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Buses and Branch Performances Considering Load Changes of The 150 kV Transmission Line in Malang Area

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Abstract

This paper examines the power flow based on load value conditions that have ascended in the 150 kV transmission system in the Malang Area. Simulations are carried out for several regions that may experience ascension load values. The simulation results show a significant change at some points, especially when the value of the load ascension is 25%. Whereas the ascension of 8.6% is not too significant considering this value is based on the production planning. These changes occur in the bus and branch of the 150 kV transmission lines which is needed for a network interconnection in the electricity system of Malang Raya as an effort to keep the ascension capacity and reliability, and to improves the quality of service to consumers.

Keywords
bus, branch, load, power flow

1. INTRODUCTION

Increasing technological developments cannot be avoided because all activities need to be supported by their existence. These developments make and need electrical energy which is increased every day [1]–[3]. Besides, population growth also influences increasing the electricity demand which certainly ascensions the value of the burden that must be borne by the plant and the quality of the transmission system that supplies it [4]–[7].

Distribution of electrical energy from the generator to the distribution system is the task of the transmission system [8]–[10]. The transmission system in the Malang Raya area itself is at a nominal of 150 kV with two main plants namely the Sutami Hydroelectric Power Plant and the Wlingi Hydroelectric Power Plant which are connected to the 150 kV East Java area network system [11], [12].

This transmission system serves 3 regional loads, namely the Kebon Agung bus as a representation of the Malang City area, the Sengkaling bus as a representation of the Batu City area and Pakis bus as a representation of the Malang Regency area. The region is likely to experience growth in terms of social, economic and technological aspects [13]–[16]. Such conditions make it possible to ascension the burden that is borne by a National Power Company which is called in the PLN as a provider of electricity. The scenario of a load ascension based on the national power providing plan which is called in the RUPTL and it is 8.6% and a drastic ascension of 25% from the peak load as a representation of the ascension load spike in an area [17].

2. LITERATURE

2.1 Classification and Characteristic of Load

The Micro-hydro Power Plant system in this paper used an induction generator, a servo motor that served as the governor, modeled using the Matlab-Simulink program. Figure 1 shows the configuration of the micro-hydro plant in this research

Based on the types of electricity consumers, the load can be classified generally into [12], [18]–[21]:

1) Household load
2) Commercial/business load
3) General / public load
4) Industrial load

The classification above is very important to do when analyzing the load characteristics of a system and when estimating loads. The determinants of load characteristics covers on [13], [14], [21]–[24]:

1) Load factor
2) Daily load
3) Load assessment factors.

2.2 Estimated Electricity Energy Requirements and Methods

Some parameters that need to be considered in determining the development of electrical energy needs, among others [25]–[28]:

1) Estimated sales data of electricity and percentage ascension
2) Loss of transmission and distribution
3) Own use (central and GI)
4) Energy production
5) Peak load
6) Load factor
7) Power installed

Then the estimation method which is a way to measure or estimate future events can be done qualitatively or quantitatively[25], [29]–[31].

2.3 Power Flow

Power flow studies are also known as load flows which are the backbone of the analysis and design of an electric power system. Power flow studies are used to obtain information about the power flow or system voltage under operating conditions [32]–[35]. This information is used to evaluate the work of the electric power system and analyze the conditions of generation and loading, as well as information on the state of the system under normal and disturbed conditions [36]–[38].

Power flow problems include calculation of system flow and the voltage at certain terminals or certain buses. The active power equation (P) and reactive power (Q) on the bus are seen in (1). With a single-phase representation, it is always done because the system is considered as the energy balanced.

$$P_p - jQ_p = E_p \,.\, I_p \tag{1}$$

3. METHODOLOGY

This research is a quantitative research by analyzing the simulation results from the information and data obtained. Figure 1 shows the research flowchart as the detailed sequencing steps for the whole analysis. The research data used are generation data, channel reactance, channel length, peak load capacity, and the peak load value ascension scenario.

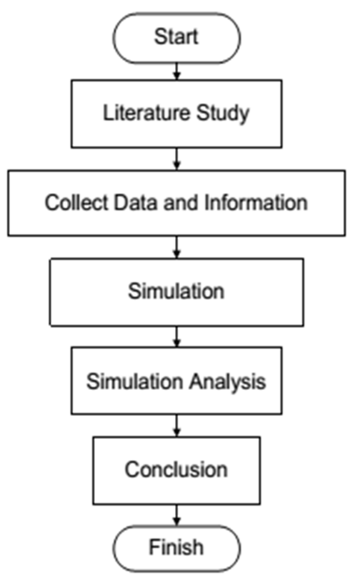

Figure 1. Flowchart

4. RESULT AND DISCUSSION

4.1 8.6 % Load Ascension

These works are conducted to be able to concern a study of power flow on the bus and branch based on the load value data which is taken in the 150 kV Malang Raya area through two scenarios of the simulation. In the first scenario, a simulation of the load of the transmission network of 150 kV has been carried out with an ascension of 8.6% from the peak load. This condition has been performed by increasing the value of the area, starting from the Kebon Agung area to Wlingi as shown in Table I. By considering this situation, bus and branch conditions on a 150 kV transmission network are shown in Fig 2 and 3.

TABLE 1
Data Load Ascension 8.6%

No	Peak	Peak Load	
		MW	*MVAR*
1	K. Agung	168.6015	87.966
2	Lawang	25.17782	10.49076
3	Pakis	44.71605	24.77709
4	Sengkaling	86.06007	50.14062
5	Sutami	24.63048	10.2627
6	Wlingi	86.35329	56.44485
	TOTAL	435.5392	240.082

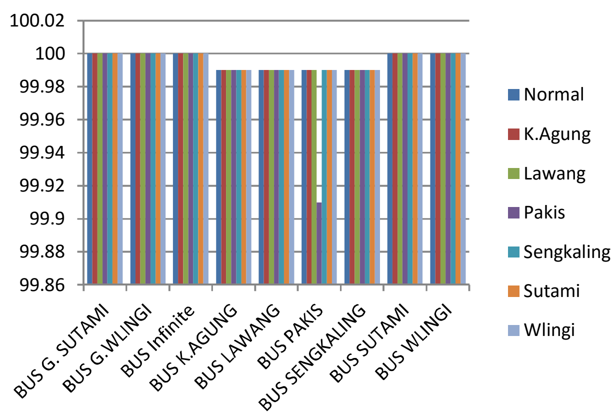

Figure 2. Comparison of conditions for the voltage values of each bus at an ascension of 8.6%

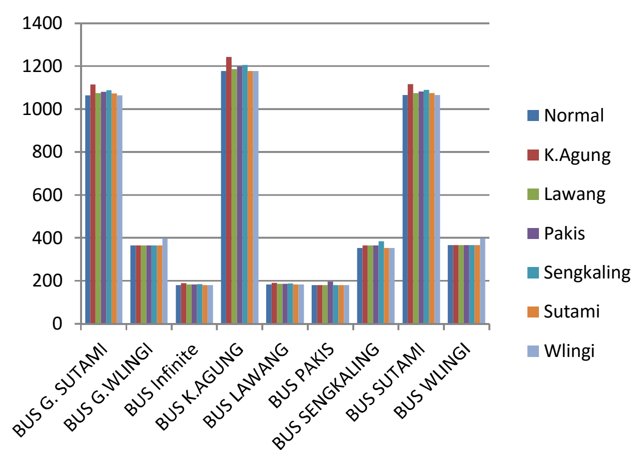

Figure 3. Comparison of conditions for the amp value of loading each bus at an ascension of 8.6%

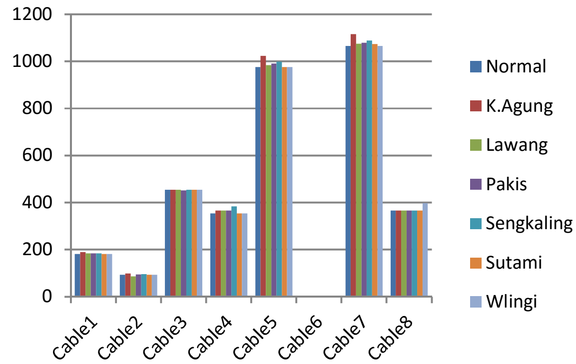

Figure 4. The amp flow value of each branch during an ascension of 8.6%

Fig 2 and 3 show the value of voltage and current on each bus when there is an ascension for the load at a point. It is seen that when the load is ascension by 8.6% in one area, the voltage value tends to be constant. However, what was noted was a decline in Pakis buses when there was an ascension in load there. Besides, judging from the amp loading in Fig 3, each bus experiences an ascension in the current value which is directly proportional to the ascension in load. Moreover, the conditions that are quite worrying for the transmission network do not seem to be given in the value of the load ascension of 8.6%. So, the condition is certainly still at the working threshold of the 150 kV transmission network system.

Besides, Fig 4 shows something similar to the amp flow value tends to be constant. The ascension only occurs when certain points have ascension for the load values such as when Kebon Agung's load ascensions, making cable 5 and cable 7 send larger currents compared to other conditions.

4.2 25 % Load Ascension

In the second scenario, a simulation of a 150 kV transmission network has been carried out with an increase of 25% from peak load based on the data in Table II. From the results of the simulations, bus and branch conditions are obtained on the 150 kV transmission network as shown in Fig 6 and 7. It can be seen that when the load is increased by 25% in one area, the voltage value tends to be constant at a number close to 100% indicating that the bus works as much as possible for the network system while the electrical energy supplied remains of good quality. However, there is a decrease in Pakis buses when there is also stay for an increasing aspect in load like presented in Fig 2 but with a different nominal.

TABLE 1
Data Load Ascension 25%

No	Load	Peak Load	
		MW	*MVAR*
1	K. Agung	195.3045	101.898
2	Lawang	29.16547	12.15228
3	Pakis	51.79815	28.70127
4	Sengkaling	99.69021	58.08186
5	Sutami	28.53144	11.8881
6	Wlingi	100.0299	65.38455
	TOTAL	504.5196	278.1061

Furthermore, Fig 6 shows that each bus experiences an increase in the current value which is directly proportional to the increase in load. It is very noticeable that 3 buses always work when there is an increase in load wherever the location is located at G. Sutami bus, Kebon Agung bus, and Sutami bus. This happened because indeed 3 buses are the main buses connecting the entire network. G. Sutami Bus and Sutami bus as the main bus are connected for the Sutami generator to all loads while the Kebon Agung bus is settled at the midpoint of the network that connects the Sutami generator to all loads.

As illustrated in Fig 6, each cable experiences an increase in the value of current which is directly proportional to load increase. Based on Fig 6 which shows three buses that always work for the cable or branch that connects the three buses, it always increases the amp flow value when the load value at one point increases. The cable 5 connects the Sutami bus with Kebon Agung bus and cable 7 connects G. Sutami bus and Sutami bus.

Seeing such network conditions, if there is a disturbance on the Sutami bus or Kebon Agung bus, there will be a faulted area that is very likely not to get electricity supply at all. So, the network interconnection is needed improvements to the quality of network components, of course in the future certainly require much higher and better specifications.

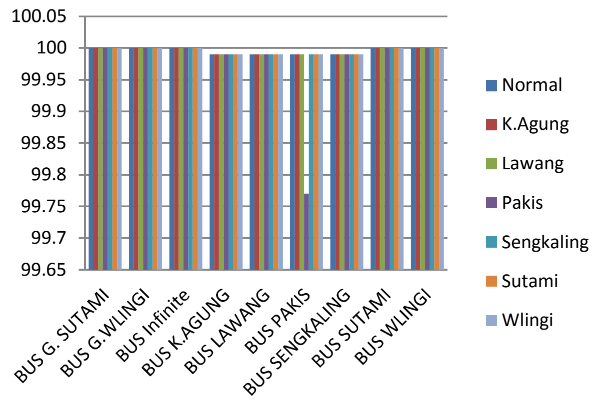

Figure 5. Comparison of conditions for the voltage values of each bus at a 25% increase

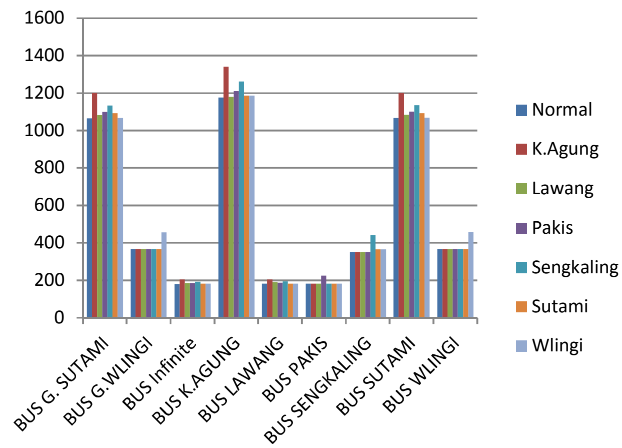

Figure 6. Comparison of the condition of the amp value of loading each bus at a 25% increase

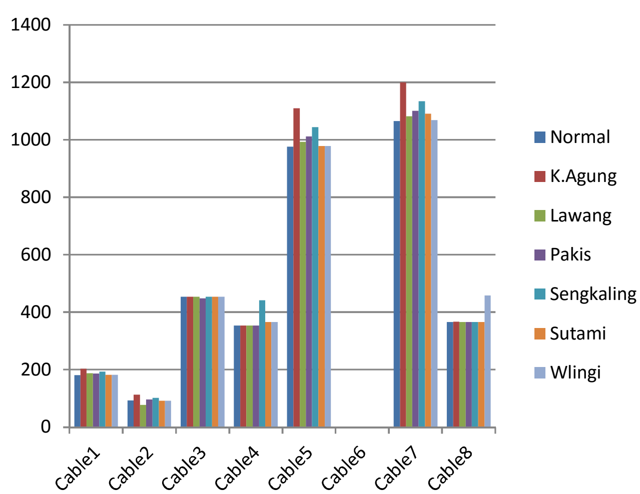

Figure 7. Amps flow value for each branch at 25% increase

5. CONCLUSION

Based on the results of the discussion of load increase scenarios in the 150 kV Malang area network, it can be concluded that there are three buses and branches that work optimally for flowing the power to the increased load. This makes and needs a network interconnection in the Malang electricity system. Because this was done to avoid the burden areas not getting electricity supply at all when disruptions run to the main buses and branches, such as G. Sutami bus, Sutami bus, Kebon Agung bus and the branch connecting the three. Besides, as an effort to increase capacity and reliability, the system should be improved for the quality of service to consumers as the recommended theme for the future works.

REFERENCES

[1] S. Zhong, "Structural decompositions of energy consumption between 1995 and 2009: Evidence from WIOD," Energy Policy, vol. 122, pp. 655–667, Nov. 2018.
[2] J. Lee, S. Yoo, J. Kim, D. Song, and H. Jeong, "Improvements to the customer baseline load (CBL) using standard energy consumption considering energy efficiency and demand response," Energy, vol. 144, pp. 1052–1063, Feb. 2018.
[3] Y. Wang, H. Lin, Y. Liu, Q. Sun, and R. Wennersten, "Management of household electricity consumption under price-based demand response scheme," J. Clean. Prod., vol. 204, pp. 926–938, Dec. 2018.
[4] R. V. A. Monteiro et al., "A medium-term analysis of the reduction in technical losses on distribution systems with variable demand using artificial neural networks: An Electrical Energy Storage approach," Energy, vol. 164, pp. 1216–1228, Dec. 2018.
[5] I. Osterroth, S. Klein, C. Nophut, and T. Voigt, "Operational state related modelling and simulation of the electrical power demand of beverage bottling plants," J. Clean. Prod., vol. 162, pp. 587–600, Sep. 2017.
[6] S. Ghandehari Shandiz, G. Doluweera, W. D. Rosehart, L. Behjat, and J. A. Bergerson, "Investigation of different methods to generate Power Transmission Line routes," Electr. Power Syst. Res., vol. 165, pp. 110–119, Dec. 2018.
[7] G. Arcia-Garibaldi, P. Cruz-Romero, and A. Gómez-Expósito, "Future power transmission: Visions, technologies and challenges," Renew. Sustain. Energy Rev., vol. 94, pp. 285–301, Oct. 2018.
[8] A. A. Abdelsalam, A. A. Eldesouky, and A. A. Sallam, "Classification of power system disturbances using linear Kalman filter and fuzzy-expert system," Int. J. Electr. Power Energy Syst., vol. 43, no. 1, pp. 688–695, Dec. 2012.
[9] F. S. Abu-Mouti and M. E. El-Hawary, "Optimal Distributed Generation Allocation and Sizing in Distribution Systems via Artificial Bee Colony Algorithm," IEEE Trans. Power Deliv., vol. 26, no. 4, pp. 2090–2101, Oct. 2011.
[10] M. K. Campbell, "Power system deregulation," IEEE Potentials, vol. 20, no. 5, pp. 8–9, Dec. 2001.
[11] A. N. Afandi, "Thunderstorm Algorithm for Assessing Thermal Power Plants of the Integrated Power System Operation with an Environmental Requirement," Int. J. Eng. Technol., vol. 8, pp. 1102–1111, Apr. 2016.
[12] A. N. Afandi et al., "Designed Operating Approach of Economic Dispatch for Java Bali Power Grid Areas Considered Wind Energy and Pollutant Emission Optimized Using Thunderstorm Algorithm Based on Forward Cloud Charge Mechanism," Int. Rev. Electr. Eng. IREE, vol. 13, no. 1, pp. 59–68, Feb. 2018.
[13] H. Cui and K. Zhou, "Industrial power load scheduling considering demand response," J. Clean. Prod., vol. 204, pp. 447–460, Dec. 2018.
[14] M. Pourakbari-Kasmaei, J. Contreras, and J. R. S. Mantovani, "A demand power factor-based approach for finding the maximum loading point," Electr. Power Syst. Res., vol. 151, pp. 283–295, Oct. 2017.
[15] M. EL-Shimy, N. Mostafa, A. N. Afandi, A. M. Sharaf, and M. A. Attia, "Impact of load models on the static and dynamic performances of grid-connected wind power plants: A comparative analysis," Math. Comput. Simul., Feb. 2018.
[16] N. Tutkun, O. Can, and A. N. Afandi, "Low cost operation of an off-grid wind-PV system electrifying residential homes through combinatorial optimization by the RCGA," in 2017 5th International Conference on Electrical, Electronics and Information Engineering (ICEEIE), 2017, pp. 38–42.
[17] Suhono and Sarjiya, "Long-term Electricity Demand Forecasting of Sumatera System Based on Electricity Consumption Intensity and Indonesia Population Projection 2010-2035," Energy Procedia, vol. 68, pp. 455–462, Apr. 2015.
[18] M. Innocent and A. Francois-Lecompte, "The values of electricity saving for consumers," Energy Policy, vol. 123, pp. 136–146, Dec. 2018.
[19] S. V. Oprea, A. Bâra, and G. Ifrim, "Flattening the electricity consumption peak and reducing the electricity payment for residential consumers in the context of smart grid by means of shifting optimization algorithm," Comput. Ind. Eng., vol. 122, pp. 125–139, Aug. 2018.
[20] T. Daglish, "Consumer governance in electricity markets," Energy Econ., vol. 56, pp. 326–337, May 2016.
[21] M. El-Shimy, M. A. Attia, N. Mostafa, and A. N. Afandi, "Performance of grid-connected wind power plants as affected by load models: A comparative study," in 2017 5th International Conference on Electrical, Electronics and Information Engineering (ICEEIE), 2017, pp. 1–8.
[22] M. Li, D. Allinson, and M. He, "Seasonal variation in household electricity demand: A comparison of monitored and synthetic daily load profiles," Energy Build., vol. 179, pp. 292–300, Nov. 2018.
[23] J. Zhou, X. Shi, C. C. Caprani, and X. Ruan, "Multi-lane factor for bridge traffic load from extreme events of coincident lane load effects," Struct. Saf., vol. 72, pp. 17–29, May 2018.
[24] A. N. Afandi et al., "Artificial salmon tracking algorithm: Preliminary designing approach for optimizing the integrated mixed energy composition," MATEC Web Conf., vol. 204, p. 04002, 2018.
[25] N. Vedachalam and M. A. Atmanand, "An assessment of energy storage requirements in the strategic Indian electricity sector," Electr. J., vol. 31, no. 7, pp. 26–32, Aug. 2018.
[26] A. Alhamwi, W. Medjroubi, T. Vogt, and C. Agert, "Modelling urban energy requirements using open source data and models," Appl. Energy, vol. 231, pp. 1100–1108, Dec. 2018.
[27] M. Chen, G. A. Ban-Weiss, and K. T. Sanders, "The role of household level electricity data in improving estimates of the impacts of climate on building electricity use," Energy Build., vol. 180, pp. 146–158, Dec. 2018.
[28] R. S. Prastika, A. N. Afandi, and D. Prihanto, "Mitigation of the alternative energy for the wind farm center considering temperature and wind speed," MATEC Web Conf., vol. 204, p. 04013, 2018.
[29] M. Curtis, J. Torriti, and S. T. Smith, "A comparative analysis of building energy estimation methods in the context of demand response," Energy Build., vol. 174, pp. 13–25, Sep. 2018.
[30] H. W. Jeon, M. Taisch, and V. Prabhu, "Measuring variability on electrical power demands in manufacturing operations," J. Clean. Prod., vol. 137, pp. 1628–1646, Nov. 2016.

[31] D. Yu, H. liu, and C. Bresser, “Peak load management based on hybrid power generation and demand response,” Energy, vol. 163, pp. 969–985, Nov. 2018.
[32] W. Bai, I. Eke, and K. Y. Lee, “An improved artificial bee colony optimization algorithm based on orthogonal learning for optimal power flow problem,” Control Eng. Pract., vol. 61, no. Supplement C, pp. 163–172, Apr. 2017.
[33] S. Chatterjee and S. Mandal, “A novel comparison of gauss-seidel and newton- raphson methods for load flow analysis,” in 2017 International Conference on Power and Embedded Drive Control (ICPEDC), 2017, pp. 1–7.
[34] M. A. Elizondo, F. K. Tuffner, and K. P. Schneider, “Three-Phase Unbalanced Transient Dynamics and Powerflow for Modeling Distribution Systems With Synchronous Machines,” IEEE Trans. Power Syst., vol. 31, no. 1, pp. 105–115, Jan. 2016.
[35] T. Kulworawanichpong, “Simplified Newton–Raphson power-flow solution method,” Int. J. Electr. Power Energy Syst., vol. 32, no. 6, pp. 551–558, Jul. 2010.
[36] A. K. Panda and N. Patnaik, “Management of reactive power sharing & power quality improvement with SRF-PAC based UPQC under unbalanced source voltage condition,” Int. J. Electr. Power Energy Syst., vol. 84, pp. 182–194, Jan. 2017.
[37] Y. Tang, J. Zhong, and M. Bollen, “Schedule of air-conditioning systems with thermal energy storage considering wind power forecast errors,” Int. J. Electr. Power Energy Syst., vol. 95, pp. 592–600, Feb. 2018.
[38] M. Žarković and Z. Stojković, “Analysis of artificial intelligence expert systems for power transformer condition monitoring and diagnostics,” Electr. Power Syst. Res., vol. 149, pp. 125–136, Aug. 2017