trend: it continues to increase every year. In the 0 year, the cumulative cash flow value was at CAD -7,250,000 or the equivalent of IDR - 79,937,557,500 and became CAD 39,314,710 in the 25th year. With an annual average addition of cumulative of CAD 1,862,588.4 starting from year 1.

The graph in figure 3 also shows a positive trend from year 0 to year 25, it is indicated by the pre-tax value, which continues to increase every year—starting from year 0 with a CAD value of - 7,250,000 to a value of CAD 3,372,679 in year 25. With an average addition of pre-tax of CAD 117,572.2 starting from the first year.

There was a spike in the addition of the pre-tax value in the 11th year. This happens because the project's debt term is ten years, so in the year 10, it is assumed that the debt has been paid so that the pre-tax value can be greater than the previous year.

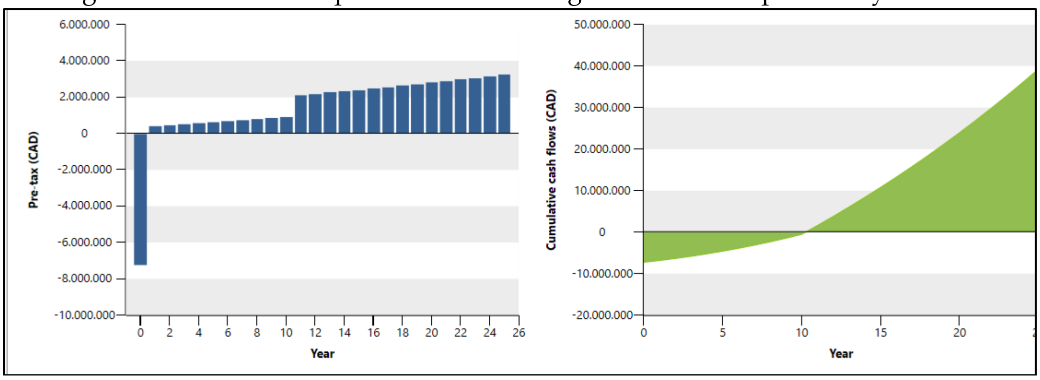

Figure 3. Pre-Tax and Cumulative Cash Flow of Photovoltaic Power Plant in Bima

Conclusion

The software modeling results of this 10 MW photovoltaic power plant study in three locations show that West Nusa Tenggara will have 50.018 MWh electricity, and it is economically feasible for investment when considering the economic viability indicator of the project. Sumbawa is able to export 17,029 MWh, Bima is able to export 16,477 MWh, and West Lombok is capable to export 16,512 MWh electricity to the system. This number is a very good amount of electricity power in fulfilling the need of electricity in the region. This fact indicates that the province of West Nusa Tenggara has the potential to develop solar plants in several locations and is not only concentrated in one place. Also, become an additional reason as to why solar power development in the West Nusa Tenggara region must continue

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