

# Feasibility Study of Solar and Wind Energy in Remote Islands (Gili Labak Madura)

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**Abstract:** GiliLabak Island is one of the Madura's remote islands, actually has the opportunity of utilization of renewable energy source that is available abundantly throughout the year such as solar and wind energy. The utilization of both alternatives energy need feasibility analysis. First step is collecting data of electricity daily energy demand in GiliLabak which was gotten approximately 61.870 Kwh/day. The next process performs an economical analysis for each type of solar cell package as the most economical option based on NPV and IRR analysis. After knowing the energy generated by each wind power package then will calculate how much wind power system's needed for all the electricity demand. To find out how many wind power plants (wind power plants) then the energy generated for one year/energy that will be generated from each hydropower package. Finally step was doing comparison of both two alternatives energy which the most economist. Based on economic analysis with NPV and IRR approach from several alternative power plants from solar cell and wind turbine can be concluded that alternative solar cell type 1000 Wp polycrystalline is a very feasible alternative to be realized because it has a value of NPV > 0 while from the value of IRR - 27% is the highest of all alternatives that have IRR value above the discount factor value (14%).

**Keywords:** GiliLabak, Madura, Electric Energy Demand, Solar and Wind Alternative Energy Potential, SHS, Wind Energy System, Feasibility Study, Economical Analysis.

## 1. Introduction

World energy consumption levels are forecast to increase by 70 percent % between 2000 and 2030. Fossil energy sources, which account for 87.7 % of the world's total energy demand, are expected to decline due to the absence of new sources of reserves (ApS, 2005; Lubis, 2011). Fossil-based energy resources worldwide are estimated to be only 40 years for petroleum, 60 years for natural gas and 200 years for coal. Besides, the increasing demand of fossil energy give other impacts of global warming and environmental pollution that is already at a very alarming level.

Madura is one area in East Java that has great potential in national and even international scale both in terms of natural tourism and fisheries (Muhsoni and Efendy, 2016). This is in line with the master plan of Madura industrialization post Suramadu. In support of the program, Madura must prepare all its structures and infrastructures including the provision of adequate, cheap, independent, renewable and environmentally friendly energy source (Hansen and Hansen, 2007; Lubis, 2011; Michalak and Zimny, 2011). That way will stimulate investor interest to invest in Madura.

Gili Labak Island is one of the Madura's remote islands where inhabited of 35 family or 105 people which currently have problem the availability of electric energy. On the other hand, Gili Labak Island actually has the opportunity of utilization of renewable energy source that is available abundantly throughout the year such as solar energy by using solar cell modules and wind energy by using wind turbine module (Kristianto, 2010; Sitompul, 2011; Goudarzi and Zhu, 2013). In the framework of utilization of both alternatives energy is required technically and economically feasibility analysis as solution of Gili Labak Island's fulfillment of electric energy.

## 2. Methods

### 2.1 Data Collection of Daily Electricity Demand

Data collection of electricity demand in the GiliLabak Islands was done by conducting direct interviews of each home electrical appliances which they need and how many hours a day approximate its used. Based on the results of the interview then made an estimate of the electricity needs of each household by setting some standard electrical power equipment eg 10 watts for living room lamp, 125 watts for water pump and 125 watts for television. After the estimated total electricity needs of each house then summed to the total electricity demand of GiliLabak community.

### 2.2 Collection of Intensity Data and Duration of Daily Solar Lighting

Monthly data of solar intensity in GiliLabak area is obtained from Meteorology Climatology And Geophysics Agency (BMKG) represents the average of the sun intensity for the period 2015 until 2016 of the GiliLabak Madura.

### 2.3 Daily Wind Speed Data Collection

Data of wind speed in Gili Labak area is obtained from Meteorology Climatology And Geophysics Agency (BMKG). The periode of the data for two years from 2015 until 2016.

### 2.4 Data Collection Types Of Solar Cell Technology And Wind Turbines

Data collection technology of solar cells and wind turbines are available in the market related to technical specifications and the price through the media internet, newspapers and other media.

The result of Solar Home System (SHS) and wind power system in the market are as shown in table 1 and table 2.

**Table 1:** Technology package of solar home system.

No	Package Type	Package (Wp)	Price (IDR)
1	Monocrystalline	50	3.300.000,-
		100	7.500.000,-
		200	11.500.000,-
		10.000	660.000.000,-
2	Polycrystalline	50	3.300.000,-
		100	6.700.000,-
		200	13.000.000,-
		10.000	49.000.000,-

**Table 2:**Technology package of solar homes system.

No	Package (W)	Price (IDR)
1	1000	30.000.000
2	2000	45.600.000
3	3000	75.500.000

## 2.5 Real location at the area that feasible for Develop Wind and Solar Energy Sistem

Real location survey by measuring solar intensity, Duration of Daily Solar Lighting and Wind Speed Data at few spot sample at the area as potential location that becomes the possibility of placement of solar cells and wind turbines in the Gili Islands of Labak to be analyzed by performing direct measurements of the intensity of solar radiation and wind speed of the greatest. The potential location of solar and wind energy system where placed are shown in figure 1 and figure 2.



**Fig. 1.** Some potential spot location for wind energy system.



**Fig. 2.** Some potential spot location for solar energy system.

## 2.6 Calculation of Alternative Wind and Solar Energy Potential and Economic Analysis with NPV and IRR Approach

Calculation of Alternative Wind and Solar Energy Potential in theoretical analysis of solar and wind alternative energy potentials in Gili Labak Islands to meet the electricity needs of the community is based on data of intensity and duration of solar irradiance and daily data of wind speed in Gili Labak for 2 years and alternative energy which is more suitable based on technical specification available on the market. Furthermore, economic analysis using Net

Present Value (NPV) and Internal Rate of Return (IRR) based on investment cost with 25 year analysis time(Kodoatie, 1995; Pujawan, 2004).

## 2.7 Selection of best technology alternatives based on the best value of NPV and IRR approach

Finally step was doing comparison of both two alternatives energy which the most economist.

## 3. Result

First Step in this study began with data collecting of daily energy demand of electricity in GiliLabak which from the observation was gotten total electrical energy demand in GiliLabakaproximatly 61.870 Kwh/day. The next was calculated of solar and wind alternative energy potential for solve electrical energy demand. The solar alternative with solar power system (SHS) in the market is 50% of home solar system (SHS) required must be powered twice the total energy demand In GiliLabak is 123.74 Kwh.

Based on BMKG data SHS working time / average duration of sun exposure for 2 years from 2015 to 2016 it's about 8,140 hours every day. So the maximum power required SHS about 15202.360 Kwh.Then calculated the SHS demand of each package that available on the market such as the type of package 50 Wp, 100 Wp, 1000 Wp and 10000 Wp. From the calculation process was gotten number of SHS needed and its price as shown in table 3.

**Table 3.** Number of SHS needed and its price.

No	Package Type	Package (Wp)	Needed (packge)	Price (IDR)
1	Monocrystalline	50	37	123.269.569,-
		100	19	140.079.056,-
		200	9	107.393.943,-
		10.000	1,0	220.000.000,-
2	Polycrystalline	50	37	123.269.569,-
		100	19	125.137.290,-
		200	9	121.401.848,-
		10.000	2,0	99.000.000,-

The next process performs an economical analysis for each type of solar cell package as the most economical option based on NPV and IRR analysis.

The Calculation process of wind potential energy began with calculating the total electrical energy demand for one year (360 days) is 21986.64 KWh. Then calculate the potential of electrical energy that can be generated by type of power plant packages which sold in the market such as the 1000 watt package with a rotor diameter of 2.7 m, 2000 watt with 3.2 m and 3000 watt package with 4.5 m.

Based on rotor diameter;

If  $\eta$  = total efficiency (0.30) and

WPD = site-specific power (W / m2),

then wind turbine energy in kWh,

$E = \eta \cdot (WPD) \cdot A \cdot t$

$= \eta \cdot \frac{1}{2} \rho V^3 \cdot A \cdot 8.760$

With;

t = number of hours in 1 year = 8760,  
 while A = the area of rotor sweep (m<sup>2</sup>)  
 ie: for the flat axis,  $A = (\pi / 4) D^2$ .

The Calculation of wind potential energy in kWh that can be generated by type of wind power system which sold in the market was done for each type such as the 1000 watt package (rotor diameter R= 2.7 m, E = 683.624 KWh), 2000 watt (R=3.2 m,E = 960.262 KWh) and 3000 watt (R= 4.5 m,E=1898.957 KWh).

After knowing the energy generated by each wind power package then will calculate how much wind power system's needed for all the electricity demand. To find out how many wind power plants (wind power plants) then the energy generated for one year / energy that will be generated from each hydropower package.

From the calculation process was gotten number of wind power system needed and its price as shown in table 4.

**Table 4.** Number of wind power system needed and its price.

Package (Wp)	Price (IDR)	Wind power system Needed
1000	30.000.000,-	33
2000	45.600.000,-	23
3000	75.500.000,-	12

After knowing of the number of wind power system needed then calculate the total cost of each packet that followed by conducting an economic analysis for each type of wind energy power plant package as the most economical option based on NPV and IRR analysis. Finally step was doing comparison of both two alternatives energy which the most economist.

Based on economic analysis with NPV and IRR approach from several alternative power plants from solar cell and wind turbine can be concluded that alternative solar cell type 1000 Wp polycrystalline is a very feasible alternative to be realized because it has a value of NPV > 0 while from the value of IRR- 27% is the highest of all alternatives that have IRR value above the discount factor value (14%). The detail analysis data of NPV and IRR value as shown in table 5 and table 6.

**Table 5.** Viable alternative for NPV analysis.

Viable alternative for NPV analysis			
No	Alternative	NPV value	information
1	mono crystalline 50 Wp	Rp51.928.496	feasible
2	mono crystalline 100 Wp	Rp50.749.555	feasible
3	mono crystalline 200 Wp	Rp73.130.062	feasible
4	mono crystalline 10.000 Wp	-Rp35.994.817	not feasible
5	poly crystalline 50 Wp	Rp58.263.847	feasible
6	poly crystalline 100 Wp	Rp53.299.236	feasible
7	poly crystalline 200 Wp	Rp59.122.157	feasible
8	poly crystalline 1000 Wp	Rp84.888.095	feasible
9	PLTA 1000 watt	-Rp784.776.933	not feasible
10	PLTA 2000 watt	-Rp888.310.826	not feasible
11	PLTA 3000 watt	-Rp747.576.477	not feasible

**Table 6.** Viable alternative for NPV analysis.

IRR			
No	Alternatives	Discountfactor	IRR
1	monocrystalline 50 Wp	14%	21%
2	monocrystalline 100 Wp	14%	21%
3	monocrystalline 200 Wp	14%	25%
4	monocrystalline 10000 Wp	14%	11%
5	polycrystalline 50 Wp	14%	22%
6	polycrystalline 100 Wp	14%	21%
7	polycrystalline 200 Wp	14%	22%
8	polycrystalline 1000 Wp	14%	27%
9	PLTA 1000 W	14%	-2%
10	PLTA 2000 W	14%	#NUM!
11	PLTA 3000 W	14%	#NUM!

#### 4. Conclusions

The conclusions of this study are as follows. Based on economic analysis with NPV and IRR approach from several alternative power plants from solar cell and wind turbine can be concluded that alternative solar cell type 1000 W polycrystalline is a very feasible alternative to be realized because it has a value of NPV > 0 while from the value of IRR - 27% is the highest of all alternatives that have IRR value above the discount factor value (14%).

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#### References

- [1] ApS, B. T. M. C. (2005) 'International wind energy development', *World Market update 2004, Forecast 2005-2009*.
- [2] Goudarzi, N. and Zhu, W. D. (2013) 'A review on the development of wind turbine generators across the world', *International Journal of Dynamics and Control*. Springer, 1(2), pp. 192–202.
- [3] Hansen, A. D. and Hansen, L. H. (2007) 'Wind turbine concept market penetration over 10 years (1995–2004)', *Wind energy*. Wiley Online Library, 10(1), pp. 81–97.
- [4] Kodoatie, R. J. (1995) 'Analisis Ekonomi Teknik', *Penerbit Andi Offset, Yogyakarta*.
- [5] Kristianto, A. N. (2010) 'Studi Kelayakan Investasi Pembangkit Listrik Tenaga Surya (PLTS) Di Pulau Biaro Dengan Menggunakan Metode Real Option'. Universitas Indonesia. Fakultas Ekonomi.
- [6] Lubis, A. (2011) 'Energi terbarukan dalam pembangunan berkelanjutan', *Jurnal Teknologi Lingkungan*, 8(2).
- [7] Michalak, P. and Zimny, J. (2011) 'Wind energy development in the world, Europe and Poland from 1995 to 2009; current status and future perspectives', *Renewable and Sustainable Energy Reviews*. Elsevier, 15(5), pp. 2330–2341.
- [8] Muhsoni, F. F. and Efendy, M. (2016) 'ANALISI DAYA DUKUNG PEMANFAATAN PULAU GILI LABAK DENGAN MENGGUNAKAN SISTEM

INFORMASI GEOGRAFIS', *Prosiding Semnas Perikanan dan Kelautan VI, UB.*

- [9] Pujawan, I. N. (2004) *Ekonomi Teknik*, Penerbit Guna Widya. Surabaya.
- [10] Sitompul, R. (2011) 'Manual Pelatihan Teknologi Energi Terbarukan yang Tepat Untuk Aplikasi di Masyarakat Pedesaan', *Jakarta: PNPM Support Facility (PSF)*, pp. 45–75.