Additional location scenarios of generation capacity with ETAP application

Hestikah Eirene Patoding¹, Matius Sau², and Rombe³

¹,²,³Department of Electrical Engineering, Faculty of Engineering, Universitas Kristen Indonesia Paulus Makassar, South Sulawesi, Indonesia. 90245

Email: hestika@ukipaulus.ac.id; matiussau@ukipaulus.ac.id; rombe87@yahoo.co.id

Abstract. This study aims to determine the distribution of electrical power by considering the addition of generating capacity and the addition of networks using ETAP applications. The simulation results show that for the first scenario, the addition of generating capacity is carried out at Barru Bus without the addition of transmission networks, the voltage on bus 36 (Barawaja) stabilizes from 0.92 pu to 1.02 pu, with losses of 17.218 MW and 30.171 MVAR. This shows that power losses have decreased from 18.853 MW and 41.291 MVAR or decreased by 1.635 MW from power losses before the addition of generation in Barru, and the second scenario is the addition of generation at Bontoala and the addition of an express network. The system voltage that previously dropped became stable at the existing tolerance limit. Besides that, there were power losses when adding a generator at the Barru Bus. Thus, the distribution of electricity will be better when there is an additional generation at Bontoala Bus and the addition of an express network in the Sulselbar system.

1. Introduction
The magnitude of the need for electrical energy with different types of loads (varies) causes more complex network structure and operation of a power system. This can cause problems in meeting the required requirements [1,2].

The development and utilization of electrical energy are based on comprehensive and integrated energy policy by taking into account the increasing needs and existing generation capabilities. Generation capacity development can be done by combining Diesel with alternative energy such as Solar Power [3,4].

Planning for generation development in the Sulselbar electricity system 2015-2025 for conditions in 2017 is located in Jeneponto, Barru, Bakaru and Sengkang. This condition requires a generation placement scenario so that electricity supply to consumers becomes reliable and meets system security standards in terms of power losses and system stability. Electricity needs in Indonesia, especially in South Sulawesi, continue to increase along with development in various sectors. This has an impact on the electrical energy crisis resulting in rotating blackouts; however, these conditions have been minimized by the addition of generating capacity.

The study of power flow can be analyzed regarding the continuity of the distribution of electrical power, security and system stability. A system is said to be continuity in its distribution if the power supply from generation to the load has not failed. This depends on the ability of a plant and the total load to be supplied. Talking about continuity cannot be separated from a power system reliability which
is expressed by the ability of an electric power system to supply electrical energy to a continuous load within a certain period of time and the electrical energy must be available when needed. In connection with the continuity of power distribution, it is necessary to analyze the security and stability of the system.

1.1. Security Approach
A power system can be said to have a safe system if there are no violations of the security constraints; in this case, it can be a static security constraint or dynamic security constraints. Security constraints that are considered in this study are static security constraints when peak loads occur [2]. Static security constraints are operating limits that must be met in the operation of the power system. The obstacles that must be met are:

a. Voltage. Operating limits that must be met with stress in each load bus (PQ bus) are: \( V_i^M \leq V_i \leq V_i^m \) with \( V_i^m \) and \( V_i^M \) each of which is the minimum voltage and maximum voltage allowed on the bus i.

b. Power flow in the lines. Operating limits that must be met by the power flowing through the T line are:

\[-T_L \leq S_T \leq T_L \]  with \( S_T \) the total power flowing in the T line while \( T_L \) the thermal operation limit of the T line

c. Active power generation. Operating limits for active power generation are: \( P_k^m \leq P_k \leq P_k^M \) with \( P_k^m \) and \( P_k^M \) each of which is the minimum power and maximum power of the generator on the bus-k.

d. Reactive power generation. Operating limits for reactive power generation are \( Q_k^m \leq Q_k \leq Q_k^M \) with \( Q_k^m \) and \( Q_k^M \) each of which is the minimum power and maximum power of the generation on the k-bus.

1.2. System stability
A system is said to state if the voltage on each bus does not exceed or less than the existing standard that has a nominal voltage not exceeding the voltage limit set at ± 5% of the normal voltage. To find out that the system is in a stable condition, a power flow study is needed. Voltage control of the system can be done by installing capacitors [5,6]. The results of this power flow will show buses that can experience an increase or decrease in voltage from the existing tolerance limits.

2. Research methodology
The implementation of the research was carried out in several stages

a. Load data, generating data, line data
b. Using the Newton Raphson Method for power flow analysis
c. Analyze simulation results in determining the stability and security of the system
d. Repeating the point b to get a stable system condition and security in terms of the voltage and power loss
3. Results And Discussion

3.1. Scenario Before Adding Generating Capacity

The simulation results of the power flow before the addition of the generator shows that the total peak load is 1050 MW and the total capable capacity is 1240 MW in accordance with the operating data of 2017, and the total losses are 18,853 MW and 41,291 MVAR. This value is still below the tolerance limit for power losses of 10% of the total power generated.

3.1.1. Analysis of system security

Voltage values indicate that on bus 33 and bus 36, the voltage is below the allowable tolerance limit of ±5% of the nominal voltage. The power flow in each line shows that the power that is passed to each line is still within the tolerance limit that is dependent on the maximum capacity the power is passed. Active power and reactive power generated by each generator is still at the limit of the capable power, meaning that the engine is operated in normal conditions because it has not exceeded the power limit of the generator [7].

3.1.2. System Stability Analysis

From the simulation results, obtained the magnitude of the voltage experienced a drop on bus 36 (Brawaja) and bus 33 (Bontoala) at night peak load conditions.
3.2. **Scenario when adding capacity on the Barru Bus without the Express Network**

The generation increase in Barru is 50 MW, the condition of bus 32 and bus 33 is still below the tolerance limit, however, the voltage on bus 36 (Barawaja) has stabilized from 0.92 pu to 1.02 pu, with losses of 17,218 MW and 30,171 MVAR. This shows that power losses have decreased from 18,853 MW and 41,291 MVAR or decreased by 1,635 MW (8.7%) from power losses before the addition of generation in Barru. The power flow in each line shows that the power passed on each line is still within the capacity of the existing line.

Active power and reactive power generated by each generator are still at the limit of the capable power of each generator, meaning that the engine is operated under normal conditions because it has not exceeded the power limit of the generator. From the simulation results, obtained the amount of voltage experienced a drop on bus 32 (Tallo lama 70 kV) and bus 33 (Bontoala) in peak load conditions at night, this can be seen in Figure 3.
3.3. Capacity addition scenarios at Bontoala Bus and the addition of the Express Network

When the location of an additional generation is placed on bus 33 (Bontoala bus) and the addition of the express network middle line (Bus Sidrap with Sungguminasa Bus), the system voltage that previously dropped becomes stable at the existing tolerance limit.

The three results of the sucked simulation above can be seen in Figure 4 comparison of the system voltage in the three conditions.
The amount of existing power losses is 15,682 MW and 11.68 MVAR. This value is less than the power losses when adding a power plant on bus 7 (Barru).

4. Conclusion
Based on the simulation results, it can be concluded that the quarantine of the distribution of electrical power to consumers in the Sulselbar system is better (increasing) when the addition of generating capacity compared to the conditions before the addition of generation. Electricity and stability of electricity in the Sulselbar system is better than before the addition of the generator both in terms of voltage and power losses that occur. The location of the optimum generation addition is shown at the Bontoala location (bus 33) in simulation in terms of system security and stability.

Acknowledgment
Thanks to the Ministry of Research, Technology and Higher Education Directorate General of Learning and Student Affairs and the Directorate of Research and Community Development that funded this Research.

Reference
[1] Feinberg E A and Genethliou D 2005 Load forecasting Applied mathematics for restructured electric power systems (Springer) pp 269–85
[2] Xifan W and McDonald J 1994 Modern power system planning London Mcgraw-hillb. Co.
[3] Sau M, Patoding H E and Kasa A 2019 Model design of solar-diesel hybrid power system with Homer Pro 4 103–8
[4] Megantoro P, Prabowo I E and Shomad M A 2020 Development of Maximum Power Point Tracking Solar Charge Controller for 120 Volt Battery System at Pandansimo Hybrid Power Plant J. Phys. Conf. Ser. 1471
[5] Wood A J and Wollenberg B 1996 Power generation operation and control–Second Edition–John Wiley & Sons
[6] Setiadi H, Krismanto A U, Mithulananthan N and Hossain M J 2018 Modal interaction of power systems with high penetration of renewable energy and BES systems Int. J. Electr. Power Energy Syst. 97 385–95
[7] Saadat H 1999 Power system analysis