Available online at www.rajournals.in

RA JOURNAL OF APPLIED RESEARCH
ISSN: 2394-6709
DOI:10.47191/rajar/v8i7.06
Volume: 08 Issue: 07 July-2022

International Open Access

Impact Factor- 7.108

Page no.- 540-544

Optimization of Load Balancing with Feeder Network Reconfiguration Using ETAP Simulation

I Wayan Sutama[1], I Wayan Dikse Pancane[2], Marco Van Nover[3], Agus Putu Abiyasa[4]

[1,2,4]Department of Electrical Engineering, Universitas Pendidikan Nasional, Indonesia 80225
[3]Distribution Unit of Bali, Perusahaan Listrik Negara, Indonesia 80234

ARTICLE INFO

Published Online:
13 July 2022

Corresponding Author:
Agus Putu Abiyasa

ABSTRACT

Increasing electricity demand for tourism in Canggu Area of Bali Province, Indonesia has made the Tangeb feeder overloaded with load current more than 150 amperes. This results in voltages drop for 84 buses (59.15 %) below 19 kV. In this research, design and simulation of network reconfiguration to improve the voltage profile and reduce power losses were done using ETAP 12.6 software. The reconfiguration of network was done by changing the Load Balancing Switch (LBS) of Dukuh Sengguan to Normally Open (NO) as well as adding a Medium Voltage Twisted Insulated Cable (MVTIC) channel from Pemaron-Munggu LBS toward Dukuh Sengguan LBS to transfer part of the load from the Tangeb feeder to the Kaba Kaba feeder. The simulation results showed that the voltage profile after reconfiguration has improved above 19 kV with the lowest value being 19.275 kV for the Tangeb feeder and 19.238 kV for the Kaba Kaba feeder, respectively. The total power losses of the two feeders after reconfiguration were decreased from 226.748 kW to 178.731 kW.

KEYWORDS: Feeder network reconfiguration, Voltage profile, Power losses, ETAP

I. INTRODUCTION

PT. PLN (Persero) as a State-Owned Enterprise (BUMN) of Indonesia engaged in the provision of electrical energy for all Indonesian people must always innovate to provide the best service to the community, provide continuous and equitable service with adequate quality and level of reliability [1]. The amount of power distributed must be able to meet the needs of the community at an affordable price in order to encourage national economic growth, and improve people's living standards. The development of various sectors of life has an influence on the growth in the number of loads. Rapid load growth must be followed by reliable supply and good quality of electricity services, including reducing the frequency of blackouts and maintaining the quality of system voltage [1].

Due to growth of tourism accommodation in Canggu Area of Bali Province in Indonesia, the Tangeb feeder as one part of the PLN network that serve the area has experienced overload condition. On the 20 kV side of the Tangeb feeder there is significant bus voltages drop happening below 19 kV based on the data from the distribution voltage measurement of Mengwi Customer Service Unit (ULP). According to the General Electrical Installation Requirements (PUIL) 2000, the distribution side voltage must be above 19 kV [2]. The operating voltage which is below the standard voltage will be detrimental to PT. PLN due to large power losses in the line and for consumers will cause damages to the electrical appliances. On the other hand, there is the Kaba Kaba feeder adjacent to the Tangeb feeder serving relatively small loads. Therefore, it is possible to balance the load on the Tangeb feeder by transferring parts of loads to the Kaba Kaba feeder using Load Balancing Switch (LBS). Hence, the overall voltages will be above 19 kV and reduce power losses in the line [3],[4],[5],[6],[7].

The purpose of this research is to simulate the reconfiguration of the feeder network to improve the voltage profile and reduce power losses so that the feeder system becomes optimal. To carry out voltage improvements, network reconfiguration simulations were carried out on Electric Transient and Analysis Program (ETAP) 12.6 software. ETAP 12.6 software is a software that supports electric power systems. This program is able to work offline for electric power simulation, work online for real time data management or used to control the system in real time [8]. The features contained in it are used to analyze electricity generation, transmission systems or electric power distribution systems. One of the problems that can be solved using the ETAP program is the analysis of power flow and short circuit [8]. To simulate the power flow and short circuit, the data needed to run the simulation program include:

generator data, transformer data, conductor data, load data, bus data.

At the moment, the Tangeb feeder is operating with a total of 142 buses and 141 channels. The number of distribution

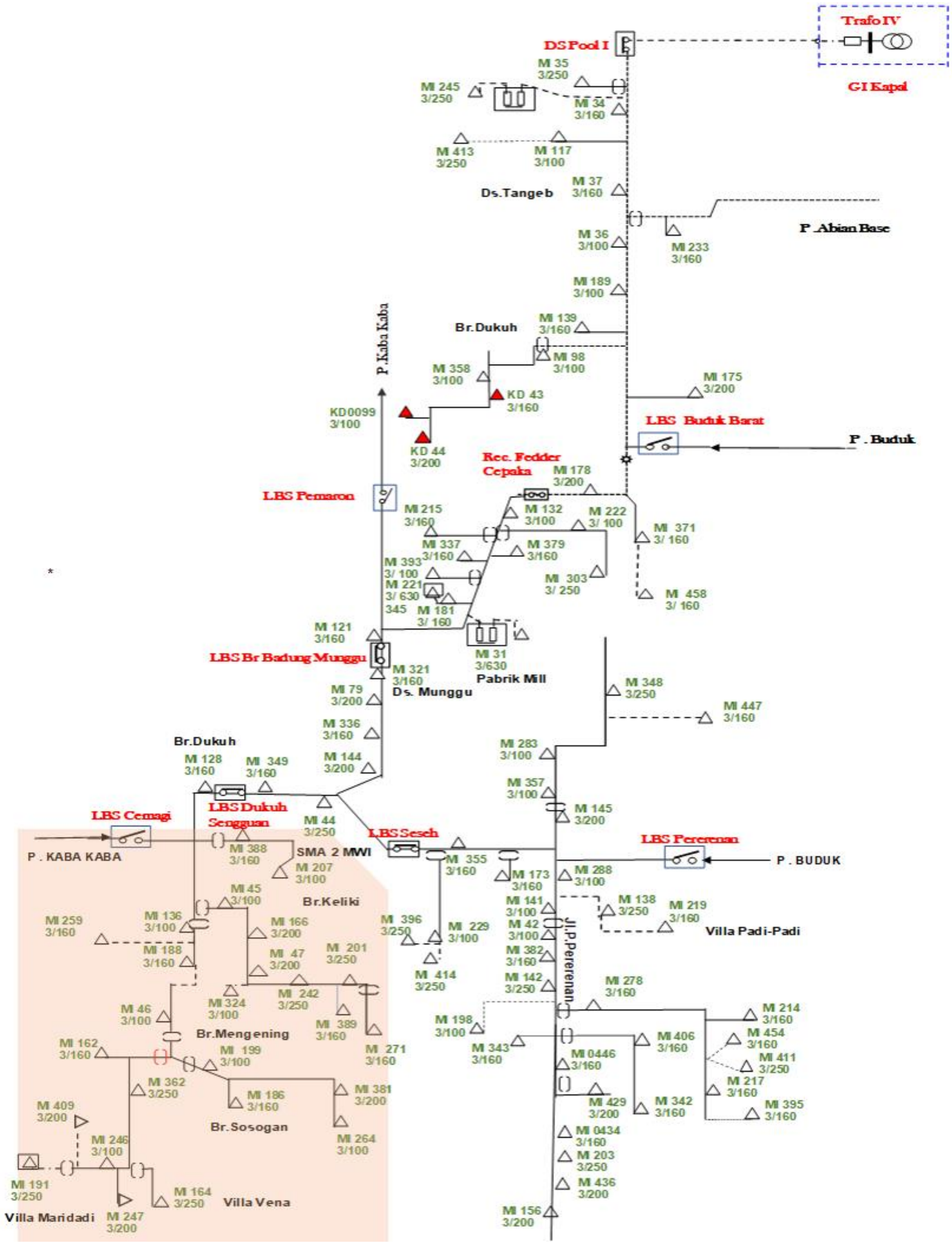

Figure 1. Single Line Diagram of Tangeb feeder with the highlighted area as the network to be reconfigured into Kaba Kaba feeder. Dukuh Sengguan LBS is at normally close condition.

Network reconfiguration is an attempt to change the shape of the distribution network configuration by operating remotely controlled switching on the distribution network without causing any risk to the operation and shape of the distribution system as a whole [8],[9],[10]. The distribution network of the Tangeb feeder and the Kaba Kaba feeder with Dukuh Sengguan LBS normally close (NC) condition is shown in Figure 1. The highlighted area is the network to be reconfigured by changing Dukuh Sengguan LBS to normally open (NO) and loads are connected to the Kaba Kaba feeder.

transformers installed is 96 transformers. Meanwhile, The Kaba Kaba feeder is a feeder supplied from Kapal Substation, with 52 buses, 50 channels and 33 distribution transformers. Based on the latest load data, the Kaba Kaba feeder carries a load below 100 amperes hence it is still possible for the Kaba Kaba feeder to receive new additional loads or loads from reconfiguring an overloaded feeder. The maximum operating load limit of the feeder is 150 amperes.

II. METHODS

This research was conducted by simulating the Tangeb feeder and the Kaba Kaba feeder using ETAP 12.6 software. The design used was before and after feeder network reconfiguration. Before feeder reconfiguration, single line diagrams of the Tangeb feeder and the Kaba Kaba feeder were made with the following steps:

1. Single line diagrams of the Tangeb feeder and the Kaba Kaba feeder were made in the existing operating state (before reconfiguration), which includes:
   a. Draw a bus, with parameters: bus name, nominal voltage.
   b. Transmission line, by completing the line length data, line geometric, conductor type and ground wire.
   c. Load, which includes filling in the name and relationship, filling in the load rating and loading.
   d. Transformer, filling transformer name, transformer rating, transformer impedance, transformer vector group.
   e. Cable, equipped with data filling name, cable length, selection of cable type in the library, selection of the number per phase of conductors, selection of cable construction, selection of impedance value of the cable used.
2. Load Flow simulation was performed for both feeders, by selecting the Newton Raphson load flow method.
3. Record the voltage profile of all buses and also the power losses on the line.

After feeder reconfiguration, single line diagrams of the Tangeb feeder and the Kaba Kaba feeder were made with the following steps:

1. Single line diagrams of the Tangeb feeder and the Kaba Kaba feeder were made in a reconfigured state, by adding a Medium Voltage Twisted Insulated Cable (MVTIC) from Pemaron-Munggu LBS to Dukuh Sengguan LBS as well as with the previously normally close (NC) operating arrangements for the Dukuh Sengguan LBS to normally open (NO) so that part of the burden on the Tangeb feeder after Dukuh Sengguan LBS has been shifted to the Kaba Kaba feeder.
2. Load Flow simulation was performed for both feeders, by selecting the Newton Raphson load flow method.
3. Record the voltage profile of all buses and also the power losses on the line.

To find out the voltage profile of each bus and also the magnitude of the power losses that occur, a power flow analysis was carried out at each simulation. As input material parameters, external library file was provided taken from PLN data to calculate line and transformer impedance values. By using the 2020PLN.lib library, the line impedance and the transformer impedance values are calculated based on the data entered into the ETAP 12.6 program.

III. RESULTS AND DISCUSSIONS

The simulation results discussed two main data namely the bus voltage profiles and line power losses before and after reconfiguration.

Before reconfiguration

After all the design parameters have been set correctly, load flow simulation was carried out to determine the value of the voltage rating on each bus and to determine the power loss in each channel before reconfiguration. The simulation results of the voltage for each bus at the Tangeb feeder are shown in Figure 2. It can be seen that from the 142 buses, as many as 84 buses (59.15%) have voltage values below 19 kV, which means that the 84 buses experienced a voltage loss greater than 5%. Furthermore, the load flow simulation results also show line losses before reconfiguration of 199.946 kW for the Tangeb feeder.

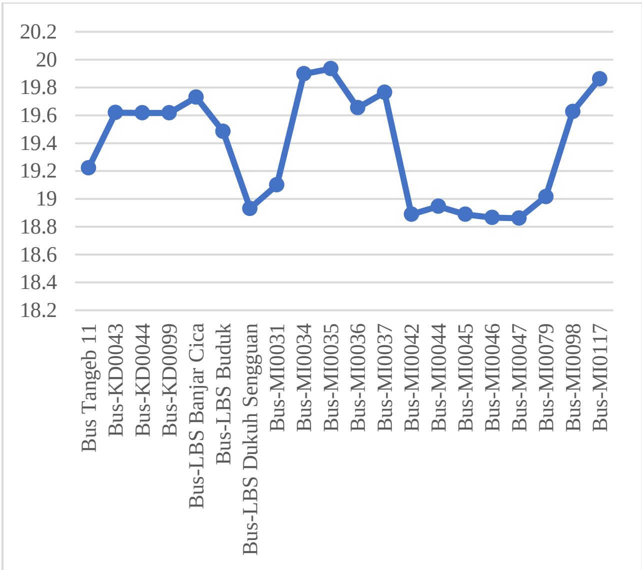

Figure 2. Voltage Profile of each the Tangeb feeder bus before reconfiguration.

The simulation results of each bus voltage from the Kaba Kaba feeder before reconfiguration are shown in Figure 3. It can be seen that all the buses have voltages above 19.7 kV well above the 5 % tolerance. The simulation results of power losses on the Kaba Kaba feeder line before reconfiguration is also relatively low at 26.802 kW compared to the Tangeb feeder.

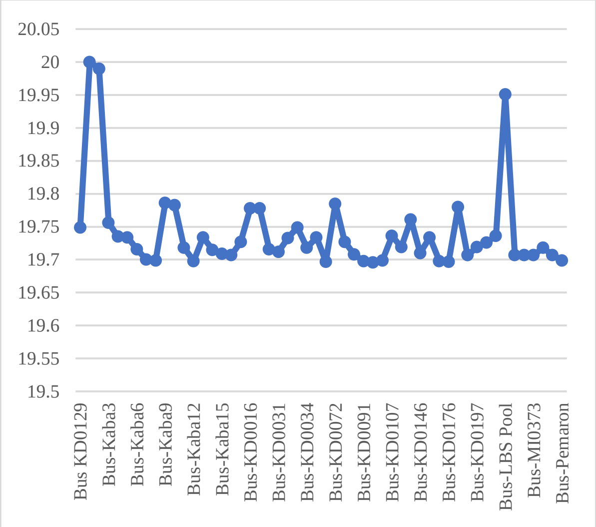

Figure 3. Voltage Profile of each the Kaba-Kaba feeder bus before reconfiguration.

After reconfiguration

Based on the results of the Tangeb feeder load flow analysis at existing condition, it is known that there are 84 buses that experience a voltage drop exceeding 5% of the normal voltage of 20 kV. These buses have voltages lower than 19 kV. Therefore, design to improve the voltage profile is done by reconfiguring the network between the Tangeb feeder and the Kaba Kaba feeder. The mechanism proposed in this study was by adding a Medium Voltage Air Cable Channel (MVTIC) from Pemaron Munggu LBS to Dukuh Sengguan LBS and setting the operation of Dukuh Sengguan LBS which was previously normally close (NC) to normally open (NO). This will transfer part of loads from the Tangeb feeder to the Kaba Kaba feeder.

After the Tangeb feeder and the Kaba Kaba feeder were reconfigured, there was a change in the feeder structure. The number of the Tangeb feeder buses after reconfiguration becomes 103 buses with 100 channels. Meanwhile on the Kaba Kaba feeder there are 90 buses with 90 channels. The simulation results for each the Tangeb feeder bus after reconfiguration are shown in Figure 4.

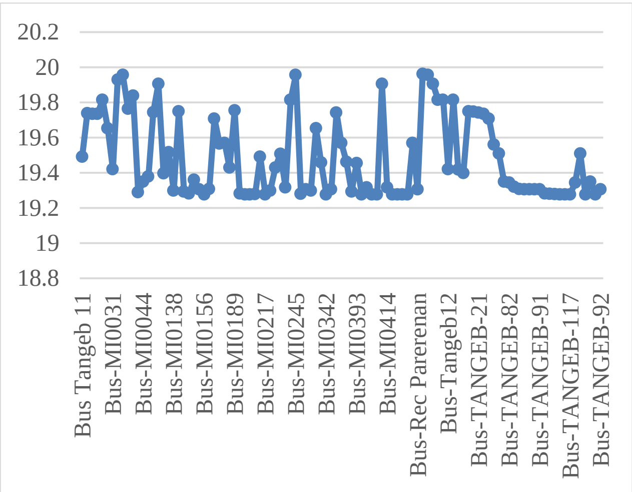

Figure 4. Voltage Profile of each the Tangeb feeder bus after reconfiguration

From Figure 4 it can be seen that the voltage of each bus after reconfiguration becomes greater than 19 kV with the lowest is 19.275 kV. This shows that the voltage loss for each bus is at the safe limit, which is less than 5%. The Tangeb feeder line power losses after reconfiguration has also reduced to 80.91 kW.

The results of each bus voltage from the Kaba Kaba feeder after reconfiguration are shown in Figure 5. It can be seen that the voltage of each bus is still greater than 19 kV even though it decreases slightly. The lowest value is found to be 19.238 kV. However, the voltage loss of each bus still at the safe limit of less than 5%. The power loss of the Kaba Kaba feeder line after reconfiguration has increased to 97.821 kW.

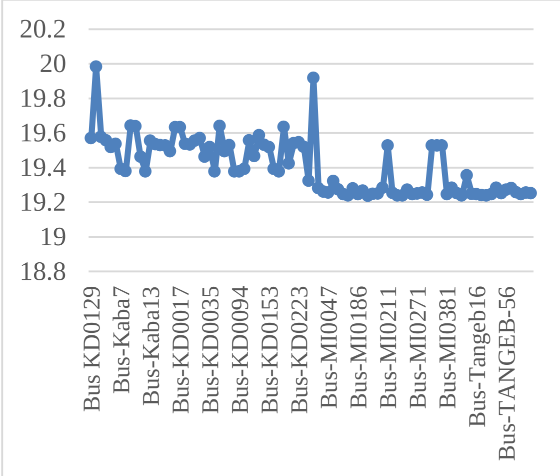

Figure 5. Voltage Profile of each The Kaba Kaba feeder bus after reconfiguration

A comparison of the total power losses before and after the reconfiguration of the two feeders is very necessary. The total power losses of the Tangeb feeder and the Kaba Kaba feeder before and after reconfiguration are shown in Table 1. It is very clear that the total power losses have decreased significantly from 226.748 kW to 178.731 kW.

Table 1. Comparison of power losses before and after reconfiguration.

Feeder	Before reconfiguration (kW)	After reconfiguration (kW)
Tangeb	199.946	80.91
Kaba Kaba	26.802	97.821
Total	226.748	178.731

IV. CONCLUSION

Based on the results of the simulation and analysis, the following conclusions can be drawn:

1. Before reconfiguration, there were 84 buses on the Tangeb feeder which experienced a voltage drop below 19 kV (> 5%) with the lowest bus voltage is 18.84 kV. However, after reconfiguration, all the bus voltage is above 19 kV with the lowest value of 19.275 kV.

2. Before reconfiguration, the Kaba Kaba feeder bus voltages were all above 19 kV with the lowest at 19.7 kV. After reconfiguration, the bus voltages slightly drop to 19.238 kV but still above 5 % condition.
3. After reconfiguration, there was a decrease in power losses for The Tangeb feeder from 199.946 kW became 80.91 kW. However, The Kaba Kaba feeder power losses increase from 26.802 kW to 97.821 kW.
4. There was a decrease in total power losses after reconfiguration, from 226.748 kW to 178.731 kW.

REFERENCES

1. D. Anteneh, "Reliability Enhancement of Distribution Substation by Using Network Reconfiguration a Case Study at Debre Berhan Distribution Substation," Int. J. Econ. Energy Environ., vol. 4, no. 2, p. 33, 2019, doi: 10.11648/j.ijeee.20190402.12.
2. B. S. Nasional, "Persyaratan Umum Instalasi Listrik 2000 (PUIL 2000)," DirJen Ketenagalistrikan, vol. 2000, no. Puil, pp. 1–133, 2000.
3. T. Abdelmonem, H. A. Hassan, M. A. M. Farrag, and Z. H. Osman, "A new method for loss reduction in distribution networks via network reconfiguration," J. Electr. Syst., vol. 14, no. 3, pp. 146–164, 2018.
4. L. Ramesh and S. Chowdhury, "Minimization of power Loss in distribution networks by different techniques," Int. J. Electr. Electron. Eng., vol. 2, pp. 521–527, 2009, [Online]. Available: http://waset.org/journals/waset/v28/v28-96.pdf.
5. R. I. Satrio and Subiyanto, "Reduction technique of drop voltage and power losses to improve power quality using ETAP Power Station simulation model," AIP Conf. Proc., vol. 1941, no. March 2018, 2018, doi: 10.1063/1.5028088.
6. A. Tanjung, "Rekonfigurasi Sistem Distribusi 20 kV Gardu Induk Teluk Lembu Dan PLTMG Langgam Power Untuk Mengurangi Rugi Daya Dan Drop Tegangan," vol. 11, no. 2, pp. 160–166, 2014.
7. S. Raut, R. Kaji, and D. Niraula, "Voltage Profile Improvement and Power Loss Reduction of Bairiya and Bankul Feeder of 33 / 11 kV Gaur Substation," vol. 8914, pp. 225–231, 2021.
8. I. Journal, "IRJET-Design Analysis of 220 / 132 KV Substation Using ETAP."
9. M. M. Algazar, "21st International Conference on Electricity Distribution: Distribution Network Reconfiguration To Improve System Performance And Reduce Power Losses", 21st International Conference on Electricity Distribution, Frankfurt, 6-9 June 2011, paper no. 0064, pp. 6–9, 2011.
10. E. Ediwan, M. Muliadi, M. Mahalla, N. Nazaruddin, and A. Mulkan, "The Reconfiguration of Network at 20 kV Distribution System Nagan Raya Substation with the Addition of the Krueng Isep Hydroelectric Power Plant," J. Nas. Tek. Elektro, vol. 10, no. 2, 2021, doi: 10.25077/jnte.v10n2.888.2021.