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Analysis Providing Diesel-Wind Hybrid Electrical Energy System in Timor Island Indonesia

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Abstract. The research objective are: (1) Analyse the capacity needs of the wind energy system based on the parameters of energy requirements, the ability of the inverter, generator capability and the ability of the local wind. (2) Generate a simulate diesel-wind hybrid power plants for Kupang city and every district in Timor island; (3) Generate an optimization of wind-diesel hybrid power plant for Kupang city and districts in Timor island; (4) Generate a scheme wind-diesel hybrid power plant for Kupang city and every district in Timor island. The method used in this research is quantitative method with the approach of simulation, optimization and sensitivity analysis used HOMER application program, i.e.: (1) simulation system of diesel-wind hybrid power plant; (2) optimization system of diesel-win hybrid generator, and (3) the sensitivity analysis system diesel-wind hybrid power plant. Conclusion of this research are: (1) Simulation in Kupang city and districts of Kupang are wind turbines 20 KW with generator capacity of 71.7 KW. Optimization result of wind-energy contribution of only 7% and ideal price of US $ 0.47 to produce wind turbines of 20,000 KWH/yr; (2) Simulation in South Central Timor (TTS) district is wind turbines 3 KW with generator capacity of 11.4 KW. The result of optimization of wind-energy contribution of only 9% and ideal price of US $ 0.525 to produce wind turbines of 1.165 KWH/yr; (3) Simulation in North Central Timor (TTU) district is wind turbines 1 KW with generator capacity of 7.62 KW. Optimization result of wind-energy contribution of only 4% and ideal price of US $ 0.53 to produce wind turbines of 1.150 KWH/yr;(4) Simulation in Belu districts is wind turbines 10 KW with generator capacity of 12.1 KW. Optimization result of wind-energy contribution of only 22% and ideal price of US $ 0.48 to produce wind turbines of 1.210 KWH/yr.

1. Introduction

Wind energy in Indonesia has large potential to be developed as a renewable energy source. This potential is not only capable of producing great energy but it can provide jobs for Indonesia people. Wind energy for the next few years is expected to be a source of energy for pedestal for Indonesia, therefore the government should strive to build wind power plants (thermal power station) with a total capacity of 1,000 MW up to 13 years. This amount is not difficult to achieve if we look at the potential of wind energy spread across the Indonesian coast. Indonesia, which has a total coastline of 81,000 km to reach the average wind speed of 3-5 m / s, even in some places reaches 10 m / s [1].

Wind energy is a new breakthrough in harnessing renewable energy to meet the needs of the public electricity supply. Based on data from the Ministry of Energy and Mineral Resources, Indonesia has a long coast 80791.42 km, is a potential area for the development of wind turbine power plant. Wind speed in Indonesia is generally between 4 m / sec to 5 m / sec. In coastal areas the wind speed can reach 10 m / sec. With these speeds, the development of wind power is less economical. However, it was built with a certain height and diameter larger propeller capable of generating electrical energy with a potential capacity of 10-100 KW.

Indonesia has 17,508 islands surrounded by a very large coastline (data from the Indonesian Naval Hydro Oceanographic Office). Realities facing currently operational PLN could not afford the installation of electricity to the remote islands, it is very appropriate technologies are developed and implemented. Implementation fired plant in Indonesia is needed, because the area in the remote Indonesian islands cannot reached by the electricity grid. The beach area is more suitable for the thermal power station, but a commercial thermal power station must meet several requirements. These requirements are: (1) Location fired plant has an average wind speed of> 5 m / sec per year (enough categories) and consistent throughout the year. (2) The area or location that still require electrical energy; (3) The range of the distribution network (grid) of electricity is not too far away. (4) Price of competitive technologies; (5) Users buy electricity at the right price; (6) the availability of adequate supporting infrastructure around the site [2][3].

Indonesia is an archipelago with a population of about 250 million people. 60% population live in remote areas without electricity access. Factors inhibiting electrical energy supply in remote areas are: geography, limited accessibility, lack of infrastructure, lack of human resources, low ability of local capital, the level of the economy is still weak. Indonesia has the potential sources of local energy / renewable (wind) is relatively abundant, but has not been used optimally. The use of alternative energy (particularly wind energy) for electricity generation is a solution to the problem of the use of fossil fuels and the reduction of the pollution.

Wind energy is the energy source that is environmentally friendly, because it comes from the wind. These energy sources do not pollute the air like power plants that rely on combustion of fossil fuels (coal or natural gas) and not throw greenhouse gas emissions into the atmosphere. Wind energy relies on wind power that can be updated (and probably will not run out, as long as weather conditions do not change drastically). In terms of economics, wind energy is one of the cheapest renewable energy technologies today [4][5].

The contribution of renewable energy in the national primary energy mix in 2025 is targeted at 17%. To achieve these targets need to work hard because it must increase the installed capacity of mMicro Hydro Power Plant amounted to 2,846 MW, 180 MW of biomass, wind power plant of 970 MW and 870 MW of solar wind power plant [6]. In the above description describes the wind power plant ranks second in priority after the national electrical energy micro-hydro. To support the wind power plant to be powered by wind conditions that exist today, in order to more clearly seen in Figure-1 [7].

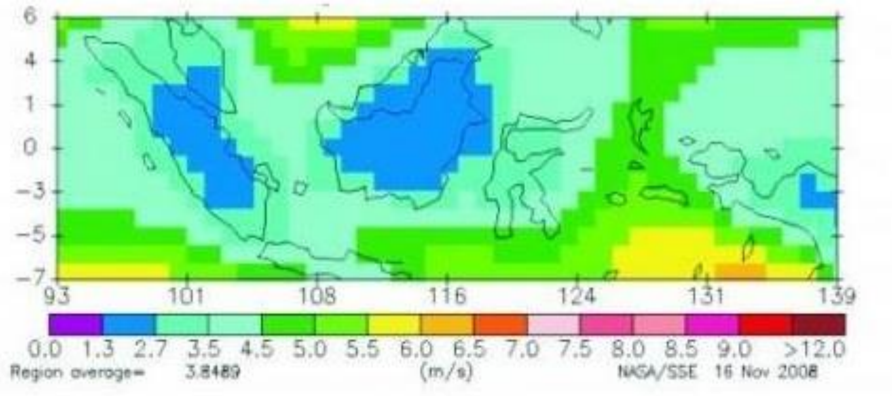

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Figure 1. Wind Potential Map in Indonesia

Figure-1, describes the average wind speed for the mainland island of Timor Indonesia ranges from 5.0 to 6 m / s, it is seen by the position coordinates of the island of Timor in the range - 8.13 to -10.36 South Latitude and 123.32 - 125.11 Longitude east. The above data is supported by the results of research . Pakpahan [8][9] describes some places in East Nusa Tenggara province shows the wind speed above the average value, namely are: Baun (6.6 m / s), Waingapu (6.6 m / sec), Rote (5.8 m / s), Soe (7.0 m / sec) and Atambua (7.3 m / sec). The above data it can be concluded that the wind potential on the mainland of Timor island can be used as a power plant that comes from the wind power.

Sampai saat ini belum ada penelitian tentang kapasitas energi listrik hibrid di pulau Timor. Penelitian ini memiliki keuntungan menghasilkan data kapasitas turbin angin yang dibutuhkan untuk masing-masing kabupaten di pulau Timor dan biaya bahan bakar solar ideal untuk masing-masing kabupaten.

Until now, Kupang has been no research on hybrid electric energy capacity in the island of Timor. This study has the advantage of wind turbine capacity to produce data needed for each district in the Timor island and the ideal cost of diesel fuel for each district.

2. Method

The method used is quantitative method with a sensitivity analysis using a simulation approach application HOMER. Analysis phase of the implementation research can be seen in Figure 2

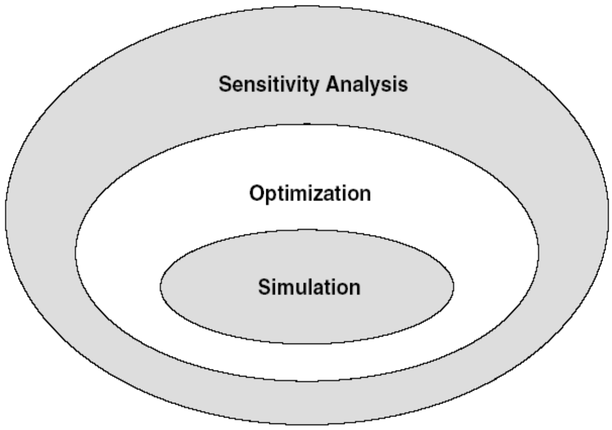

Figure 2. Relation simulation, optimization and analysis concept [10].

HOMER use three basic principles are: (1) the simulation. (2) Optimization and (3) sensitivity. Model performance using HOMER in the form of micro-generation configuration system through a unit time hours in a year to determine the feasibility studies of engineering and life-cycle costs [7] and [6]. The hybrid models are built based on an application made as in figure- 3.

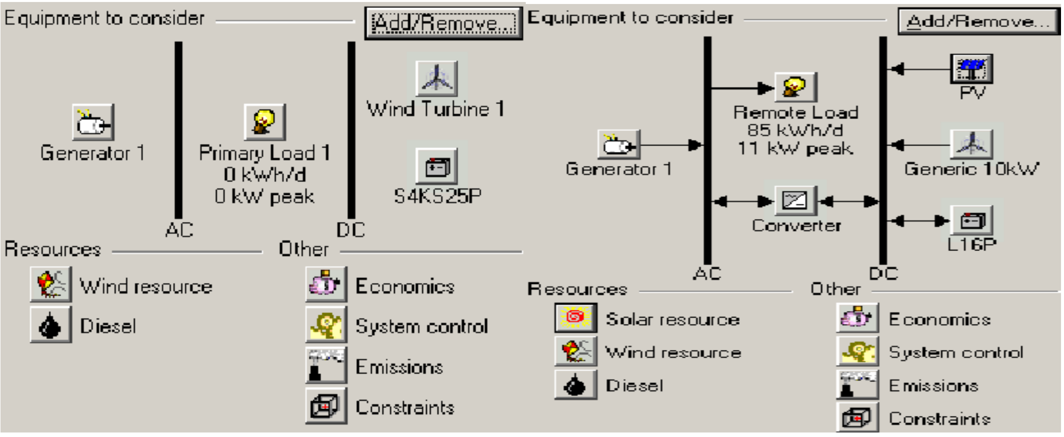

Figure 3. Model Hybrid Simulation of Wind- Diesel and Diesel-PV [11].

This study was conducted in five regions, name of region are: Kupang city, Kupang district, South Central Timor District (TTS), North Central Timor District (TTU) and Belu district in Timor island. Data collection using application program HOMER. The data will be used in applications HOMER program are: (1) cost of electricity; (2) source of energy (solar radiation); (3) the technical components; (4) constraints; (5) control. Achievement Indicator: The calculation of the performance of the existing system for predicting energy consumption or energy generation on a system. At this stage of the design required precise weather data. The feasibility study is based on weather data to determine the availability and level of resources (eg, wind speed and solar radiation) which are then combined to meet the requirements of a particular region.

The reliability of information on climatic conditions specific area determines the quality of the designed solution. After the feasibility study, selecting the right size of an equipment based on local climatic conditions (wind and weather data), the load required and capacity. The basic stages of development of energy systems using Kaldellis, these stages are: evaluation of local condition, system configuration, the hybrid system development models, sizing of system components and simulation and operational analysis. In detail, the basic stages of development can be seen in the following figure.

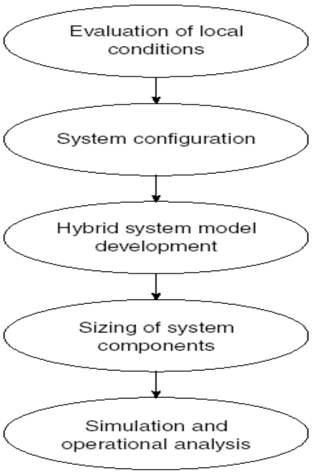

Figure 4. Phase of Basic Development Energy Systems Phase [12]

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3. The Result of The Research

3.1. Description Input of Diesel Data and Diesel Fuel Sensitivity Prices

This research applies three stages: *First*, input data for the purposes of the simulation, optimization and sensitivity analysis. *Second*, determination of the patterns of simulation with input basic data on installed power, peak load and wind data at the location to be studied. *Third,* optimization and sensitivity analysis which are the result or output of this research.

Input data is grouped into two, namely are: (1) input the same data for each region, i.e.: input Diesel Data and Diesel Sensitivity Prices, input Economic Data, Constrain input, Input Control System. Input different data for each region, i.e.: input of local wind data; (2) Input load peaks data, Input converter / inverter data, input wind turbine and Input Data Battery. This data used benchmark diesel prices applied in US dollar terms. Based on the data in August 2015, the basic price of industrial diesel Area IV is Rp. 9,650 and when converted to US dollars was 0.451. Then used a range of up and down used is the lower limit of the range of 0,400 and 0,550 for the upper limit (see figure-5).

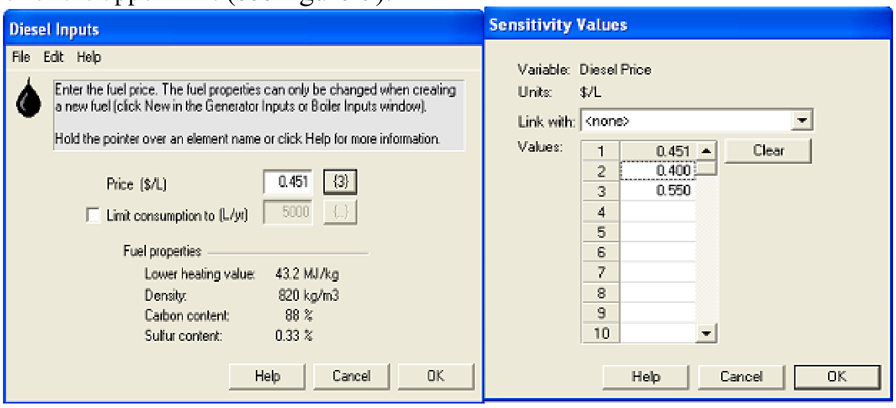

Figure 5. Diesel Data and Sensitivity Diesel Prices

3.1.1. Economic Data

Economic data expected remaining life is 25 years with the common fixed cost is US $ 1,200 (see figure-6).

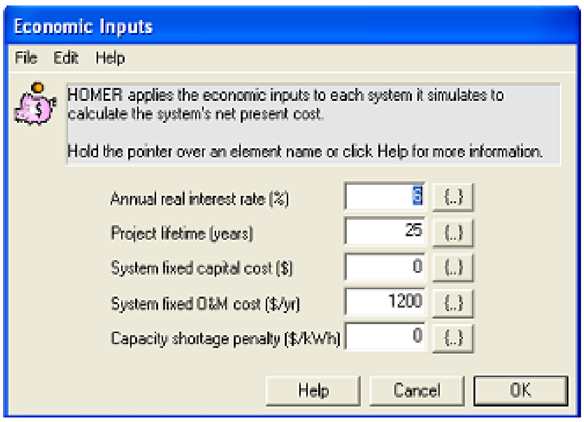

Figure 6. Economic Data

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3.1.2. Constrain Data

The maximum value of annual capacity shortage at 0%, then the value of unmet electric load or the rate at which power is not being met by the system is limited less than 0.09% so close to the value 0%. So the combination generated by the system can always meet their needs. Constrain Data can be seen in Figure-7.

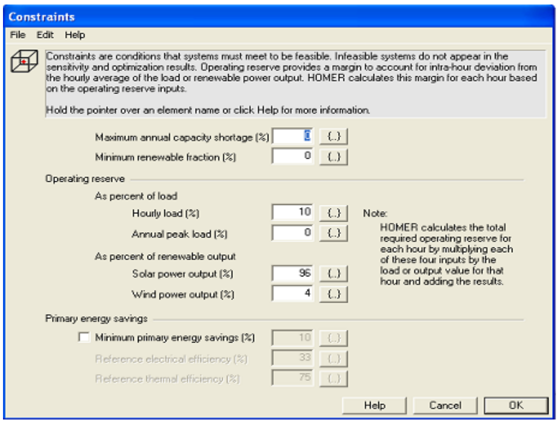

Figure 7. Constraint Data

3.1.3. Data Control System

Selection of the charging cycle or set point state of charge at 80%, then the power plant generator is also used to supply the load, is also used to supply charging up to maximum capacity.

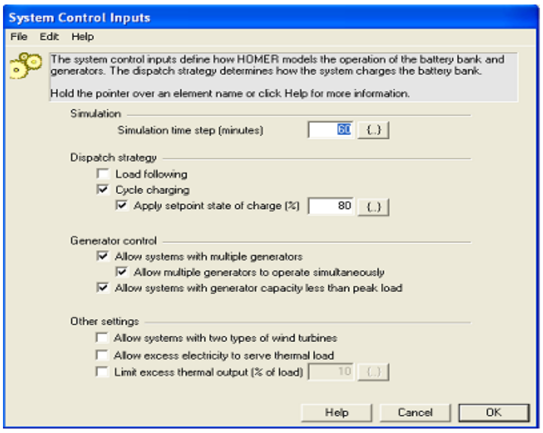

Figure 8. Data Control System

3.2. Simulation, Optimization and Sensitivity Analysis in Kupang City and District of Kupang

Preliminary data input of simulation is the form of data installed power capacity, power capacity and peak load, while the wish made by the hybrid wind turbine clearly using local wind data so that it can be made hybrid simulations. Installed power of 71 704 kW, capable of 52 100 KW power and peak load 45 372 KW. Peak load data apply overview of the peak load during the day and the evening peak load. In general, the evening peak load is greater than the peak load during the day. Form hybrid simulation for the Kupang city and district of Kupang applying 20 KW wind turbine and diesel generator 72 KW. Simulation and graph in Kupang city can be seen in figure-9- figure-12.

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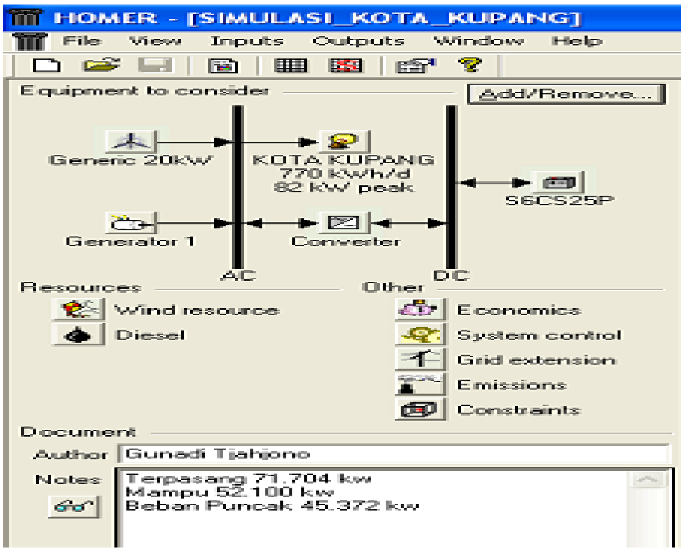


Figure 9. Simulation in Kupang City

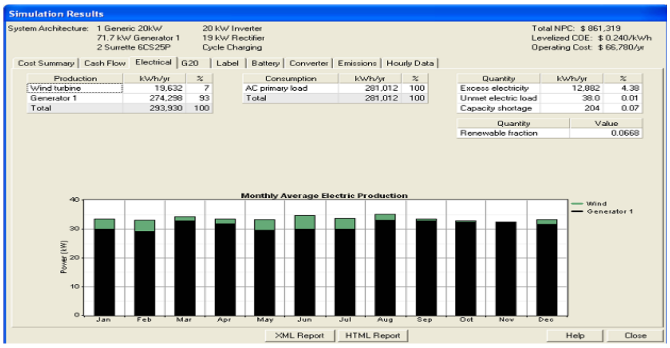


Figure 10. Summary of Electrical Kupang City

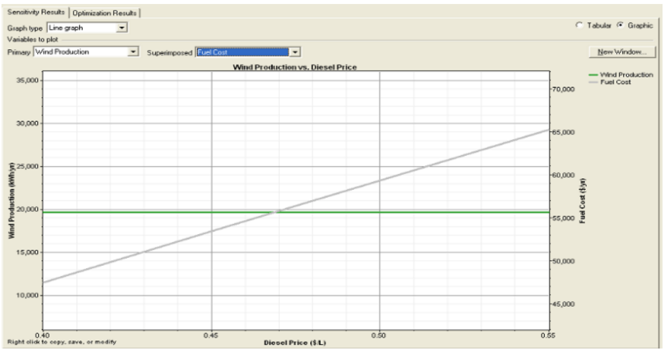


Figure 11. Graph Wind Production VS Fuel Cost in Kupang City

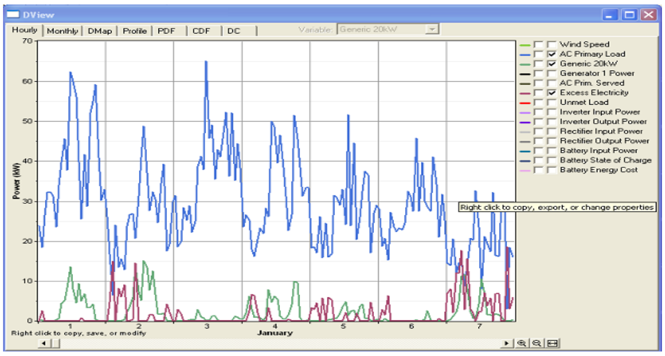


Figure 12. Graph Energy Use Daily in Kupang City

3.3. C. Simulation, Optimization and Analysis Sensitivities Analysis in South Central Timor (TTS) District

Preliminary data simulation input is data installed power capacity, power capacity and peak load. Hybrid with wind turbines using local wind data so that it can be made hybrid simulations. Installed power of 11 365 kW, capable power of 8577 KW, peak load 5,133 KW. Simulation and Graph in TTS District can be seen in figure-13- figure-16.

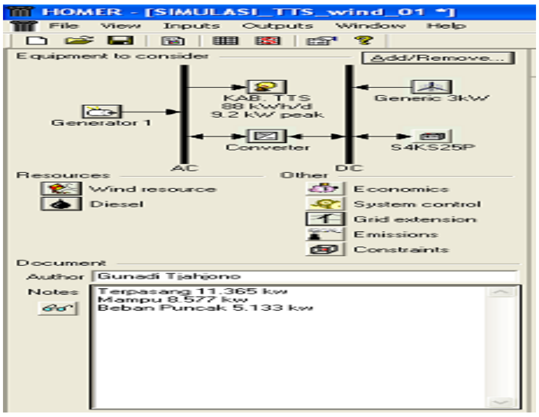
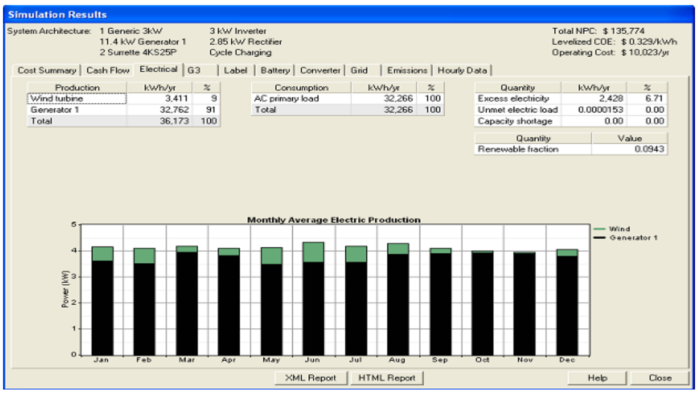


Figure 13. Simulation in TTS District



Production	kWh/yr	%
Wind turbine	3,411	9
Generator 1	32,762	91
Total	36,173	100

Consumption	kWh/yr	%
AC primary load	32,266	100
Total	32,266	100

Quantity	kWh/yr	%
Excess electricity	2,428	6.71
Unmet electric load	0.0000153	0.00
Capacity shortage	0.00	0.00

Quantity	Value
Renewable fraction	0.0943

Figure 14. Electrical Summary in TTS District

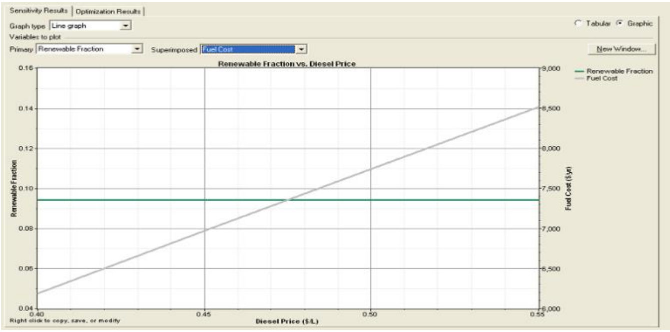


Figure 15. Graph Renewable Fraction VS Diesel Consumption in TTS District

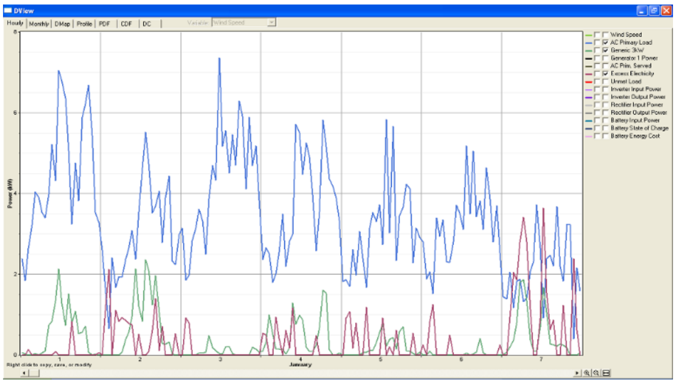


Figure 16. Graph Daily Energy Usage in TTS District

4. Simulation, Optimization and Sensitivity Analysis in North Central Timor (TTU) District

Preliminary simulation data is form of data installed power capacity, power capacity and peak load. Creating a hybrid wind turbine using local wind data so that it can be made hybrid simulations [13]. Installed power of 7617 kW, capable power of 5,630 KW and peak load 4,450 KW. Simulation and Graph in TTS District can be seen in figure 17 -figure-20.

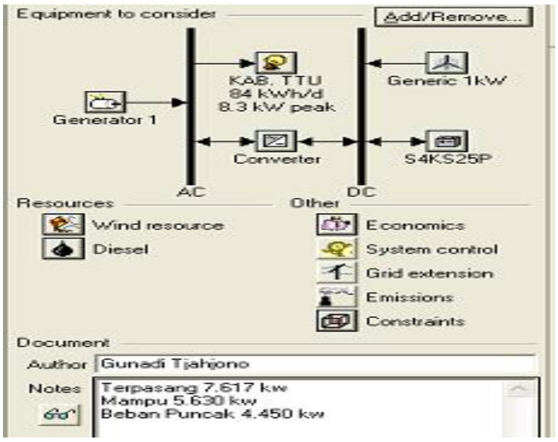


Figure 17. Simulation in TTU District

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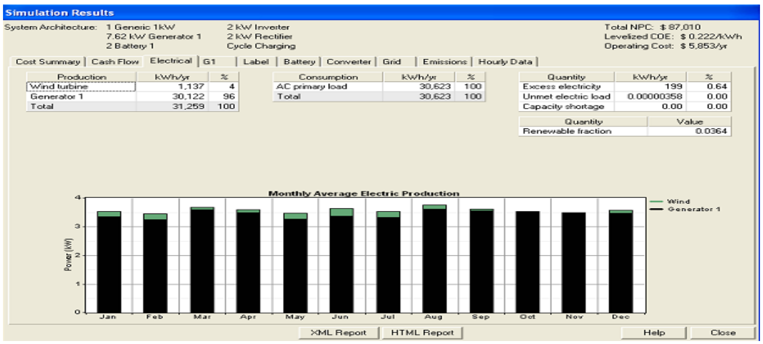

Figure 18. Electrical Summary in TTU District

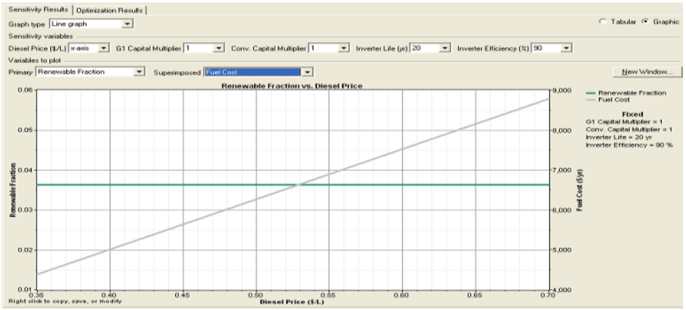

Figure 19. Graph Renewable Diesel Fraction VS Consumption in TTU District

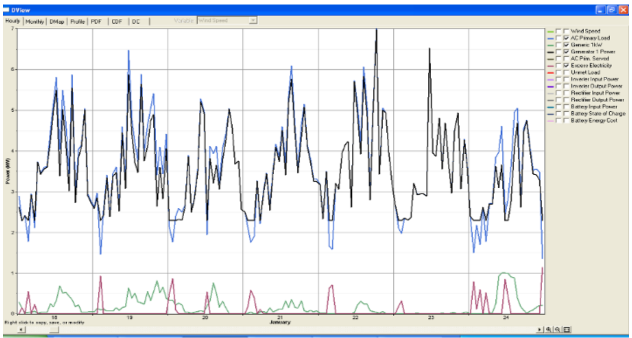

Figure 20. Graph of Daily Energy Usage in TTU District

5. Simulation, Optimization and Sensitivity Analysis in Belu District

Preliminary simulation data is form of data installed power capacity, power capacity and peak load. Creating a hybrid wind turbine using local wind data so that it can be made hybrid simulations. Installed power of 12.084 KW, capable power of 9.872 KW and peak load 7.700 KW. Simulation and Graph in Belu District can be seen in figure 21 - figure-24.

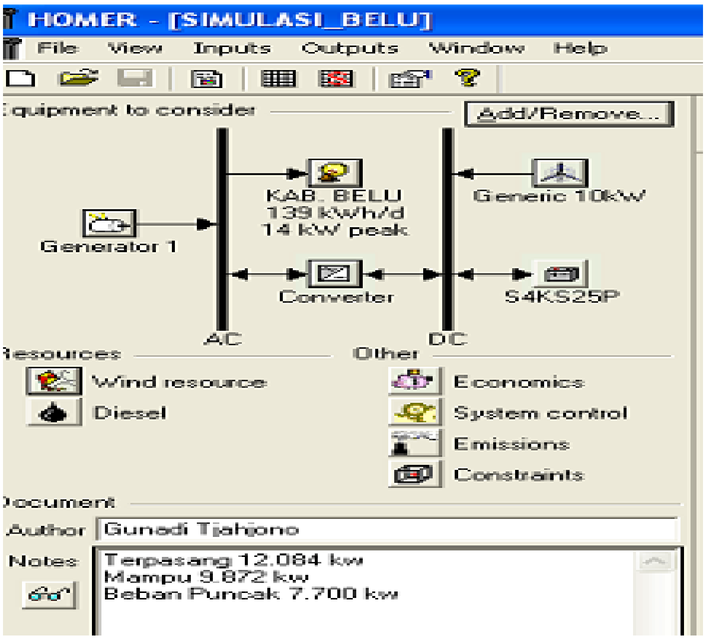

Figure 21. Simulation in Belu District

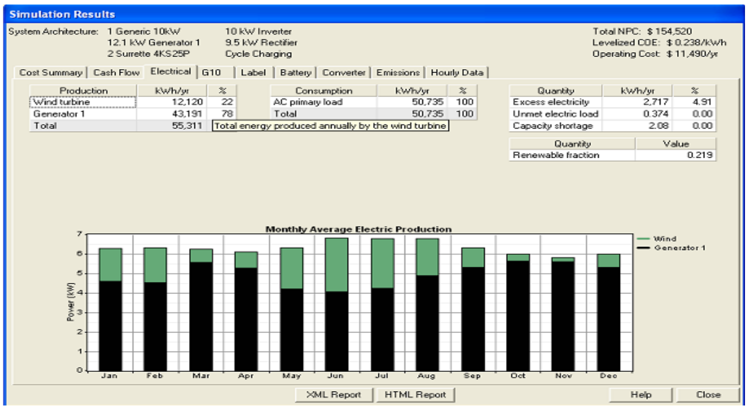

Figure 22. Electrical Summary in Belu District

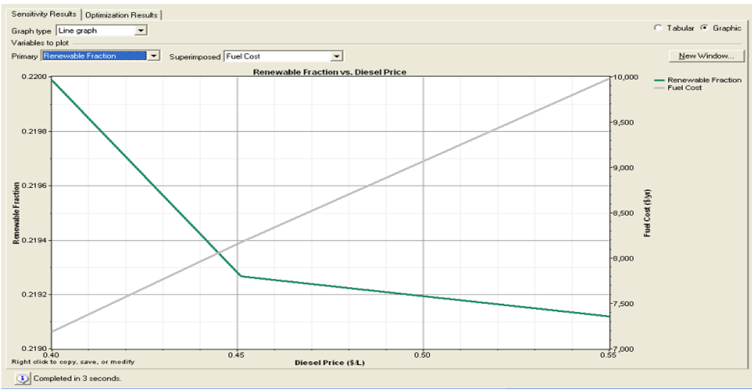

Figure 23. Renewable production VS Fuel Cost in Belu District

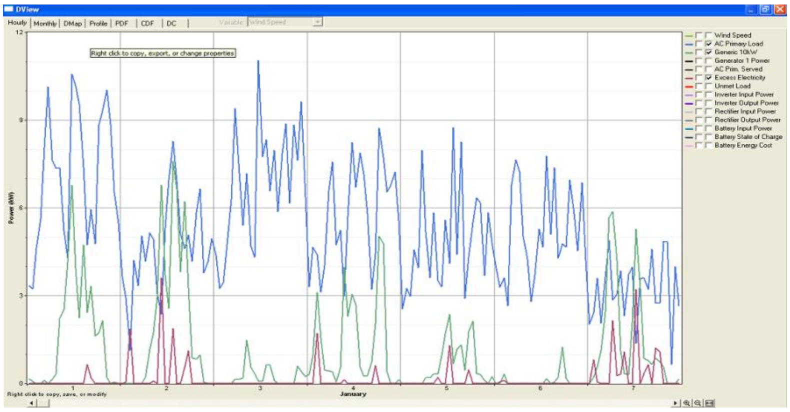

Figure 24. Energy Use Daily of Belu Districh

6. CONCLUSION

(1) Simulation in Kupang city and districts of Kupang are wind turbines 20 KW with generator capacity of 71.7 KW. Results of optimization of wind-energy contribution of only 7%. Analysis of wind turbine production costs to of fuel diesel cost in ideal price of US $ 0.47 to produce wind turbines of 20,000 KWH / yr. (2) Simulation in South Central Timor (TTS) districts is wind turbines 3 KW with generator capacity of 11.4 KW. Optimization result of wind-energy contribution of only 9%. Analysis of wind turbine production costs to of fuel diesel cost in ideal price of US $ 0.525 to produce wind turbines of 1.165 KWH / yr. (3) Simulation in North Central Timor (TTU) districts is wind turbines 1 KW with generator capacity of 7.62 KW. Optimization result of wind-energy contribution of only 4%. Analysis of wind turbine production costs to of fuel diesel cost in ideal price of US $ 0.53 to produce wind turbines of 1.150 KWH / yr. (4) Simulation in Belu districts is wind turbines 10 KW with generator capacity of 12.1 KW. Optimization result of wind-energy contribution of only 22%. Analysis of wind turbine production costs to of fuel diesel cost in ideal price of US $ 0.48 to produce wind turbines of 1.210 KWH / yr.

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