Simulation of the Power Flow of a Solar and Wind Hybrid Power Plant in the Situ Bunderan Garut Tourist Area

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***Abstract*— Solar and wind energy as renewable energy sources have great potential to be used as clean energy sources but are hampered by high installation operational costs, so a feasibility simulation study of the system model to be installed is needed to see whether it meets the criteria for safe and reliable power flow. This research aims to determine the power analysis of two types of renewable energy generators through power flow simulations for 14 IEEE system buses and contribute to the use of hybrid buses for wind power plants and solar power plants so that the use of renewable energy in interconnection with PLN energy sources can still be carried out because it meets the specified requirements. Based on the existing component data, modeling is carried out in the form of a single diagram of the electrical system which will be input to each parameter and run the simulation. The simulation results show that the voltage value on each bus still meets the input voltage safety tolerance limit of 105% for overvoltage and 95% for undervoltage. equipment connected to an energy source supplies active power according to the equipment specifications that have been determined and there is no critical or marginal failure in supplying the existing load. This simulation also shows that there are losses in the system of 190,811 kW so it is necessary to add a capacitor bank component with a capacity of 1 MVAR to improve the power factor in the network.**

Keywords*— *ETAP, Hybrid Energy, Power Flow, Solar, Wind.

I. INTRODUCTION

The use of renewable energy as a source of electrical energy among the public is increasing with the increasing number of producers offering various products for converting renewable energy into electrical energy. Solar and wind energy as renewable energy sources have great potential to be used as clean energy sources but are hampered by high installation operational costs, so a feasibility simulation study of the system model to be installed is needed to see whether it meets the criteria for safe and reliable power flow.

Power flow is an analytical study to determine the magnitude of the voltage, current, active power, and reactive power contained in an electric power system model so that it still meets the limits in each interconnected equipment and network.

Many studies have been carried out to simulate the power flow of a system before the system is installed. Reference [2] explains the use of ETAP software for planning the placement of reclosers due to disturbances in the distribution network. In contrast, References [3]-[6] carry out power flow simulation calculations in gas-fired power plants. The two studies above have advantages because they focus on one simulation characteristic, but this study also has weaknesses because it only assesses simulations for one generator. Hybrid energy from several generators, especially new types of renewable energy generators, has special constraints. The planning process is not only focused on one generator problem but must cover all the generators used.

Another study carried out power flow analysis by [7] who carried out power flow analysis in the feeder area of the petroleum processing industry using the Newton Raphson method. The research results show that after carrying out the simulation, there is a reduction in power losses in the electricity network. Another simulation was carried out by [8] using one type of renewable energy generator, namely PLTS connected to a hybrid with PLN energy sources. The research results show that energy from PV can reduce the power used by 22.41% of the total power used during 1 month of use. The research above has advantages because it uses more than one research object. Still, the disadvantage is that it has not revealed the use of more than 1 unit of renewable energy generator so the constraints resolved only apply to 1 type of generator.

Not many studies have discussed simulating the hybrid use of two generators or more types of renewable energy to fulfill loads using power flow analysis software. The difference between previous research and the research carried out is the use of two types of generators, namely PLTS and PLTB, and also the use of the IEEE 14 bus system [9]. This research aims to determine the power analysis of two types of renewable energy generators through power flow simulations for 14 IEEE system buses. This research is expected to contribute to the use of single-line diagram IEEE 14 hybrid buses for wind power plants and solar power plants so that the use of renewable energy in interconnection with PLN energy sources can still be carried out because it meets the specified requirements.

II. METHOD

Figure 1 shows the research flow chart starting from the literature study, design, tool testing, data analysis, and the conclusion of the research. This hybrid generator power flow study research uses several stages of research design according to the research flow shown in Figure 1. This study uses the IEEE 14 bus power system model by attaching flow diagram lines and generation data, bus data, generator data, transformer data, and load data, as well as several other supporting component data [10]-[12].

Based on the existing component data, modeling is carried out in the form of a single diagram of the electrical system which will be input by Figure 2 – Figure 4. The data will be entered into the single line diagram parameters of the ETAP Powerstation software, then Load Flow Analysis will be carried out and the values analyzed power flow that occurs on each connected bus.

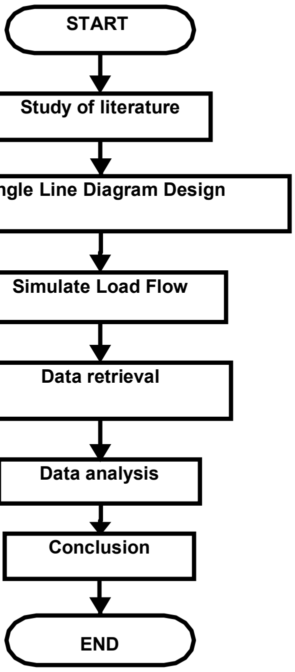

Figure 1. Research Flow Study

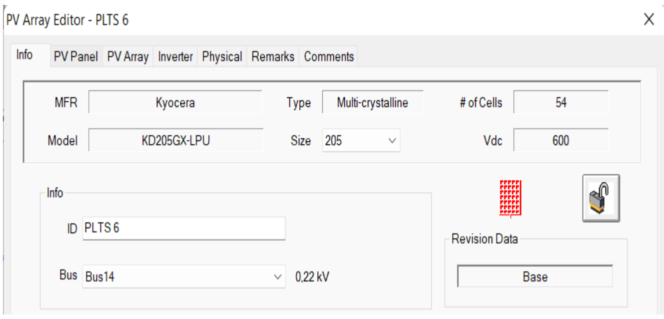

Figure 2. PV Array Parameter

The PV used in this research is Kyocera type KD205GX-LPU with a total of 54 solar cells of a mixture of mono and polycrystalline types. The output voltage from this PV is 600 Vdc, meanwhile, the parameters of the wind power generator used are an active power rating of 22kW, 4 poles, and a voltage rating of 600 V. This generator is simulated to have an average wind speed of 10 m/s[13]. parameters for PV and wind turbine generators are shown in Fig. 2 and Fig. 3.

A transformer is an important component for transferring power between one electrical circuit and another electrical circuit. This power flow analysis uses a step-up transformer with a primary voltage of 0.6 kV while the secondary voltage is 4.16 kV. This transformer also has a liquid cooling system (ONAN) with a power capacity of 2.5 MVA as shown in Fig 4.

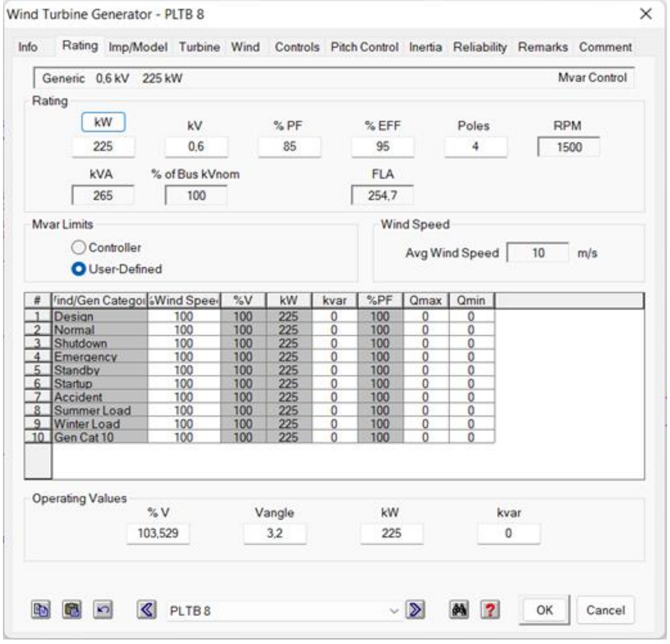

Figure 3. Wind Turbine Generator Parameters

Figure 4. Transformer Parameters

III. RESULTS AND DISCUSSION

A. Load Flow

Based on data on the number of PLTS and PLTB plants that will be used and the IEEE 14 bus model that has been designed, the single-line hybrid diagram for PLTS and PLTB plants is as follows:

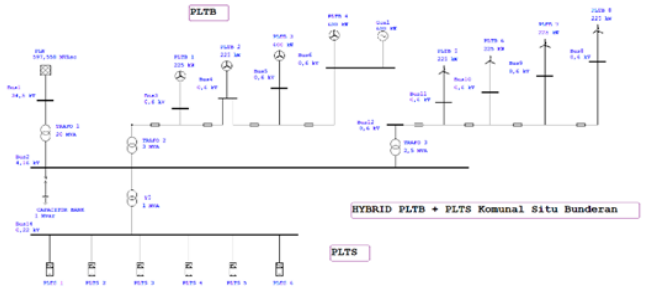

Figure 5. Single Line Diagram IEEE 14 Bus

Figure 5 shows a simulation of the power flow that occurs on a single-line diagram using ETAP software. This hybrid generator consists of 8 wind power plants and 6 solar power plants which have a grid-connected connection to the PLN electricity source. The simulation results of the generator are shown in Table 1:

TABLE I
BUS LOAD FLOW SIMULATION TEST

Bus ID	Nom kV	Type	Voltage	MW Loading	Amp Loading
Bus1	34,5	SWING	100	3,002	50,35
Bus2	4,16	Load	100	3,004	447,4
Bus3	0,6	Gen	99,12	2,166	2300
Bus4	0,6	Gen	99,69	1,974	2141
Bus5	0,6	Gen	100,05	1,782	1950
Bus6	0,6	Gen	100	1,2	1469
Bus7	0,6	Load	100	1,2	1469
Bus8	0,6	Load	103,38	0,225	209,4
Bus9	0,6	Load	102,83	0,449	420
Bus10	0,6	Load	101,44	0,668	633,4
Bus11	0,6	Load	100,92	0,889	847,9
Bus12	0,6	Load	100,24	0,883	847,9
Bus13	0,6	Load	100,24	0,883	847,9
Bus14	0,22	Load	100	0,018	47,91

Table 1 shows that the power flow that occurs in the system still meets the input voltage safety tolerance limits of 105% for overvoltage and 95% for undervoltage. The system is designed in a safe condition for voltage injection, apart from that the presence of power losses or voltage drops is still reasonable and meets the tolerance limit according to PLN standards ± 10% [14].

Based on Figure 6, it can be seen that all equipment connected to the energy source, namely the generator, has active power by the equipment specifications that have been determined and does not have critical or marginal information. From this information, it can also be informed that hybrid PLTS and PLTB energy are capable of supplying 100% of the existing load.

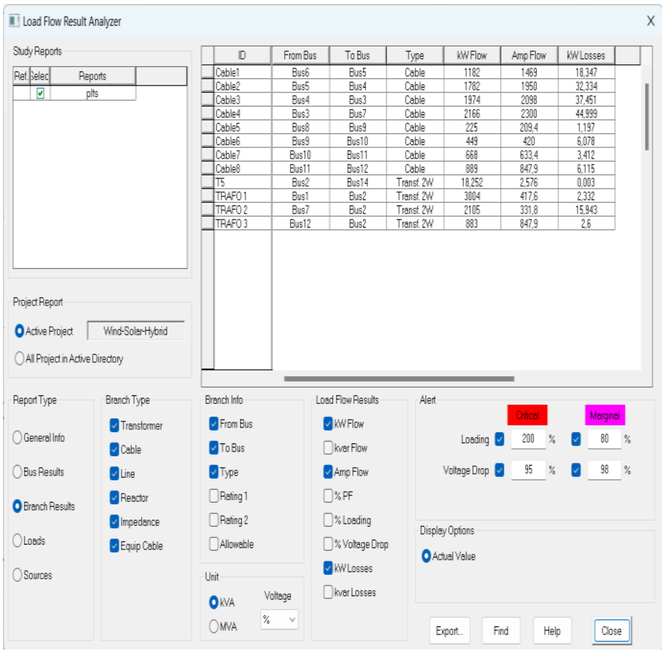

Figure 6. Load Flow Simulation For Branch

However, several active power losses on the network can be repaired by providing a capacitor bank to the network [15]. The capacitor bank used to improve the power flow is shown in Figure 7:

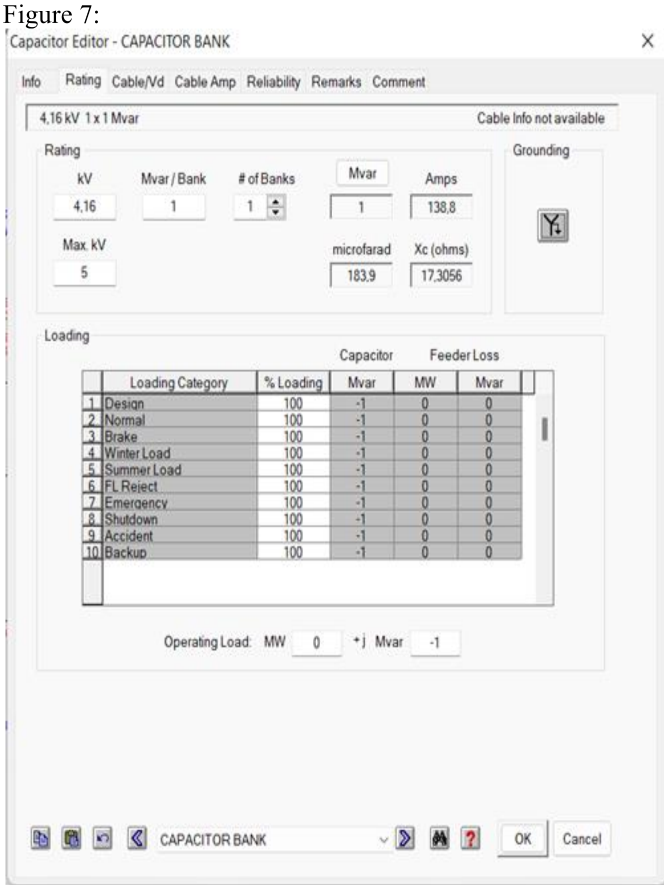

Figure 7. Capacitor Bank Improvement

Figure 7 shows the capacitor parameters used to repair power flow losses in the 14-bus network. The capacitor used is 1 MVAR with a nominal voltage of 4.16 kV. The use of capacitors in the network is to reduce the value of reactive power consumed by the system so that the ratio between active power compared to reactive power will be greater so that the network power factor becomes better.

IV. CONCLUSION

The simulation results of the hybrid power flow generator consisting of 8 wind power plants and 6 solar power plants with a grid-connected connection to the PLN electricity source show that the voltage value on each bus still meets the input voltage safety tolerance limit of 105% for overvoltage and 95% for Undervoltage. equipment connected to an energy source supplies active power according to the equipment specifications that have been determined and there is no critical or marginal failure in supplying the existing load. This simulation also shows that there are losses in the system of 190,811 kW so it is necessary to add a capacitor bank component with a capacity of 1 MVAR to improve the power factor in the network.

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