Load Flow Analysis After the Entry of Renewable Power Plants in the Sulselrabar System

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Abstract -- Power flow analysis in an electric power system is an analysis that reveals the performance of an electric power system and the flow of power (active and reactive) for certain conditions when the system is working. The analysis was carried out using the ETAP 16.00 software, the method used was the newton rapshon by taking a case study of normal conditions. From the results of the study, it can be seen that the power flow that occurs in each channel of the 150 kV system in the South Sulawesi system. The amount of active power (MW) that occurs during normal conditions based on the simulation is 1730.87 MW, where the active power is the largest, which is 171 MW from BUS15_TLASA to BUS13_SGMNSA. For the voltage data, there is a slight comparison of the voltage during the simulation compared to the PLN data.

Keywords: Power flow, active power, voltage, simulation, software ETAP 16.

I. Introduction

In the 1970s Renewable energy was first recognized as a way to offset energy developments with fossil fuels and nuclear. Indonesia's potential for renewable energy for electricity has reached 443 GW, including wind, geothermal, water and micro-mini hydro, solar bioenergy, and ocean waves. One of the renewable energies that the government is now ogling about is wind power or more commonly called wind power. Several eastern regions in Indonesia have the potential to generate electricity due to their wind speed. The wind speeds that have the potential to generate electricity are Oelbuluk, NTT the average speed is 6.1 m/s, Sidrap, South Sulawesi the average speed is 6.43 m/s and Jeneponto, South Sulawesi the average is 7.96 m/s.

South Sulawesi itself, which is an industrial area in Eastern Indonesia, often experiences blackouts due to a power deficit. The blackout that occurs certainly affects the production process of industrial companies. Industries that require large electricity consumption, such as the food processing and plastic industries, sometimes have to experience obstacles due to long hours of blackouts. In addition, the number of electricity consumers continues to grow. From the results of the estimated number of customers, it is known that the amount of power needed or connected power in the following years, the amount of connected power in the household sector in 2015 is 1,296467,311 VA and it is estimated that in 2025 it will increase to 2,597,148,624VA. Therefore, the government is encouraged to build wind power plant installations in the South Sulawesi area which will later affect the distribution of electricity in the Sulselrabar system.

After the presence of the Wind Power Plant (WPP), it can increase the stock of available power capacity in the South, Southeast, and West Sulawesi (Sulseltrabar) regions, thus increasing the number of burdens that must be borne. For this reason, it is necessary to conduct a power flow analysis to determine the overall condition of the electric power system in the current Sulselrabar system. Power flow analysis in an electric power system is an analysis that reveals the performance of an electric power system and the flow of power (real and reactive) for certain conditions when the system is working [1]. The main result of the power flow is the magnitude and phase angle of the voltage on each line (bus), the real power and reactive power present in each line.
In this study, an analysis of the system under normal conditions was carried out. Under normal conditions it will be known how much active power and reactive power occur and the Performance Index (IP) obtained from the calculation. The calculation of the power flow for the electric power system in the Sulselrabar System section after the entry of renewable plants if done manually will be very complicated and requires a lot of time, therefore in this study computer software was used to simplify and speed up the process of calculating the power flow. ETAP (Electrical Transient Analysis Program) Power Station is a software that can be used for calculating the flow of power in an electric power system. By using the ETAP Power Station 16.00 software, you will be able to analyze a very wide electric power system and many conditions [3].

Previously, there have been studies discussing power flow analysis, both the Gauss-Seidel method to the Newton Raphson method, as well as under normal and contingency conditions, among others [4] which discusses power flow analysis in the Sulselrabar system when renewable power has not yet entered, [5] discusses the analysis of the power flow of the electric power system in the texturizing section at PT Asia Pacific Fibers Tbk Kendal, [6] discusses the voltage analysis of each bus in the Gorontalo electric power system through power flow simulation, [7] discusses the study of power flow in the South Sulawesi electrical system, [8] discusses the contingency analysis of the Riau electric power system using the Newton Raphson power flow method, [9] discusses the load flow analysis on the East Kalimantan interconnection system. From this research, the development of power flow analysis needs to be carried out such as an up to date analysis by testing several case studies. The current Sulselrabar system continues to develop [10], especially after the inclusion of several renewable plants. The characteristics of the power flow need to be reviewed to see the characteristics of the system. In this study, a power flow analysis approach will be proposed for the entry of renewable power plants in the Sulselrabar system.

II. Research Method

The research was conducted by simulating the electric power system of the Sulselrabar system of PT. PLN AP2B Sulselrabar Region due to the entry of renewable power plants using the ETAP 16.00 application. The modeling of the system to be carried out, adjusts the parameters needed and has been accepted by the researcher when collecting data. The simulated system is designed in such a way as to achieve similarity to the real 150 kV Sulselrabar network system.

The initial step of the research is to determine the parameters or technical data supporting the desired value. This data will be obtained when researchers carry out data collection at PT. PLN AP2B for Sulselrabar Region, Makassar. After the data and method analysis have been carried out, the next step is to design a single line diagram of a 150 kV network for the Sulselrabar system on the ETAP 16.00 application which is useful for facilitating the next stage.

Network modeling is the next step by entering data in each installed component with data that is already available, the modeling stage plays an important role for this research because the network is made according to the real conditions of the Sulselrabar system. After the design and modeling is complete, the next step is to run load flow on the ETAP 16.00 application to ensure the modeling runs well. After successfully simulating, the results of the power flow are obtained, then identify the parameters of active power and bus voltage under normal conditions.

The next step, the researchers began to simulate contingency by removing one channel installed in the selected system, and conducting a power flow analysis during contingency. Then analyze the power flow generated during contingency by identifying the parameters needed for the calculation of the Performance Index. The active power and bus voltage will be recorded at the time of line disconnection.

III. Results and Discussions

The currently active Sulselrabar electricity system consists of 21 generating units, namely 6 PLTA, 8 PLTU, 1 PLTG, 1 PLTGU, 3 PLTMH and 2 WPP, operating at 150 kV. The Sulselrabar Electricity System is dominated by Steam Power Plants (PLTU) such as PLTU Sengkang, PLTU Barru, PLTU Jeneponto and PLTU Mamuju, each of which has a different generating capacity. The Sulselrabar bus system numbering is shown in Table 1.

III. 1. Power Flow Simulation Results

Analysis using ETAP 16.00 Software was carried out on the Sulselrabar System with normal loading and generation conditions using operating data on
Tuesday, May 21 2019, at 15.00 WITA. As a comparison data, the results of the analysis will be compared with the results of the power flow analysis study from the research [3] as data before the entry of WPP, the results obtained are as follows

The simulation with the ETAP 16.00 software uses the Newton Raphson Method which is completed in the 2nd iteration, resulting in data on Active Power, Reactive Power, Current and Power Factor Efficiency flowing in each channel based on the simulation results of power flow when the Sulselrabar system under normal conditions is given in Table 2.

On the results of the power flow from the 43 Bus interconnection system 150 kV Sulselrabar System, it can produce the following data conclusions,

a) The total active power contained in the channel under normal conditions is 1730.87 MW, where the active power is the largest, which is 171 MW from BUS15_TLASA to BUS13_SGMNSA.

b) The largest reactive power is 25.68 Mvar from BUS8_PANKEP to BUS8_BOSOWA.

c) The highest power factor efficiency reached 100% occurred from BUS21_SENGKANG to BUS16_SIDRAP, while the lowest efficiency occurred on the WPP Sidrap Bus channel to BUS16_SIDRAP which was 19.72%.

| TABLE I | BUS NUMBER |
|--------|------------|
| ID BUS | kV | ID BUS | kV |
| BU28_MAROS | 150 | BUS21_SENGKANG | 150 |
| BUS1_BAKARU | 150 | BUS22_BONE | 150 |
| BUS2_POLMAS | 150 | BUS23_SIJI | 150 |
| BUS3_MAJENE | 150 | BUS24_BLKMA | 150 |
| BUS4_PINRANG | 150 | BUS25_JNPNTO | 150 |
| BUS5_PARE | 150 | BUS26_PLTUMmuju | 150 |
| BUS6_SUPPA | 150 | BUS27_PUNAGAYA | 150 |
| BUS7_BARRU | 150 | BUS28_ENRKG | 150 |
| BUS8_PNGKEP | 150 | BUS29_WPP Sidrap | 150 |
| BUS9_BOSOWA | 150 | BUSBNTAENG | 150 |
| BUS10_TELLO | 150 | BusBOLANGI | 150 |
| BU11_TLAMA | 150 | BUS26_PANGKEP70 | 70 |
| BUS12_PKANG | 150 | BUS27_TNASA70 | 70 |
| BUS13_SGMNS | 150 | BUS29_MMDAY | 70 |
| BUS14_TBNGA | 150 | BUS30_DAYA | 70 |
| BUS15_TLASA | 150 | Bus31_TELLO70 | 70 |
| BUS16_SIDRAP | 150 | BUS32_BRLOE | 70 |
| BUS17_MKALE | 150 | Bus33_TLAMA70 | 70 |
| BUS18_PALOPO | 150 | BUS34_BNTLA | 70 |
| BUS19_MMUJU | 150 | Bus35_TELLO30A | 30 |

TABLE II

| ID | From Load Flow | To Load Flow |
|----|----------------|--------------|
| BUS18_PALOPO | BUS15_TLASA | BUS13_SGMNSA | 150 |
| BUS21_SENGKANG | BUS16_SIDRAP | BUS13_SGMNSA | 150 |
| BUS22_BONE | BUS23_SIJI | BUS24_BLKMA | 150 |
| BUS25_JNPNTO | BUS26_PLTUMmuju | BUS27_PUNAGAYA | 150 |
| BUS28_ENRKG | BUS29_WPP Sidrap | BUS30_WPP Sidrap | 150 |
| BUS9_BOSOWA | BUSBNTAENG | BusBOLANGI | 150 |
| BU10_TELLO | BUS26_PANGKEP | BUS27_TNASA | 70 |
| BUS12_PKANG | BUS27_TNASA | BUS29_MMDAY | 70 |
| BUS14_TBNGA | BUS30_DAYA | BUS31_TELLO | 70 |
| BUS15_TLASA | Bus31_TELLO | BUS32_BRLOE | 70 |
| BUS16_SIDRAP | BUS33_TLAMA | Bus33_TLAMA | 70 |
| BUS17_MKALE | Bus34_BNTLA | Bus35_TELLO | 30 |
| BUS18_PALOPO | BUS15_TLASA | BUS13_SGMNSA | 150 |
| BUS21_SENGKANG | BUS16_SIDRAP | BUS13_SGMNSA | 150 |
| BUS22_BONE | BUS23_SIJI | BUS24_BLKMA | 150 |
| BUS25_JNPNTO | BUS26_PLTUMmuju | BUS27_PUNAGAYA | 150 |
| BUS28_ENRKG | BUS29_WPP Sidrap | BUS30_WPP Sidrap | 150 |
| BUS9_BOSOWA | BUSBNTAENG | BusBOLANGI | 150 |
| BU10_TELLO | BUS26_PANGKEP | BUS27_TNASA | 70 |
| BUS12_PKANG | BUS27_TNASA | BUS29_MMDAY | 70 |
| BUS14_TBNGA | BUS30_DAYA | BUS31_TELLO | 70 |
| BUS15_TLASA | Bus31_TELLO | BUS32_BRLOE | 70 |
| BUS16_SIDRAP | BUS33_TLAMA | Bus33_TLAMA | 70 |
| BUS17_MKALE | Bus34_BNTLA | Bus35_TELLO | 30 |
| BUS18_PALOPO | BUS15_TLASA | BUS13_SGMNSA | 150 |
| BUS21_SENGKANG | BUS16_SIDRAP | BUS13_SGMNSA | 150 |
| BUS22_BONE | BUS23_SIJI | BUS24_BLKMA | 150 |
| BUS25_JNPNTO | BUS26_PLTUMmuju | BUS27_PUNAGAYA | 150 |
| BUS28_ENRKG | BUS29_WPP Sidrap | BUS30_WPP Sidrap | 150 |
| BUS9_BOSOWA | BUSBNTAENG | BusBOLANGI | 150 |
| BU10_TELLO | BUS26_PANGKEP | BUS27_TNASA | 70 |
| BUS12_PKANG | BUS27_TNASA | BUS29_MMDAY | 70 |
| BUS14_TBNGA | BUS30_DAYA | BUS31_TELLO | 70 |
| BUS15_TLASA | Bus31_TELLO | BUS32_BRLOE | 70 |
| BUS16_SIDRAP | BUS33_TLAMA | Bus33_TLAMA | 70 |
| BUS17_MKALE | Bus34_BNTLA | Bus35_TELLO | 30 |
| BUS18_PALOPO | BUS15_TLASA | BUS13_SGMNSA | 150 |
| BUS21_SENGKANG | BUS16_SIDRAP | BUS13_SGMNSA | 150 |

If the analysis is compared as data after the entry of the WPP with the analysis before the entry of the WPP using data from, then what happens is that the Active Power (P) that occurs in each channel has increased. The channel that experienced the highest increase in power was BUS7_BARRU to BUS8_PANKEP with an increase in active power (P) of 66.62 MW. This can be seen in Table 3.
TABLE III
RESULTS OF POWER FLOW SIMULATION OF THE 150 KV INTERCONNECTION SYSTEM IN SULSELBARA BEFORE AND AFTER WIND POWER INSTALLING

| LINES  | LOAD FLOW | BEFORE | AFTER |
|--------|-----------|--------|-------|
| From   | To        | P (MW) | Q (Mvar) | P (MW) | Q (Mvar) |
| BUS28  | BUS13     | 37.36  | 1.53     | 42.83  | -2.63    |
| BUS1   | BUS2      | 11.8   | -0.11    | 56.59  | 12.01    |
| BUS3   | BUS19     | 3.93   | 0.52     | 4.07   | 2.86     |
| BUS4   | BUS5      | 6.99   | 0.95     | 71.08  | -18.71   |
| BUS5   | BUS6      | 42.76  | -0.5     | 7.40   | -2.68    |
| BUS6   | BUS5      | 28.46  | 4.3      | 19.98  | 5.83     |
| BUS7   | BUS8      | 62.46  | -2.79    | 27.27  | -4.16    |
| BUS8   | BUS9      | 27.59  | 4.17     | 13.97  | 25.68    |
| BUS9   | BUS10     | 6.91   | -7.26    | 13.86  | -25.79   |
| BUS10  | BUS11     | 14.93  | -4.92    | 32.66  | 9.69     |
| BUS11  | Bus33     | 9.2    | -1.72    | 42.62  | 8.00     |
| BUS13  | BUS14     | 13.53  | 6.96     | 24.90  | 4.42     |
| BUS10  | BUS1      | 40.07  | 7.35     | 124.29 | 8.68     |
| BUS15  | BUS13     | 12.4   | 9.32     | 171.25 | 23.11    |
| BUS16  | BUS17     | 5.6    | -4.39    | 61.80  | -13.31   |
| BUS17  | BUS18     | 8.41   | 1.27     | 20.21  | 3.38     |
| BUS18  | BUS20     | 8.23   | 3.11     | 15.06  | 4.60     |
| BUS20  | BUS16     | 10.53  | 3.87     | 26.39  | 4.08     |
| BUS21  | BUS20     | 49.8   | -1.8     | 59.13  | -0.32    |
| BUS20  | BUS21     | 33.65  | -10.41   | 17.31  | -12.77   |

The number of losses obtained is 12,123 kW, where the largest losses are in the BAKARU-PINRANG line, namely 1,662 kW. In addition to transmission losses there are also losses in the transformer. For more details, see the literature. The Table 4 shows the losses that occur in the transmission line.

III. 2. Active Power and Reactive Power on Bus Loading

From the simulation results using ETAP with Newton Raphson method, it can be seen the difference in active power, reactive power, and PF that occurs in each channel.

Bus Loading which has the largest active power is found in the BOSOWA Loading bus which is 231.5 MW with 45 Mvar reactive power and 98.16% Power Factor, while the complete results can be seen in Table 5.

Next, compare the results of the power flow analysis simulation on the bus loading before entering and after entering the WPP by taking comparative data from the study [3].

The total active power (P) that occurs at the bus loading before the entry of WPP in the 150 kV interconnection system is 455.61 MW, while the total active power (P) after the entry of the WPP is 610.31 MW, more details can be seen in Table 6.
TABLE V
RESULTS OF POWER FLOW BUS LOADING INTERCONNECTION SYSTEM 150kV SULSELBARABAR

| NO | ID BUS   | P (MW) | Q (Mvar) |
|----|----------|--------|----------|
| 1  | BD1_BNTLA | 5.97   | 0.00     |
| 2  | BD1_BONE  | 6.27   | 1.97     |
| 3  | BD1_DAYA  | 11.63  | 0.00     |
| 4  | BD1_MNDAI | 7.98   | 2.56     |
| 5  | BD1_PLPO  | 15.47  | 0.30     |
| 6  | BD1_PNGAYA| 0.74   | 0.11     |
| 7  | BD1_PNKNG | 16.74  | 3.14     |
| 8  | BD1_PNRNG | 24.38  | 6.34     |
| 9  | BD1_TLAMA | 12.22  | 4.02     |
| 10 | BD1_TLLASA| 16.04  | 4.58     |
| 11 | BD2_BONE  | 6.28   | 1.97     |
| 12 | BD2_DAYA  | 11.86  | 4.53     |
| 13 | BD2_MNDAI | 11.02  | 0.00     |
| 14 | BD2_PLPO  | 11.02  | 0.00     |
| 15 | BD2_PNKNG | 14.52  | 6.16     |
| 16 | BD2_PNRNG | 17.80  | 4.14     |
| 17 | BD2_TLAMA | 1.00   | 0.01     |
| 18 | BD2_TLLASA| 30.74  | 4.28     |
| 19 | BD3_PNKNG | 30.59  | 7.69     |
| 20 | BD_5      | 95.00  | 9.50     |
| 21 | BD_9      | 89.80  | 15.00    |
| 22 | BD_10     | 231.50 | 45.00    |
| 23 | BD_BARRU  | 4.53   | 1.35     |
| 24 | BD_BKRU   | 1.00   | 0.00     |
| 25 | BD_BLMKBA | 0.74   | 1.61     |
| 26 | BD_BNTEANG| 6.17   | 1.17     |
| 27 | BD_BOLANGI| 16.41  | 3.79     |
| 28 | BD_BOSOWA | 44.91  | 9.84     |
| 29 | BD_BROLOE | 6.14   | 0.85     |
| 30 | BD_BRWJA  | 22.67  | 0.01     |
| 31 | BD_ENRKG  | 6.01   | 0.00     |
| 32 | BD_JNPTNO | 12.79  | 3.63     |
| 33 | BD_MJNE   | 10.45  | 1.42     |
| 34 | BD_MKLE   | 2.97   | 0.13     |
| 35 | BD_MMJU   | 21.72  | 2.83     |
| 36 | BD_MROS   | 16.93  | 4.82     |
| 37 | BD_PARE   | 17.63  | 4.07     |
| 38 | BD_PLMAS  | 4.75   | 1.52     |
| 39 | BD_PNGKEP | 24.96  | 10.98    |
| 40 | BD_SDRP   | 17.40  | 5.68     |
| 41 | BD_SGMNSA | 34.28  | 0.97     |
| 42 | BD_SIWA   | 6.25   | 1.41     |
| 43 | BD_SNJKNG  | 19.49  | 5.37     |
| 44 | BD_SNJAI  | 12.18  | 4.12     |
| 45 | BD_SPENGLB | 6.97   | 5.41     |
| 46 | BD_TBNGA  | 49.64  | 0.99     |
| 47 | BD_TELLO  | 35.31  | 14.13    |
| 48 | BD_TELLO2 | 35.97  | 8.65     |

III. 3. Voltage Simulation Results on each Bus

The voltage obtained from the simulation results of the power flow of each bus on the 150 kV Sulselbarab interconnection system after the entry of the WPP can be seen in Table 7. So it can be concluded:

a) Bus 150 kV the largest voltage before the entry of the WPP occurred at BUS22_BONE of 152.31 kW or 101.54%, while the largest voltage after the entry of the WPP occurred at BUS24_BLKMB of 152.31 kW or 104.02%.

b) The smallest voltage value before the entry of the WPP occurred at BUS9_BOSOWA with a value of 147.07 kV or 98.05%, while the voltage after the entry of the WPP occurred at BUS18_PALOPO with a value of 148.09 kV or 98.72%.

c) The same voltage value with PT. PLN data occurs in BUS1_BAKARU with a value of 150 kV or 100%. The following is a graphic image of the results of the 150 kV analysis. This can be seen in Figure 1 and Table 7.

TABLE VI
RESULTS OF POWER FLOW SIMULATION OF THE 150 kV SULSELBARABAR BUS LOADING INTERCONNECTION SYSTEM BEFORE AND AFTER WIND POWER ENTER

| BUS | Before | After |
|-----|--------|-------|
| P (MW) | Q (Mvar) | P (MW) | Q (Mvar) |
| BD1_BNNTA | 7.99 | 5.97 | 0.00 |
| BD1_BONE | 4.04 | 6.27 | 1.97 |
| BD1_DAYA | 11.45 | 11.63 | 0.00 |
| BD1_MNDAI | 7.86 | 7.98 | 2.56 |
| BD1_PLPO | 12.78 | 15.47 | 0.30 |
| BD1_PNKNG | 3.79 | 16.74 | 3.14 |
| BD1_PNRNG | 12.51 | 24.38 | 6.34 |
| BD1_TLAMA | 12.08 | 12.22 | 4.02 |
| BD1_TLLASA | 0.68 | 16.04 | 4.58 |
| BD2_BONE | 10.24 | 6.28 | 1.97 |
| BD2_DAYA | 11.68 | 11.86 | 4.53 |
| BD2_MNDAI | 10.86 | 11.02 | 0.00 |
| BD2_PLPO | 8.72 | 14.52 | 6.16 |
| BD2_PNKNG | 13.86 | 17.80 | 4.14 |
| BD2_PNRNG | 7.23 | 1.00 | 0.01 |
| BD2_TLAMA | 19.40 | 30.74 | 4.28 |
| BD2_TLLASA | 26.44 | 30.59 | 7.69 |
| BD_BARRU | 4.23 | 4.53 | 1.35 |
| BD_BKRU | 2.92 | 1.00 | 0.00 |
| BD_BLMKBA | 9.13 | 0.74 | 1.61 |
| BD_BOSOWA | 20.56 | 44.91 | 9.84 |
| BD_BROLOE | 7.09 | 6.14 | 0.85 |
| BD_BRWJA | 5.23 | 22.67 | 0.01 |
| BD_JNPTNO | 9.74 | 12.79 | 3.63 |
| BD_MJNE | 5.21 | 10.45 | 1.42 |
| BD_MKLE | 3.81 | 2.97 | 0.13 |
| BD_MMJU | 7.85 | 21.72 | 2.83 |
| BD_MROS | 4.90 | 16.93 | 4.82 |
| BD_PARE | 20.00 | 17.63 | 4.07 |
| BD_PLMAS | 6.63 | 4.75 | 1.52 |
| BD_PNGKEP | 13.38 | 24.96 | 10.98 |
| BD_SDRP | 12.21 | 17.40 | 5.68 |
| BD_SGMNSA | 11.90 | 34.28 | 0.97 |
| BD_SNJKNG | 11.72 | 19.49 | 5.37 |
| BD_SNJAI | 5.75 | 12.18 | 4.12 |
| BD_SPENGLB | 14.00 | 6.97 | 5.41 |
| BD_TBNGA | 27.00 | 49.64 | 0.99 |
| BD_TELLO | 34.55 | 35.31 | 14.13 |
| BD_TONASA | 36.64 | 21.23 | 21.83 |
Fig. 1. 150kV voltage comparison graph from Power flow analysis and data from [3]

At Bus 70 kV, the largest voltage before the entry of the WPP occurred at Bus31_TELLO70 of 70.625 kV or 100.89%, while the largest voltage after the entry of the WPP occurred at BUS32_BRLOE with a voltage value of 71.493 kV or 102.13%.

The smallest voltage value before the entry of the WPP occurs at BUS27_TNASA70 with a value of 69.951 kV or 99.93%, while the voltage after the entry of the WPP occurs at BUS34_BNTLA with a voltage value of 69.351 kV or 99.07%. This can be seen in Figure 2.

Fig. 2. 70kV voltage comparison graph from Power flow analysis and data from [3]

While the buses after the entry of the WPP experiencing Critical Voltage Conditions are found in two distribution buses, including:

1. Bosowa 11 kV distribution bus of 9.7475 kV or 88.61% experiencing Under Voltage Condition.
2. Pangkep 20 kV distribution bus with 18,429 kV or 92.14% experiencing Under Voltage Condition. It is described in Table 8.

| ID BUS | Before | After |
|-------|--------|-------|
| BU28  | 149,895| 149,475|
| BUS1  | 150    | 150    |
| BUS2  | 149,511| 150,721|
| BUS3  | 149,086| 151,33  |
| BUS4  | 150,38 | 149,729|
| BUS5  | 150,572| 151,015|
| BUS6  | 150,831| 151,256|
| BUS7  | 149,536| 151,368|
| BUS8  | 147,783| 150,894|
| BUS9  | 147,071| 149,154|
| BUS10 | 147,537| 149,165|
| BUS11 | 147,751| 148,775|
| BUS12 | 147,23  | 148,805|
| BUS13 | 147,802| 149,679|
| BUS14 | 147,501| 149,404|
| BUS15 | 148,379| 151,836|
| BUS16 | 150,425| 151,189|
| BUS17 | 149,339| 149,041|
| BUS18 | 148,745| 148,091|
| BUS19 | 148,809| 152,199|
| BUS20 | 151,512| 152,917|
| BUS21 | 151,064| 152,022|
| BUS22 | 152,315| 154,696|
| BUS23 | 151,244| 154,735|
| BUS24 | 151,217| 156,031|
| BUS25 | 148,83 | 154,396|
| BUS26 | -      | 153,831|
| BUS27 | -      | 154,103|
| BUS28 | -      | 150,27  |
| BUS29 | -      | 149,643|
| BUS30 | -      | 155,048|
| BUS31 | -      | 149,014|
| BUS32 | -      | 150,425|
| BUS33 | -      | 69,396  |
| BUS34 | -      | 69,351  |
| BUS35 | -      | 29,411  |

While the buses after the entry of the WPP experiencing Critical Voltage Conditions are found in two distribution buses, including:

1. Bosowa 11 kV distribution bus of 9.7475 kV or 88.61% experiencing Under Voltage Condition.
2. Pangkep 20 kV distribution bus with 18,429 kV or 92.14% experiencing Under Voltage Condition. It is described in Table 8.
Marginal Voltage Condition events can be seen in the Table 9. Where for this condition, the voltage is still within the Standard Voltage, namely +5% and -5% so that it is still allowed to operate. The following is the result of the calculation of the voltage for each bus that experiences Under Voltage or Over Voltage Conditions.

**IV. Conclusion**

The conclusion obtained from the results of Power Flow Analysis Power Flow Analysis Due to the Entry of Renewable Energy Plants in the Sulselbar System Using ETAP 16, is:

1. The Newton-Raphson method used for power flow simulation in this study shows efficiency in terms of computational processing speed in ETAP 16.00 Software.
2. The total active power (P) contained in the channel under normal conditions is 1730.87 MW, where the active power is the largest, which is 171 MW from BUS15_TLASA to BUS13_SGMNSA.
3. The largest reactive power is 25.68 Mvar from BUS8_PANKEP to BUS8_BOSOWA.
4. The highest Power Factor efficiency reached 100% occurred from BUS21_SENGKANG to BUS16_SIDRAP, while the lowest efficiency occurred on the WPP Sidrap Bus channel to BUS16_SIDRAP which was 19.72%.

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