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STUDY ON THE DESIGN OF SOLAR-WIND ENERGY SYSTEM TO REDUCE THE USE OF GAS FUEL IN THE SOUTHEAST SUMATRA BLOCK

Eko Adi Nugroho*, Suhanan, Rochim Bakti Cahyono
Faculty of Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia
Email: eko.adi.n00@gmail.com*

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ABSTRACT

The Southeast Sumatra block produces oil and gas. Natural gas production of 15,300 MSCF is used as fuel for turbine generators to generate 38 MW of electrical energy, while the rest is used as business products. The application of the solar-wind system can reduce the load on the turbine generator so that gas fuel consumption is also reduced. Five platforms have areas that can be utilized for a solar-wind system. This study aims to determine the amount of gas fuel consumption that can be reduced by the solar-wind system application. The method is simulation using the HOMER software to determine the amount of electrical energy that can be supplied and the costs required by the solar-wind system. The components used are found in the HOMER software and on the market. The simulation results show that the off-grid solar-wind system can provide electricity supply of 50,235 kWh per year and reduce gas fuel consumption by 20,094 MSCF per year. The on-grid solar-wind system can provide electricity supply of up to 81,230 kWh per year and reducing the use of gas fuel by 32,492 MSCF per year. The off-grid solar-wind system will increase gas sales by $132,620 per year with NPV>0 and ROI 21%, while the on-grid system will increase gas sales by $214,447 per year with NPV>0 and ROI 57%. Both models of solar-wind systems have positive economic values so that they are feasible to implement.

INTRODUCTION

The Southeast Sumatra block is one of the offshore oil and gas exploration and exploitation work areas located in the Indonesian Java Sea. This working area has 23 offshore oil platforms that function for oil exploitation activities by operating more than 120 oil well. The geographical location of the work area on the high seas is very suitable when utilizing solar and wind energy as a source of electrical energy. Based on data from the NASA database, the average solar energy received at the site is about 5 kWh/m2/day and the average wind speed is about 4 m/s (SAO, 2014). Some platforms have an open area at the top that can receive the maximum energy potential of sunlight and wind (Manwell, McGowan, & Rogers, 2010). In Indonesia, the distribution of petroleum products, which are crucial commodities, relies on maritime shipping (Surury, Syauqi, & Purwanto, 2021). The main business products carried out by this working area are oil and natural gas. Petroleum products are processed into profitable business products, while gas products are used as fuel for turbine generators and some are processed into business

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products. The natural gas production is around 30 MMSCFD of which around 14 MMSCFD is sold to consumers as business products. 15,300 MSCF of natural gas is used as fuel for the turbine generator, and the rest is burned through flare.

Natural gas, which is one of the business products of the Southeast Sumatra Block, can increase its sales volume if it is not used as fuel for turbine generators. Solar and wind power can be used as a source of electrical energy for oil and gas production supporting equipment, thereby reducing the electrical load from the turbine generator. This can save gas fuel and reduce emissions generated by the generator. Gas that is not used as fuel can be diverted to increase the number of gas products sold, thereby increasing the company's profits. The Southeast Sumatra block uses electricity generated by 11 units of gas turbine generators to supply electricity. This field has 23 oil rigs, consisting of 1 process rig and 22 remote rigs. The total electricity consumption for the 23 platforms currently reaches 38 MW. Equipment that uses electricity on the platform consists of transformers, air compressors, centrifugal pumps, rotary equipment, welding equipment, lifting equipment, lighting lamps, navigation lamps, and others. Each platform has a different consumption of electrical energy depending on the number of electrical equipment on the platform. Equipment that affects the consumption of electrical energy on the platform is divided into two parts, namely primary equipment and secondary equipment. Primary equipment is equipment that has a direct impact on oil and gas production, while secondary equipment is supporting equipment that does not have a direct impact on oil and gas production. The primary equipments on the platform include oil well pumps, air compressors, and process fluid pumps. Secondary equipment includes welding equipment, cranes, lighting, navigation lights, and air conditioners. The largest consumption of electrical energy is in oil well pumping equipment, which accounts for about 80% of electrical energy consumption on the platform. Then the pumps for processing fluids (oil, water, gas) on the platform account for about 10% of the electrical energy consumption. Air compressor as a source of wind supply for pneumatic equipment consumes about 5% of electrical energy on the bridge. Meanwhile, secondary equipment only consumes about 5% of the electrical energy on the platform.

The solar-wind energy system in the Southeast Sumatra Block cannot be applied to supply electricity to primary equipment. This is due to the high risk to production in the event of a failure in the solar-wind system. The application of the solar-wind system is focused on secondary equipment such as lighting and air conditioners that do not have a direct impact on oil and gas production. Therefore, this research is focused on assessing the application of the solar-wind system for lighting and air conditioners at each designated platform location. The design of the solar-wind system in the Southeast Sumatra Block can only be applied to a few platforms and is applied to equipment that does not have a direct impact on oil production, such as lighting and air conditioners. The area available on some of these platforms will determine the maximum number of solar panels and wind turbines that can be installed. The problem in this research is how much electrical load can be supplied by the solar-wind system? How much gas fuel consumption can be reduced by implementing a solar-wind system? What is the economic value?

Based on previous studies, a study and modeling of the HOMER software solar-wind system with the location of the Southeast Sumatra Block offshore oil platform in the Java Sea region of Indonesia, where its application can reduce gas fuel consumption and increase sales of gas products for companies that manage it have not found.

Photovoltaic System

Photovoltaic (PV) cells produce power whose magnitude depends on the material used. A PV module is a series of several PV cells connected in series and parallel to produce the required current and voltage (Luque & Hegedus, 2011). The function of the PV system may vary due to fluctuations in the intensity of solar radiation over a period of time. When the light received by the PV cell changes, the power produced also changes (Albert, 2018).

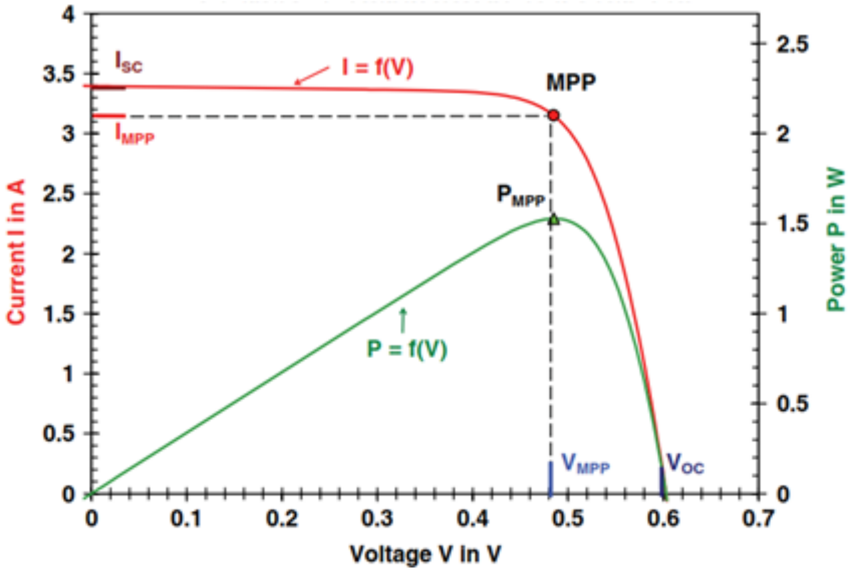

Figure 1. PV cells characteristic curves (Luque & Hegeus, 2011)

The PV cell characteristic curve as shown in figure 1 describes the relationship between current, voltage and power generated by a PV module. The variation of this curve depends on the percentage of solar radiation that hits the PV cell panel.

$$P_{max} = V_{max} \times I_{max} = \gamma \times V_{oc} \times I_{sc} \qquad (1)$$

The maximum power of the PV module can be calculated using equation 1. Open circuit voltage (V_{oc}) is a voltage that has a maximum capacity when there is no current, so the power generated is zero. Meanwhile, short circuit current (I_{sc}) is the maximum current produced by photovoltaic when there is no resistance (short circuit). V_{max} and I_{max} are the terminal output voltage and current of the PV module at Maximum Power Point (MPP), and γ is the cell efficiency factor which is a measure of the quality of the PV cell.

There are several factors that affect the amount of power generated by PV cells when operating, namely PV cell material, temperature, barrier, intensity of solar radiation, and orientation (Hosseini, Moazzami, & Shahinzadeh, 2017). PV cells can achieve different energy efficiencies depending on the materials and manufacturing methods used, for example the efficiency of amorphous silicon ranges from 5% to 7%, for polycrystalline silicon the efficiency does not exceed 12% and for monocrystalline silicon the efficiency is more than 12% and does not exceed 18% (Electronica, 2014). The PV module temperature can increase due to the influence of environmental temperature, causing the maximum power generated will decrease (Luque & Hegedus, 2011). The optimal installation position of the PV module may vary according to the position. If the location of the PV module is on the north side of the equator, then the sun is usually in the south position and the panels must be installed facing south. On the other hand, for module locations on the south side of the equator, the panels must be installed facing north (Mahesh & Sandhu, 2015). Considering that the sun moves in an arc of 180^0 relative to the Earth from east to west, the angle of elevation of the sun (γ) varies between 0-90° and the best absorption of solar radiation on the panel occurs when the angle of incident light is 90^0, the energy yield can be increased by tilting the panel towards sun, i.e. at an angle relative to the horizontal plane. Generally, for non-adjustable panels, the angle of inclination of the panels should be equal to the latitude of the location plus 10^0 (Stapleton & Neill, 2012).

Wind Turbine

The basic principle of a wind turbine is to convert mechanical energy from the wind into rotating energy in the windmill, then the rotation of the windmill is used to turn a generator, which will eventually produce electricity (Chun, 2015). The energy produced by the wind depends on the density of the air (where the standard value of is 1.225 kg/m3), the area of the turbine blades (wheel diameter), and wind speed. Air density is highly dependent on temperature, altitude, and humidity (Lee & Liew, 2020). The power generated by the wind turbine can be formulated as in equation 2, where P_{wind} is the power (kW), ρ is the air density (kg/m^3), A is the turbine cross-sectional area (m^2), and V is the wind speed (m/s) (Zahran & Yousef, 2014). Cp is a dimensionless power coefficient or Betz limit, and is a measure of the efficiency of a wind turbine in extracting the kinetic energy content of the wind stream which can be converted into mechanical work.

$$P_{wind} = \frac{\Delta E}{\Delta t} = \frac{1}{2} \times Cp \times \rho \times A \times V^3 \quad (2)$$

Wind resources vary widely in nature. Combining meteorological and statistical techniques for estimating wind energy can give us very useful predictions for the output power of a particular wind turbine, so it can be a consideration for selecting the appropriate Wind Energy Conversion System (WECS) (Ragheb & Ragheb, 2011). In the industrial world, the Weibull probability distribution function (PDF) is the most widely used to describe the wind speed distribution for WECS applications.

Battery

Batteries are energy storage devices in the form of electrochemistry which are widely used to store energy in various applications. There are several types of batteries on the market, namely wet or conventional, hybrid and MF (Maintenance Free) batteries. Wet or conventional batteries mean that they still use sulphuric acid (H2SO4) in liquid form. While the MF battery is often called a dry battery because the sulphuric acid is already in the form of a gel. There are two types of batteries that are often used, namely primary batteries and secondary batteries. Primary battery is a battery where the electrochemical reaction is non-reversible, so that after use it must be discarded (Augustine et al., 2012). A secondary battery is a battery commonly known as a rechargeable battery. In this battery the electrochemical reaction is reversible, so after being used on this battery it can be recharged. The most commonly used type of rechargeable battery is the Lead-acid type because of its high technology and performance, and relatively cheap price.

All types of batteries perform better at low currents than high currents, both for charging and discharging. The slow charge or discharge procedure extends the life of any battery and allows for sustained high levels of capacity throughout its life cycle. Fast charging as well as rapid discharge that draws high currents can easily lead to poorer performance and shorter life for all types of electrochemical batteries. Life cycle is the number of cycles a battery can perform before reaching 80% of nominal capacity and is basically determined by the battery type and depth of discharge (DoD). The higher the DoD, the shorter the lifespan for all battery types. It is recommended that the battery discharge cycle should not regularly be below 60% DoD or 40% charge condition (Häberlin, 2012).

Inverter

Inverter is a system component that is used to convert DC current from solar panels or batteries into AC current (Tawiah, Marfo, & Benah, 2016). The output voltage generated after conversion through this inverter can be fixed or variable as needed. The output waveform of the inverter is ideally a sine wave. But in reality this is not the case because of the harmonics. Inverters are divided into 2 types, namely single-phase inverters and three-phase inverters. According to the type of wave, there are three types of inverters on the market, namely sine wave inverters, modified sine waves, and square wave inverters. The inverter capacity can be formulated into equation 3, where $P_{inverter}$ is the inverter power capacity (watt), P_{max} is the peak load (watt), and the compensation is 125%.

$$P_{inverter} = P_{max} \times 125\% \tag{3}$$

Based on the characteristics of the required performance, inverters for off-grid and on-grid systems have different characteristics. In an off-grid system, the inverter must be able to supply a constant AC voltage for variations in production from energy sources and load demands. Whereas in the on-grid system, the inverter can regenerate the exact same voltage as the grid voltage at the same time, to optimize and maximize the energy output generated by the energy source.

Solar-Wind System

Solar power can only provide a fraction of the power required for offshore rigs due to lack of space and weight constraints (Tawiah et al, 2016). Wind power and solar energy can be combined into a hybrid system for more stable and consistent energy conversion. The unstable wind and solar energy can be partially or completely overcome, thereby ensuring continuity and quality of electricity generated by the system. Solar panels, wind turbines and batteries can be incrementally upgraded to the system as long as financial resources, energy potential and area for system installation are available. Another advantage of this hybrid system is that both are environmentally friendly renewable energies.

The application of solar energy alone is not sufficient for equipment on offshore platforms that require a stable energy supply. These problems can be overcome by adding wind energy so that the power produced is more stable and reliable (Lee & Liew, 2020). The HOMER software can be used to obtain the optimal configuration of an off-grid hybrid solar-wind system by combining economics and reliability (LPSP). The higher the LPSP value, the less energy required by the load is fulfilled (Hosseini et al, 2017).

A major concern in the design of a solar-wind hybrid energy system is to determine the size of each component that plays a role in the system so that the load can be met economically and reliably. Therefore, the component system is selected with consideration to determine the total cost of the system and ensure that the requirements are met according to certain criteria. The objective function of the total cost should be minimized, and this cost function is generated by the sum of the present worth (PW) of all components, annual operating and maintenance costs, initial or capital investment, and system component costs (Ramoji & Kumar, 2014).

$$min\ C_T = \sum_{k=1}^{3} I_k + R_{PWk} + OM_{PWk} - S_{PWk} \tag{4}$$

The objective function of the total cost can be formulated by equation 4, where C_T is the total cost, I_k is the initial capital or investment of each k component. R_{PWk} is PW of the replacement cost of each k component. OM_{PWk} is the operation and maintenance cost of each k component. S_{PWk} is the PW of the residual value of each k component. The k index is the component of the PV module, wind turbine, and battery. Constraints that must be met when the total cost must ensure that the load is carried out in accordance with a certain. Another limitation that may need to be considered is the limited area of the system installation.

METHOD

The method used in this study is a simulation method using HOMER Pro 3.14 software based on data in the Southeast Sumatra Block offshore working area. The HOMER software is easy to operate and can perform technical and cost analysis on hybrid systems. Theoretical and measurable calculations are carried out to complete the required data.

HOMER simulates the operation of a system by calculating the energy balance at each time step (interval) in a year (HOMER, 2021). For each time step, HOMER compares the load demand with the energy the system can supply, and calculates the energy flow into and out of each system component. HOMER has two optimization algorithms. The genetic algorithm simulates all feasible system configurations obtained by Search Space. The new HOMER Optimizer® algorithm is exclusively derivative-free to find the least expensive system. HOMER then displays a list of configurations, sorted by net present cost or life cycle cost, which can be used to compare system design options.

The modelling of a hybrid system consisting of solar panels and wind turbines in the HOMER device includes solar radiation and regional wind speed data into the software. HOMER calculates the amount of energy from renewable energy sources in hourly steps. The HOMER software uses the net present cost (NPC) for life cycle costs. These NPCs include initial investment costs, replacement costs, maintenance costs, fuel, and electricity purchases from the main grid, air pollution penalties, and electricity sales to the grid.

This Research was carried out in the following stages: literature study and data collection for simulation and calculation; identify the location and measure the area, as well as calculate the electricity needs of lighting lamps and air conditioners at that location; select and determine the number of solar panels, wind turbines, converters, and batteries based on the available area using the HOMER software; conducting simulations using the HOMER software so that the capacity of the electrical energy produced and the costs required are known; calculating the amount of gas that can be converted from generator fuel into business products and conducting financial analysis.

RESULTS AND DISCUSSION

A. Location and Area

The location selection is determined based on the availability of space on the platform for the planned installation of the solar-wind system. The available area measurement is carried out as a basis for determining the number of solar panels and wind turbines that can be installed. The Southeast Sumatra block has five platforms with an area on the top deck that can be used for the planned installation of a solar-wind system, namely platforms 1, 4, 13, 15, and 17. The available areas at the five platforms are 6 meters long and 6 meters wide. 5.5 meters. The structure of these areas is still very strong for the installation of solar panels and wind turbines. The coordinates of the location and available area on the platform are shown in table 1.

Table 1
Coordinates of location and area

Platform	Coordinate		Area available (m^2)
	Latitude	Longitude	
1	4° 40' 01.0690" S	106° 37' 44.3799" E	33
4	4° 40' 51.2002" S	106° 36' 36.2460" E	33
13	4° 35' 04.7263" S	106° 38' 34.5579" E	33
15	4° 34' 48.0600" S	106° 39' 37.6259" E	33
17	4° 33' 35.3402" S	106° 42' 01.2200" E	33

B. Load Identification

The solar-wind energy system in the Southeast Sumatra Block aims to supply electricity to equipment that does not have a direct impact on oil and gas production. The equipment includes lighting and air conditioners. The air conditioner used has a capacity of 1 pk with a power of 840 W, while each lighting lamp has a power of 150 W. The lighting and air conditioner on the bridge is on or on continuously. Based on the results of data collection and calculations, it is obtained that the electrical load needs of lighting lamps and air conditioners in the selected locations, as shown in table 2.

Table 2
Electricity requirements of secondary equipment on site

Platform	Lighting lamp (150 watt)		Air conditioner (1 pk)		Total power (kW)	Total power per day (kWh/day)
	Amount	Power (kW)	Amount	Power (kW)		
1	40	6	3	2,52	8,52	204,48
4	36	5,4	3	2,52	7,92	190,08
13	36	5,4	3	2,52	7,92	190,08
15	40	6	3	2,52	8,52	204,48
17	36	5,4	3	2,52	7,92	190,08

1. Component Selection

The selection of the SunPower E20-327 solar panel was carried out by considering the capacity, efficiency, dimensions, and service life of the product. These solar panels are easily

available in the market. The number of solar panels that can be installed at each location of the platform is 15 units and each solar-wind system at the site only requires 1 converter. The specifications of the SunPower E20-327 solar panel are shown in table 3.

Table 3
Specifications of SunPower E20-327 solar panels

Rated power	327 W
Type	Monokristalin
Efficiency	20,4%
Maximum current (Isc)	6,46 A

Maximum voltage (Voc)	64,9 V
Panel dimension (long x wide)	1558 x 1046 mm
Lifetime	25 years

The type of wind turbine used is the horizontal type by considering the capacity, tower height, mill diameter, and lifetime. The Xzeres Skystream 3.7 wind turbine has a capacity of 2.4 kW with a mill diameter and tower height according to the bridge structure. The diameter of the wind turbine blade is an important consideration because of the limited installation area on the platform. Wind turbines can be placed in all four corners of the available area by considering the distance between the mills. The available area on the platform is 6 meters long and 5.5 meters wide, so the maximum number of wind turbines that can be installed is 4 pieces.

Table 4
Xzeres Skystream 3.7 wind turbine specifications

Rated power	2,4 kW
Cut in speed	3 m/s
Cut out speed	63 m/s
Generator	AC
Mill diameter	3,72 m
Tower height	11,07 m
Lifetime	20 years

The converter consists of an inverter to convert DC current to AC and a rectifier to convert AC current to DC. The choice of converter is carried out by considering the peak load and capacity of the solar panels. The converter used in this study is the Schneider Conext XW+8548 which has a power capacity of 6.8 kW.

Table 5
Specifications of the Schneider Conext XW+8548 converter

Rated power	6,8 kW
DC input voltage	40-64 Vdc (48Vdc nominal)
Maximum DC input current	180 A
Maximum battery charging current	140 A
Frequency	50/60 Hz
AC input voltage	165-280 V
AC output voltage	230 V ± 3%
Efficiency	95%
Dimension (height x wide x thick)	58 cm x 41 cm x 23 cm
Lifetime	10 years

Batteries are selected by considering the appropriate capacity and dimensions because of limited storage room. The PowerSafe SBS-190F 12V battery is a Valve Regulated Lead Acid (VRLA) type battery. The batteries will be used with a series arrangement of 4 batteries in 1 string so that it increases the voltage to 48V.

Table 6
PowerSafe SBS-190F battery specifications

Voltage	12 V
Power capacity	2,57 kWh
Maximum capacity	214 Ah
Roundtrip efficiency	97%
Maximum charging current	190 A
Maximum discharging current	983 A
Dimension (long x wide x height)	56,1 cm x 12,5 cm x 31,6 cm
Lifetime estimation	5 years

The optimization using the HOMER software is limited to 10 strings battery arranged in parallel. Limiting the number of batteries is carried out by considering the availability of battery storage room on each platform. If there are 4 batteries in series on each string, then 40 batteries are needed in each off-grid solar-wind system. This means that a total of 200 batteries are needed in off-grid solar-wind system for 5 locations in the Southeast Sumatra Block.

2. Technical Analysis

Solar radiation data on GHI (Global Horizontal Irradiance) and annual wind speed in the Southeast Sumatra Block area obtained using the HOMER software are shown in Figures 2 and 3. The data was obtained in February 2022. Each platform has similar data on solar radiation and wind speed because of nearby location coordinates. The average solar radiation data is 5.05 kWh/m2/day, while the average wind speed data is 4.45 meters per second.

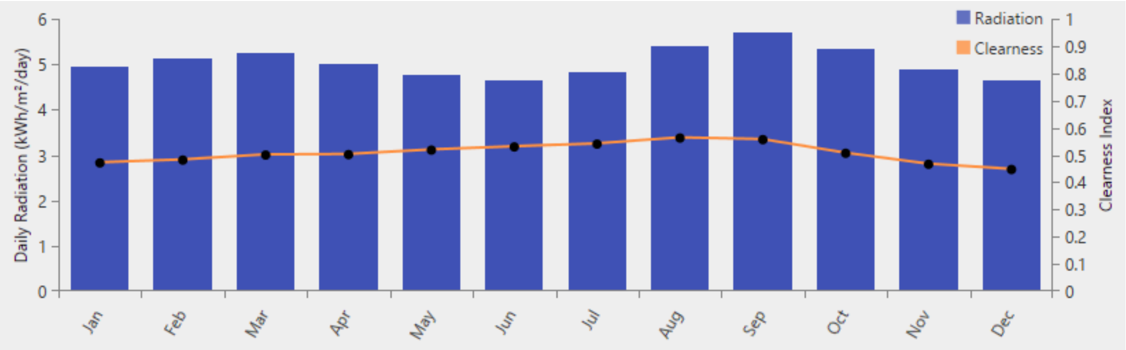

Figure 2. GHI solar radiation data in the Southeast Sumatra Block area

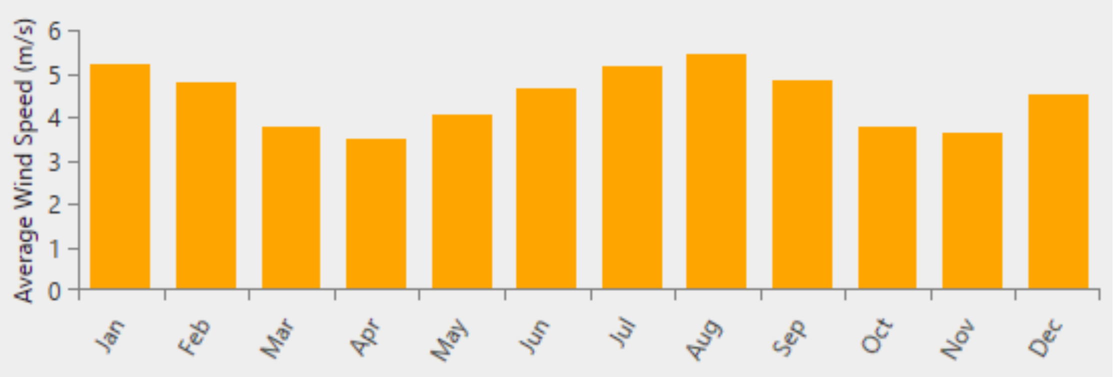

Figure 3. Wind speed data in the Southeast Sumatra Block area

3. Off-grid Solar-Wind System

The HOMER software calculates total electrical energy produced by solar panels and wind turbines. Calculation of power on solar panels consider the rating decrease factor, efficiency, and temperature. The system configuration in the off-grid simulation can provide electricity supply to load of 27.5 kWh per day with a peak load of 2.1 kW. The summary of the off-grid system technical data simulation result is shown in table 7.

Table 7
Technical simulation results on off-grid systems

Variable		Solar Panel	Wind Turbine	Converter	Battery
Amount		15 unit	4 unit	1 unit	10 strings
Capacity		4,91 kW	8,4 kW	6,8 kW	103 kWh
Operational		4.380 hours per year	6.396 hours per year	7.766 hours per year	-
Average output power		0,81 kW	1,08 kW	0,765 kW	-
Energy in		-	-	6.995 kWh per year	4.126 kWh per year
Energy out		-	-	6.700 kWh per year	4.006 kWh per year
Electricity	Production	7.077 kWh per year	9.466 kWh per year	-	-
		16.543 kWh per year			
	Consumption	10.047 kWh per year (27,5 kWh per day)			
	Excess	6.056 kWh per year (36,6%)			

The total electricity production of the off-grid solar-wind system in the Southeast Sumatra Block is 82,715 kWh per year and electricity consumption is 50,235 kWh per year. Gas fuel consumption is 0.4 MSCF per 1 kW, so the gas fuel consumption that can be reduced based on electricity consumption from the off-grid solar-wind system is 20,094 MSCF per year.

4. On-grid Solar-Wind System

The on-grid solar-wind system is built without using batteries, so it does not require investment or operational costs for batteries. The simulation is carried out by providing a load of 8 kW or 192 kWh per day. The load is assumed to be close to the value of the lighting and air conditioner loads on the platforms used as research locations. The summary of the on-grid system technical data simulation result is shown in table 8.

Table 8
Technical simulation result of on-grid system

Variable		Solar Panel	Wind Turbine	Converter
Amount		15 unit	4 unit	1 unit
Capacity		4,91 kW	8,4 kW	6,8 kW
Operational		4.380 hours per year	6.267 hours per year	4.380 hours per year
Average output power		0,81 kW	1,08 kW	0,774 kW
Energy in		-	-	7.077 kWh per year
Energy out		-	-	6.780 kWh per year
Electricity	Production	7.077 kWh per year	9.466 kWh per year	-

	7.077 + 9.466 = 16.543 kWh per year
Consumption	6.780 + 9.466 = 16.246 kWh per year (44,5 kWh per day)
Excess	16.543 - 16.246 = 297 kWh per year (1,8%)

The total electricity production of on-grid solar-wind system in the Southeast Sumatra Block is 82,715 kWh per year, while electricity consumption is 81,230 kWh per year. Gas fuel consumption is 0.4 MSCF per 1 kW, so the gas fuel consumption that can be reduced based on electricity consumption from the on-grid solar-wind system is 32,492 MSCF per year.

5. Financial Analysis

The project is planned for 25 years. The variables used as assumptions in the financial analysis are component prices, a discount rate of 3.5%, and an average inflation rate of 1.87 in 2021. The cost calculation in this study is influenced by the cost of the main components without taking into account the costs of construction, material delivery, and system commissioning.

The initial investment cost of the solar-wind system in this study is limited to the price of the main components. Overall price information for the main components of the solar-wind system is obtained from various sources. The difference in the initial investment cost of the two systems lies in the battery component. The initial investment cost of the on-grid solar-wind system is lower because it does not use batteries in its application.

Table 9
Initial investment cost of off-grid solar-wind system in Southeast Sumatra Block

Component	Amount	Price	Total Price
Solar panel SunPower E20-327	75	$650	$48.750
Wind turbine Xzeres Skystream 3.7	20	$12.000	$240.000
Converter Schneider Conext XW+8548	5	$5.000	$25.000
Battery PowerSafe SBS-190F	200	$350	$70.000
Total cost			$383.750

Table 10
Initial investment cost of on-grid solar-wind system in Southeast Sumatra Block

Component	Amount	Price	Total Price
Solar panel SunPower E20-327	75	$650	$48.750
Wind turbine Xzeres Skystream 3.7	20	$12.000	$240.000
Converter Schneider Conext XW+8548	5	$5.000	$25.000
Total cost			$313.750

HOMER software performs the process of calculating the net present cost (NPC) of the total costs incurred during the project period minus the total costs incurred during the project period. Levelled Cost of Electricity (LCOE) is the average cost of electrical energy from producing consumable electricity. Investment costs (CAPEX), operational costs (OPEX), NPC, and LCOE were simulated using the HOMER device for each platform, where all five platforms had the same solar-wind system configuration. Solar panels are assumed to be without operational and maintenance costs because they can be carried out by company workers. The annual wind turbine operating and maintenance costs are assumed to be 10% of the price, which is $1200. The converter operating and maintenance costs are assumed to be $250 per year (5% of the price), while battery maintenance costs are assumed to be $17.5 per battery.

The summary of the results of the financial optimization of the solar-wind system on each platform obtained from the simulation results of the HOMER software is shown in table 11.

Table 11
Financial simulation results of the solar-wind system on each platform

Variable	Off-grid system	On-grid system
Investment cost (CAPEX)	$76.750	$62.750
Operational cost (OPEX)	$8.830 per year	$5.878 per year
Net Present Cost (NPC)	$257.526	$183.094
Levelized Cost of Electricity (LCOE)	$1,25 per kWh	$0,55 per kWh

The off-grid solar-wind system in the Southeast Sumatra Block can reduce gas fuel consumption by up to 20,094 MSCF per year. If the selling price of gas in the Southeast Sumatra Block is $6.6 per MSCF, then the selling value of gas is $132,620 per year. The return on investment (ROI) value for the off-grid solar-wind system is calculated at 21% and the payback period is 56-57 months. The gas sales value of the on-grid solar-wind system is $214,447 per year with an ROI of 57% and a payback period of 21-22 months. The net present value (NPV) for the off-grid system is $1,190,475, while the on-grid system is $2,812,995. The NPV value is greater than zero, so it can be said that the investment in the solar-wind system is feasible.

CONCLUSION

The purpose of this study is to determine how much electrical load can be supplied by the solar-wind system, how much gas fuel consumption can be reduced by implementing a solar-wind system, and what is the economic value.

Based on the result of the research, the off-grid solar-wind system can provide electricity supply of 50,235 kWh per year (137.6 kWh per day) in the Southeast Sumatra Block. Meanwhile, the on-grid solar-wind system can provide electricity supply of up to 81,230 kWh per year (222.55 kWh per day).

Gas fuel consumption from turbine generators can be reduced by the use of an off-grid solar-wind system in the Southeast Sumatra Block by 20,094 MSCF per year. Meanwhile, the on-grid solar-wind system is able to reduce the use of gas fuel by 32,492 MSCF per year.

The economic value of the off-grid solar-wind system in the Southeast Sumatra Block based on gas sales of $132,620 per year obtained NPV of $1,190,475 (NPV > 0), ROI of 21%, and a payback period of 56-57 months. The on-grid system with gas sales of $214,447 per year resulted in an NPV of $2,812,995 (NPV>0), an ROI of 57%, and a payback period of 21-22 months. Both solar-wind systems have a positive economic value so they are feasible to implement. It can be considered and recommended the application of an on-grid solar-wind system for platforms rather than an off-grid solar-wind system.

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