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Fossil Energy Crisis Solutions using Wind and Solar Power Plants

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Abstract: *Based on the high growth rate of the Indonesian population and the flow of urbanization, Indonesia's demand for energy is predicted to increase every year. According to the law of demand, the increasing population will increase electricity demand, which in turn will increase the amount of fuel used. Indonesia can become an importer of pure oil shortly with rapid growth without new energy resources and energy efficiency efforts. The use of renewable energy that is more environmentally friendly must be maximized by using wind and sun as an energy source for rural electricity sources. Season changes play an essential role in assisting in this energy income. In the dry season, the sun will play a role. In the rainy season, the wind will play a role in producing a source of electrical energy. Both of these energy sources aim to complement each other in supporting the creation of electricity. The concept of a combination or hybrid between solar panels and wind turbine will significantly help accelerate the charging of energy into the battery so that wind and solar energy are made separately. Measurement of solar panels shows 100wp and vertical type wind turbines with low rpm < 300, which have been combined can produce 700 watts of electricity. This resource can generate little electricity for one household.*

Key Words: *hybrid power plant, renewable energy, solar panels, wind turbine, electricity, energy consumption.*

1. INTRODUCTION:

Energy consumption is cultivated by oil, gas, coal, and hydro energy [1]. Imports of oil and petroleum products will increase in line with domestic demand. Without new energy resources and energy efficiency efforts, Indonesia could become an importer of pure oil shortly with rapid consumption growth [2]. The government has taken the initiative to increase the use of renewable energy sources to reduce the share of fossil fuels, especially for electricity generation. The use of renewable energy for rural electrification in Indonesia is beneficial because thousands of islands from the islands make it difficult to build an electric distribution system that is mutually distributed both materially and financially. Coal is one of the fossil energies [3]. Dependence on coal is substantial; this can be caused by competitive coal prices and the rapid development of coal-based industries (cement, paper, textiles) [4]. In line, increasing demand for other energy such as natural gas is predicted to also increase, with an average growth of 3.9 percent per year. On the other hand, fossil fuel energy consumption still dominates. The energy mix consumed in Indonesia is 25% derived from oil, 11% from natural gas, 11% electricity, 6.2% coal, 4.8% LPG, and still very minor for renewable energy such as biodiesel, geothermal, wind, water, and the sun.

Potential energy sources in Indonesia include 4.8 KWh / m2 / day solar energy, 458 GW biomass 3-6 M / sec wind power, and 3 GW nuclear. Not only here, but Indonesia also has a sizeable hydro energy source with a potential total estimated at 75.67 GW [5]. Energy is not used significantly even though the potential of renewable energy such as biomass, geothermal energy, solar energy, water energy, wind energy, and ocean energy is relatively high. Its use was only less than 4% in 2007. Indonesia's national energy policy aims to reduce dependence on oil and gas and to vary energy mixes, by increasing the share of other energy sources such as renewable energy. Indonesia has targeted to meet the share of renewable energy up to 17% in 2005, as stated in the Blueprint of the National Energy Implementation Program for 2007-2025 [6].

2. THEORIES:

2.1 Hybrid Energy

A hybrid power plant is a power plant that consists of more than 1 type of generator which combines several renewable energy sources with and or which cannot be renewed [7]. Hybrid energy systems are one of the renewable energies that are becoming popular as stand-alone electric power systems to provide electricity. Hybrid power systems, usually consisting of two or more renewable energy sources that are used together to provide increased system efficiency and a more excellent balance in energy supply. In this case, the author utilizes the potential of the sun and wind. Electrical energy can be generated by converting solar radiation through a process called photovoltaic. Photo refers to light, and voltaic refers to voltage. This terminology produces direct current electrical energy from solar radiation energy [8]. Photovoltaic cells are made of mainly silicon semi-conductive materials which are coated with special additives. If the sun's light reaches the cell, the electrons will be released from the silicon atom and flow forms an electrical circuit so that energy can be generated. Solar cells are always designed to convert light into as much electrical energy as possible and can be combined in series or parallel to produce the desired voltage and current [9].

2.2 Wind Turbine

Wind turbines are windmills used to generate electricity [10]. This wind turbine was initially made to accommodate the needs of farmers in carrying out rice milling, irrigation and other purposes. Previous wind turbines have been built in Denmark, the Netherlands, and other European countries and are better known as Windmill. Now wind turbines are more widely used to accommodate the electricity needs of the community, using the principle of energy conversion and using renewable natural resources, namely wind. Although until now, the construction of wind turbines still cannot compete with conventional power plants. Wind turbines are still more developed by scientists because shortly humans will be faced with the problem of lack of non-renewable natural resources as a base for generating electricity [11].

Wind turbines are a tool for converting wind energy into mechanical energy which converts into electrical energy. The rotation of the wind turbine shaft is connected to the generator to produce electrical energy. Based on previous research, many types of wind turbines produced one example is Vertical Axis Wind Turbine (VAWT). VAWT is a wind turbine with a vertical or perpendicular axis, and the rotor is parallel to the wind direction so that the rotor can rotate in all wind directions. VAWT also has several advantages and disadvantages. The advantage is that it has high torque so that it can rotate at low wind speeds, the generator can be placed at the bottom of the turbine so that it facilitates maintenance and the work of the turbine is not affected by wind direction. This turbine has drawbacks, the wind speed at the bottom is slow so that if it does not use the tower, it will produce low rotation, and efficiency is lower than the Horizontal Axis Wind Turbine (HAWT) [12].

3. METHODLOGY

This research performed a literature review to determine hybrid parameter, collecting data in the field, data analysis, discussion, and conclusion. Based on the data obtained, the calculation is done using the following equation.

$$PE = TE * ME * TC * PF * SF * A$$

Where :

PE	=	solar cell energy / day (kWh).
TE	=	total solar radiation on that day (kWh / m2)
ME	=	module efficiency, 8% - 20%
TC	=	correction factor for temperature efficiency, generally 150^0-350^0 C higher than the average daily temperature of the field
PF	=	gasket factor, usually calculated in efficiency module
SF	=	fouling factor.
A	=	area (m2)

To project the amount of output energy produced by the arrangement of solar cells, the following equation functions to obtain the plan power as the basis for determining the diameter of the rotor.

$$P = 0.5\, \rho\, \pi r2\, vr3\, Cp\, \eta t\, \eta g$$

4. RESULT AND DISCUSSION:

4.1 Overview

Systems that support solar and wind hybrid power plants are solar cell systems, energy conversion systems, battery systems, inverter systems, and control systems. The quality of an inverter is a determinant of the quality of the power produced by a system. The inverter functions to change the DC battery or rectifier-charger circuit to AC voltage. The following table is data obtained from PT. PLN (Persero) North Sumatra Region is related to the regional electricity conditions of Sumatra from 2015 to 2018.

Table 1. Sumatra regional electricity conditions from 2015 to 2018

Sumatra	Unit	10 October 2015	20 October 2017	18 May 2018
Peak Load	MW	4684	5368	5219
Supply Power	MW	4474	5826	6297
Inter Unit Transfers	MW	0	0	1078

Reserve	MW	-210	458	21
Reserve Margin	%	-4	9	

SBU	Unit	10 October 2015	20 October 2017	18 May 2018
Peak Load	MW	1841	2057	2043
Supply Power	MW	1651	2403	2447
Transfer to SBT	MW	-63	0	-38
Reserve	MW	-253	346	465
Reserve Margin	%	-14	17	23

SBT	Unit	10 October 2015	20 October 2017	18 May 2018
Peak Load	MW	1213	1500	1485
Supply Power	MW	967	1321	1220
Transfer from SBU	MW	-63	0	-56
Transfer to SBS	MW	226	280	534
Reserve	MW	43	101	211
Reserve Margin	%	4	7	14

SBS	Unit	10 October 2015	20 October 2017	18 May 2018
Peak Load	MW	1630	1811	1654
Supply Power	MW	1836	2102	2650
Transfer from SBT	MW	-226	280	534
Reserve	MW	0	101	402
Reserve Margin	%	0	7	24

Table 1 describes the highest annual burden occurring in October while the peak load in May 2018 is still lower than in October 2017 with a difference of 149 MW. The following figure describes the data obtained from PT. PLN (Persero) North Sumatra Region.

Figure 1. Plans for developing power plants in North Sumatra in 2018-2027

Figure 2. EBT Development Plan in North Sumatra

4.2 Hybrid Generator Concept

The workings of this hybrid system power plant in general and sequentially starting from all the energy produced by all existing power sources, namely solar cell systems, and wind energy systems are channeled into the control unit. The energy entering the control unit takes the form of direct current electricity. If there is an excess of energy, then the energy will be stored in the battery, then before being channeled to the consumer, direct current energy is converted into alternating current energy by the inverter. After being converted into alternating current energy, energy flows through the distribution of alternating current to the consumer, which consists of various types and needs.

Solar cell calculations:

1 cell power (M0)	=	1.96 Wp
Material	=	Silicon Crystal
Size	=	10 x 10 cm
Voltage (V)	=	0.5 Volt
Flow (I)	=	0.98 Ampere
Temperature (T)	=	25 0C
Planned power	=	500 watts

In the first analysis, the module area used using the following equation.

$$P = \frac{A * 1000\,W}{m2 * ME * PF}$$

Where :

Power (P)	=	1000 Watts
Module efficiency (ME)	=	20%
Pecking factor (PF)	=	98%
Module area (A)	=	?

Solution:

$$A = \frac{P}{1000\ W/m2\ x\ ME\ x\ PF}$$

$$A = \frac{1000\ W}{1000\ W/m2x0{,}2x\ 0{,}98}$$

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A $=\frac{1000}{96}$

A = 5,10 m^2

The number of module will be used:

Area	=	5.10 m^2
Size in 1 module 10x10 cm	=	0.01 m^2
Number of module	=	$\frac{5,10}{0.01}$
Number of module	=	510 pieces

Solar cell can be calculated by:

PE	=	TE $\frac{MO}{1000}$ xTC x N
PE	=	1000 Wh/m^2x 1,9 W /1000 W x 25^0 C x 510
	=	24,225 Kwh

The next analyze is to get voltage from the data above:

1 module voltage	=	0,5 volt
Voltage wanted	=	24 volt
Module arrangement	=	24 / 0,5
	=	48

Module installed in parallel is 48 pieces. Power wanted 1000 Watt, voltage 24 Volt.
Based on the power pattern P = V . I.

I	=	$\frac{P}{V}$
	=	$\frac{1000}{24}$
	=	41,66 Ampere

In cell flow data at standard temperature 25^0 C is 0,98 Ampere, so module arrangement is = $\frac{41,66}{0,98}$ = 42,5 ~ 43. To get current wanted, module installed series is 43 pieces. The culculation of wind energy conversion will be calculated in analyzing about wind speed Cut-in (Vci), wind speed Cut-off (Vco) and wind speed plan (Vr).

V	=	5 m/dt
Wind speed Cut-in		
Pattern: Vci	=	0,7. 5 = 3,5 m/s
Wind speed Cut-off		
Pattern: Vci	=	3. 5 = 15 m/s
Wind speed plan		
Pattern: Vr	=	$\frac{3.5+15}{2}$ = 9,25 m/s

To know the wind in rotor blade with assumsion that the angle is 2/3 from the wind velocity analysis.

V	=	5 m/sec ----→ V = $\frac{2}{3}$ 5
	=	3.3 m/sec

To determine number of rotor blade turning as the same as power plan

V	=	5 m/s
U	=	7.1 . 5 m/s = 35,5
W	=	$\sqrt{(35,5)^2+(5)^2}$ = 11,28

The blade rotor diameter is obtained from:

$D^2 = \sqrt{P/0.086V}$
$= 7{,}6$ m---→ r = 3,8

Planning a diameter of the gear and the rotation is needed for transmission in turning the generator can be determined.

U = 35,5
D = 7,6 m
$n = \frac{35{,}5(60)}{3{,}14(7{,}6)}$
= 32,9 rpm

so the power produced is :

$P = \frac{16}{27}\frac{1}{2}(0{,}2925)(1{,}226)(3{,}14)\ 5^2.5^3$
= 1042,60 Watt

5. CONCLUSION:

The potential of solar and wind energy is still very widely available in nature as an alternative energy substitute for fossil energy. The Hybrid Power Plant has excellent potential in tackling the energy crisis in Sumatra. Based on Hybrid energy calculations can produce power of ± 1000 W, and this can meet the power needs of one house.

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