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Stabilizing Voltage and Managing Power Loss in Medium Voltage Distribution Systems Through Strategic Maneuvers

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ABSTRACT- Repairs and maintenance on the electrical power system often require power outages. To ensure safety and security during maintenance, limiting the extent of these outages is essential. This study aims to analyze the impact of network maneuvers on voltage drop and power loss in feeders in Medan, Indonesia. The research involves simulating the feeder circuit under various maneuver scenarios using ETAP 19.0.1 software to analyze voltage drop and power loss in the 20 kV distribution network. The end voltage on the backup feeder decreased from 20.31 kV before maneuvering to 20.10 kV after maneuvering. Despite the maneuvers causing an increase in voltage drop from 0.724 kV (3.24%) to 1.080 kV (4.23%) and in active power losses from 152.59 kW (2.29%) to 226.92 kW (3.02%), both remained within the acceptable standard of 5%. To mitigate the voltage, drop, the study proposes uprating the conductor by replacing the existing AAAC conductor with an XLPE-insulated cable. This upgrade can increase the end voltage from 20.09 kV to 20.49 kV, thus improving the overall performance of the feeder during maintenance activities.

Keywords: Conductor uprating; Electrical distribution; Power loss; Maneuvering; Voltage drop.

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1. INTRODUCTION

There are several ways to enhance the reliability of the power distribution system. The first approach is reducing the frequency of disturbances, and the second is minimizing the duration of disturbances [1,2]. Preventive measures are taken through periodic network maintenance to reduce the frequency of disturbances. This is essential to ensure the overall performance of the system. Meanwhile, to decrease the duration of disturbances, additional backup sources from alternative power supplies or feeders are introduced [3]. These sources can provide backup power when the primary source experiences a failure. Power supply maneuvers can be carried out to minimize the areas affected by power outages during disturbances or network maintenance work, aiming to avoid power interruptions for customers with critical load categories [4]. Moreover, it is crucial to reduce voltage drops to improve the overall performance of distribution networks [5,6]. Technically, continuous monitoring of voltage drops is necessary to maintain power quality and minimize losses in distribution networks. The voltage drops on electrical feeders is primarily determined by the impedance of the feeders and the current flowing through them [7]. This issue poses a considerable challenge within the electricity distribution system.

Several studies have been conducted to minimize the occurrence of voltage drop. For example, creating a linear relationship between voltage drop and apparent power has been explored in the presence of distribution generation [8]. In addition, Woldesemayat et al. [9] conducted a combination of backward/forward sweep load flow analysis and particle swarm optimization (PSO) algorithm to mitigate voltage drop and reduce power losses. Meanwhile, Visser et al. [10] addressed reducing the power output of PV systems using active power curtailment. Other methods, such as maneuvering feeders, have also been employed [11]. This method can also address voltage drop and load losses using modified capacitors [12]. For example, Mtonga et al. [13] mitigated voltage drop and load losses through strategic placement and sizing of shunt capacitors. Furthermore, a study successfully reduced voltage drop using a specific power electronic device [14]. Therefore, maneuvering is preferred for decreasing voltage drop in medium voltage distribution systems. Its standout feature lies in its ability to swiftly adapt to changes in demand or network conditions, rendering it flexible and effective. Unlike alternative solutions, maneuvering has a localized impact, minimizing disruptions to the overall network. Network maneuver is carried out in response to disruptions or when work needs to be performed on the network requiring a power outage. Consequently, the network is altered and supplied from an alternative power source to minimize areas experiencing

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outages and maintain the most efficient distribution of electrical energy [15].

There are several benefits of manoeuvring in distribution systems. These include enhancing system reliability, improving operational efficiency, maintaining system stability, and minimizing losses [16-18]. Meanwhile, a drawback of manoeuvring is the difficulty in determining manoeuvre points due to the need to consider adjacent feeders [19]. Therefore, careful and thorough measurements are necessary before performing manoeuvring. The constraints that may arise if the manoeuvring measurement process is not conducted accurately include operational errors, such as disruptions in the distribution system, increased downtime, and reduced system reliability. However, manoeuvring remains an essential technique because it can efficiently utilize renewable energy by effectively harnessing distributed generators from within the network rather than externally [20].

Previous studies have investigated distribution network performance using ETAP software. Hasibuan et al. [21] focused on the installation of distributed generation to address voltage drop and power loss in a 20 kV distribution system. However, they did not explore other potential strategies for managing voltage stability and power loss during necessary maintenance and repair activities. Additionally, Abass et al. [22] conducted a study on voltage instability and transient stability in a power system integrated with a solar combined cycle plant. Nevertheless, they did not examine the specific impacts of strategic manoeuvres during maintenance operations on voltage drop and power loss. Mehtre and Dubey [23] carried out an optimization of load flow analysis and improved the visualization of energy systems through ETAP and single-line diagram integration. While they highlighted the benefits of these tools for analysing power systems, they did not specifically address the challenges of maintaining voltage stability and managing power losses during maintenance activities. Meanwhile, Mujtaba et al. [24] explored the benefits of integrating distributed generation, particularly solar plants, to improve grid performance. However, they did not provide strategies for managing voltage stability and power losses without the integration of distribution generators, which is a crucial aspect of traditional grid management.

Building on these studies, there remains a gap in understanding how strategic manoeuvres during maintenance activities can stabilize voltage and manage power losses in medium voltage distribution systems without relying on the integration of distributed generation. The novelty of the present study lies in its focus on using strategic manoeuvres to stabilize voltage and manage power losses in medium voltage distribution systems during maintenance activities. Specifically, the study proposes traditional grid management approaches rather than relying on distributed generation or renewable energy sources. Therefore, this study aims to evaluate the impact of manoeuvres on medium voltage distribution systems on voltage drop and power loss. Additionally, this study proposes a conductor uprating method to improve the feeder's end voltage during manoeuvring.

2. METHODS

2.1 Research Site

This study was carried out at the PT PLN (Persero) Customer Service Unit of Medan City, located at Listrik St. No. 8, Petisah Tengah, Medan Petisah District, Medan City, North Sumatra, Indonesia. Geographically, it is situated at the coordinates 3°35'09.5"N latitude and 98°40'33.9"E longitude.

2.2 Data Collection

The data source was obtained through direct measurements conducted by the researcher and from data provided by the Technical Supervisor, Technical Staff, and Technical Service Officers. The collected data includes single-line diagrams, feeder specifications, and voltage measurements on a feeder. Observations began with the feeder in normal condition, followed by maneuvering the feeder. Field observations conducted were:
(1) Voltage measurements during normal and maneuvered conditions; (2) Identifying the effects of maneuvers on voltage and power; and (3) Calculation of voltage drop and power loss during maneuvered conditions using ETAP 19.0.1 software.

2.3 ETAP Simulation

In this stage, the research involves extracting planning outcomes from existing data through several key activities. These include entering the length of the network and specifications of feeder cables into the ETAP software and ensuring simulation results align with field data. Additionally, simulating maneuvered feeder circuits using ETAP facilitates analysis of their impact on voltage drop and power. Eventually, the research analyzes how voltage drop affects a 20 kV distribution network during maneuvers, exploring factors influencing voltage drop and power under these conditions. *Table 1* presents the parameters used in the ETAP simulation.

Table 1. ETAP simulation parameters and data specifications

Parameter	Value
Power Grid Data	
Grid Configuration	a. Short-Circuit Rating: 3-Phase: MVAsc = 60 MVA; X/R ratio = 5 1-Phase: Short-circuit rating = 40 MVA
	b. SC Impedance: Positive Sequence: %R = 6.65%, %X = 0.02% Negative Sequence: %R = 6.65%, %X = 0.02% Zero Sequence: %R = 6.65%, %X = 0.02%
Voltage Levels	20 kV
Transformer Data	
Primary Voltage	20 kV
Secondary Voltage	0.4 kV
Impedance (Z)	5%
X/R Ratio	3.87
Bus Data	
Bus ID	MK 608
Voltage	20 kV
Voltage Angle	Initial Voltage Angle = 0 Operating Voltage Angle = -0.1

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Static Load Data	
Model Type	Conventional
Rated kV	0.4 kV
Constant kVA	80%
Constant Z	20%
Ratings	28.2 kVA

The short-circuit ratings were set to 60 MVA for the 3-phase system and 40 MVA for the 1-phase system, aligning with typical values for medium voltage networks. The short-circuit impedance values, including a positive sequence resistance and reactance and similar values for negative and zero sequences, reflect standard characteristics for transformers and lines. The voltage level of 20 kV was chosen to match the operational voltage of the distribution system. For the transformer data, the primary voltage of 20 kV and secondary voltage of 0.4 kV were selected to represent typical step-down transformers used in such networks, with an impedance of 5% and an X/R ratio of 3.87, which are common for medium voltage transformers. In the bus data, Bus ID MK 608 and a voltage of 20 kV were chosen based on the actual configuration of the system, with a small operating voltage angle change of -0.1 degrees reflecting minor phase shifts. The static load data included a conventional load model with parameters such as rated voltage, constant kVA, constant impedance, and load rating, representing typical load characteristics for the system.

2.4 Primary Data

Figure 1 depicts a distribution network diagram, specifically the DA.05 feeder, the simulation maneuvering area.

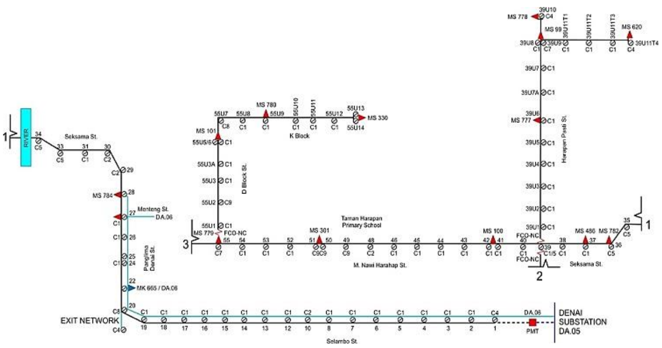

Figure 1. Single line diagram of DA.05 feeder

Tables 2 and *table 3* display the specifications of the main substation and feeders utilized. The feeders, which constitute the simulation maneuver area, feature a power transformer capacity of 60 MVA.

Table 2. Main substation data (Denai, Medan, Indonesia)

Power Transformer Code	Power Transformer Capacity (MVA)	Number of Feeders
DA	60	7
DN	60	6
DI	60	1

Note: Output voltage = 21 kV.

Table 3. Feeder specifications

Feeder	Number of Sections	Length of Feeder (km)	Cable Type	Cable Cross-Sectional Area (mm^2)
DA.02	1	10.15	AAAC	150
DA.03	4	9.00	NA2XSEBY	240
		2.10	AAAC	150
DA.05	4	5.24	AAAC	150
DN.03	4	6.20	NA2XSEBY	240
		3.40	AAAC	150

3. RESULTS AND DISCUSSION

3.1 Maneuver Scenario

Table 4 summarizes the disruption data for feeder DN.03, including the sequence of events, reconnection attempts, fault tracking, and the cause of the trip.

Table 4. Disruption data for feeder DN.03

Event	Details
Time	10:14:40 (Local Time)
Fault current	Not readable
Indication	Not readable
Reconnection attempts:	
- L.01 to L.02	Safe
- L.02 to L.03	Failed
- L.04 to End	Loaded from DA.05
Full recovery time	13:05 (Local Time)
Fault tracking by the officer	LA Transformer MK 608 phase S blown
Cause of trip (DN.03 Rec L.01)	Blown lightning arrester; wire secured
Conclusion	Lightning arrester failure in Section 3
Network maneuvers suggested	Feeder DA.02 and Feeder DA.05
Safety criteria for maneuver	Transfer current within cable capacity and current protection setting limits

Based on *table 4*, the trip was caused by a lightning arrester failure in *section 3*. Therefore, network manoeuvres can be carried out to the nearest feeders [25], feeder DA.05 and feeder DA.02. The load current transferred to these feeders can be seen in *table 5*.

Table 5. Feeder load currents (normal condition)

Feeder	Protection Setting Current (A)	Used Current (A)	Maximum Transfer Current (A)	Cable Current Carrying Capacity (A)
DN.03	500	135	365	596
DA.02	360	148	212	423
DA.05	360	215	145	423

Table 6 shows a scenario of currents for maneuvering for DN.02 and DN.05 due to a fault between sections 3 and 4 on DN.03. A maneuver is considered safe if the transfer current does not exceed the cable capacity and the current protection setting limits [26].

Table 6. Feeder load currents (maneuvering condition)

Maneuvering Feeder	Network Maneuver Scenario	Transfer Current (A)	Total Load (A)
DA.02	The fault area is isolated by opening the Load Break Switch (LBS) in sections 3 and 4. The load from section 4 is then maneuvered to DA.02 by closing the LBS at the DN.03-DA.02 junction.	30	178
DA.05	Same as the scenario for DA.02.	30	245

Based on the scenario in *table 6*, both DA.02 and DA.05 propose safe conditions for manoeuvring since the total load after manoeuvring would be 178 A and 245 A, respectively, which are still within the safe limits of the protection setting current and the cable current carrying capacity. Therefore, either feeder can be chosen for the manoeuvre based on operational preferences or other strategic considerations. However, DA.05 has a shorter network length (5.24 km) than DA.02 (10.15 km). A shorter network length generally results in lower voltage drops and less power loss, which can be advantageous in maintaining network stability [27]. Therefore, the manoeuvre was done on the DA.05 feeder.

3.2 Voltage Drop and Power Loss Measurement

Table 7 shows the results of the voltage drop measurement before and after manoeuvring. The results indicate that the voltage drop does not exceed the standard of 5%, demonstrating the success of the manoeuvre [28].

Table 7. Voltage drops

Condition	Voltage Drop (kV)	Percentage (%)	Voltage Drop Standard
Before Maneuver	0.724	3.24	Complies
After Maneuver	1.080	4.23	Complies

Note: I = 215 A; R = 0.2162 Ω/km; X = 0.3305 Ω/km; L of DA.05 = 5.24 km (before maneuver) and 6.10 km (after maneuver).

Additionally, *table 8* presents the power loss calculation results under simulation conditions before and after maneuvering on the DA.05 feeder. Both active and reactive power losses increase because of the maneuver. Despite the increase, they remain within the specified power loss standards of 5% for active and 10% for reactive power loss.

Table 8. Power loss

Condition	Active Power Loss (kW)	Reactive Power Loss (kvar)	Power Loss Standard
Before Maneuver	152.59 (2.29%)	239.79 (5.89%)	Complies
After Maneuver	226.92 (3.02%)	356.59 (7.75%)	Complies

Note: I = 243 A; R = 0.2162 Ω/km; X = 0.3305 Ω/km; L of DA.05 = 5.24 km (before maneuver) and 6.10 km (after maneuver).

3.3 Distribution Network Simulation

The ETAP simulation results can be obtained after inputting data for segments, cross-sectional areas, network length, substations, and loads. Under normal conditions, the voltage at the feeder's end is 20.31 kV (*figure 2)*. The simulation results indicate a voltage drop of 0.724 kV or 3.24% of the sent voltage. This value is within the allowed voltage drop standard of 5%.

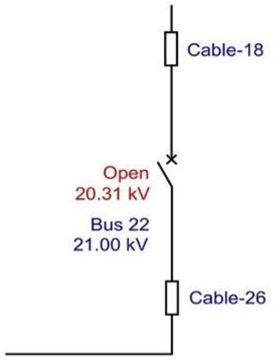

Figure 2. End voltage of feeder DA.05 in normal condition

Meanwhile, the disturbance condition in the DN.03 feeder is depicted in *figure 3*, illustrating the distribution network engineering by isolating the affected area, specifically in Section 3. To minimize the blackout area, the breakers, or LBS in Sections 3 and 4 are normally open (NO). Subsequently, the load in Section 4 is maneuvered by normally closing (NC) the junction between the DA.05 and DN.03 feeders *(figure 4)*. Since Section 4 is not affected by the disturbance, the load in Section 4 is maneuvered to the DA.05 feeder. This prevents customers in Section 4 from experiencing a blackout, minimizing the blackout area.

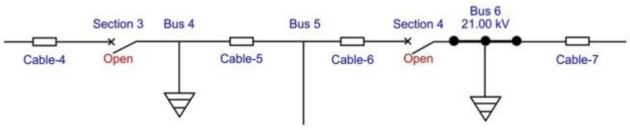

Figure 3. Section 3 and Section 4 of feeder DN.03 opened (NO)

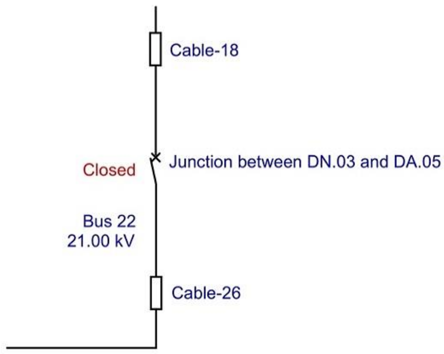

Figure 4. The junction between DN.03 and DA.05 in closed condition (NC)

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During the 20 kV distribution network manoeuvre, the end voltage at the DA.05 feeder is 20.10 kV (decrease). The simulation results indicate a voltage drop of 1.080 kV or 4.23% of the sent voltage. This value still falls within the allowed voltage drop standard of 5%. The voltage drop during the distribution network manoeuvre condition can be observed in *figure 5*.

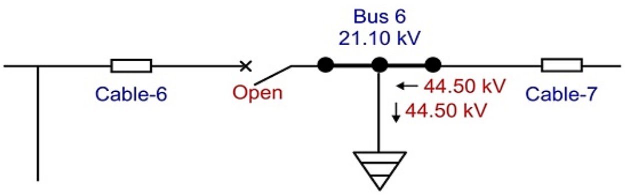

Figure 5. End voltage of feeder DA.05 in maneuver condition

3.4 Voltage Drop Mitigation Simulation

One effort to mitigate voltage drop involves increasing the cross-sectional area of the conductor in the distribution network [29]. The DA.05 feeder initially used a conductor with a cross-sectional area of 150 mm². A conductor with a cross-sectional area of 240 mm² was used in the network manoeuvre simulation. Sivanagaraju et al. [30] indicate that larger cross-sectional areas can improve voltage regulation by minimizing resistive losses, which directly affects the end voltage delivered to loads. Similarly, Milardovich et al. [31] reported that larger conductors can handle higher loads with reduced losses, thereby maintaining end voltage levels.

After replacing the cross-sectional area of the cable in the DA.05 feeder, the voltage drop can be improved. The initial end voltage during the manoeuvre was 20.10 kV, which increased to 20.49 kV. Additionally, *figure 6* illustrates the end voltage results after modifying the conductor.

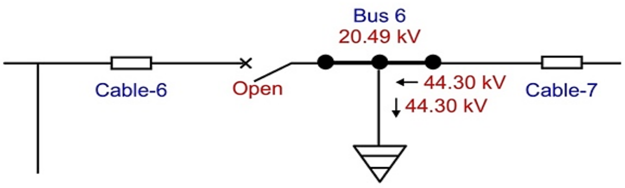

Figure 6. End voltage of feeder DA.05 in reconductored condition

Table 9 provides data for the DA.05 feeder before and after manoeuvring the DN.03 feeder. Furthermore, *table 9* indicates an increase in power load and feeder length in the DA.05 feeder, whereas a decrease is observed in the DN.03 feeder.

Table 9. Electrical feeder parameter data before and after the manoeuvre

Feeder	Power Load (kW)		Feeder Length (km)	
	Before Manoeuvre	After Manoeuvre	Before Manoeuvre	After Manoeuvre
DA.05	215	243	5.24	6.10
DN.03	135	104	9.60	8.70

Table 10 compares end voltage values in all scenarios for the DA.05 feeder. Following the manoeuvre, end voltage values have decreased in all scenarios, with the difference in each scenario not exceeding 0.2 points. Notably, end voltages from ETAP simulation tend to be lower than other sources, including manual calculation and field measurement. This aligns with Jaya et al. [32], who found that ETAP simulations resulted in lower power losses compared to manual calculations, indicating that simulations may underestimate real-world losses and thus produce lower end voltage values than field measurements. Therefore, the value chosen for the report is based on field measurement, as it accurately reflects the actual conditions. In the improvement scenario, replacing the conductor with a cross-sectional area of 240 mm² results in an enhanced end voltage.

Table 10. Comparison of end voltage in several scenarios

Condition	End Voltage (kV)		
	Manual Calculation	ETAP Simulation	Field Measurement
Before Manoeuvre	20.32	20.31	20.32
After Manoeuvre	20.11	20.10	20.12
Improvement Simulation (Conductor Uprating)	-	20.49	-

The results of this study provide significant implications for the field. This study offers insights into stabilizing voltage and managing power losses during maintenance activities in medium voltage distribution systems. Focusing on strategic manoeuvres rather than relying on distributed generation or renewable sources presents practical solutions for enhancing grid performance during maintenance, leading to more efficient and reliable operations. Additionally, the effectiveness of increasing conductor cross-sectional areas to reduce voltage drop showcases an effective upgrade for maintaining voltage stability and improving distribution network performance. It is also important to note that integrating accurate field measurements with simulation results is essential for planning; real-world conditions must be considered to ensure that simulations align with actual performance.

6. CONCLUSIONS

The manoeuvre of feeders in Medan, Indonesia, was successfully conducted and simulated using ETAP as well. Positive outcomes were indicated by voltage drop and power loss values, which do not exceed the standard limits. Specifically, the voltage drop increased from 0.724 kV (3.24%) to 1.080 kV (4.23%), and active power losses increased from 152.59 kW (2.29%) to 226.92 kW (3.02%). The mitigation in voltage drop can be attributed to the uprating of the conductor, achieved by replacing the conductor wire with one of a larger cross-sectional area, resulting in an increase in the end voltage from 20.09 kV to 20.49 kV. The study significantly contributes to the field of power distribution by presenting an approach to stabilizing voltage and managing power losses in medium voltage distribution systems during maintenance activities. Additionally, the effective use of increased conductor cross-sectional areas to reduce voltage drop demonstrates a practical upgrade for maintaining voltage stability and improving network performance. Furthermore, integrating accurate field measurements with simulation results ensures that theoretical models align with real-world conditions.

Future research should focus on several areas to advance the field. Developing and testing advanced control algorithms for dynamic feeder configuration adjustments is crucial for enhancing voltage stability, with pilot studies validating these algorithms in different feeder scenarios. For example, research should focus on adjustable reactive power devices such as capacitor banks, transformers, and reactors to manage voltage stability and enhance grid protection, particularly in the context of integrating renewable energy sources. In addition, investigations into the impact of integrating renewable energy sources, such as solar and wind, on feeder performance are needed, including both simulations and real-world testing to assess how these sources can be incorporated while maintaining voltage stability and power quality. For instance, studying how factors like temperature, internal network losses, and power electronics affect the efficiency of photovoltaic plants. Additionally, exploring the adoption of smart grid technologies for automating and optimizing feeder operations, alongside incorporating environmental impact assessments and sustainable practices, will ensure long-term benefits. To integrate high levels of renewable energy and adopt new grid technologies, future research should focus on managing the variability of supply from wind and solar sources and its impact on power quality and grid congestion. Studies should also explore advanced tools for small-scale distributed generation and develop new methods to address this variability.

REFERENCES

[1] X. Xiao, Y. Zhou, W. Zhang, Y. Wang, Z. Zheng and W. Hu, "Power disturbance waveform analysis and proactive application in power systems," Energy Conversion and Economics, vol. 4, no. 2, pp. 123–136, Apr. 2023, doi: 10.1049/enc2.12084.

[2] N. Bhusal, M. Abdelmalak, M. Kamruzzaman and M. Benidris, "Power system resilience: Current practices, challenges, and future directions," IEEE Access, vol. 8, pp. 18064–18086, 2020, doi: 10.1109/ACCESS.2020.2968586.

[3] G. S. Bolacell, D. E. D. Calado, L. F. Venturini, D. Issicaba and M. A. da Rosa, "Distribution system planning considering power quality, loadability and economic aspects," in 2020 International Conference on Probabilistic Methods Applied to Power Systems (PMAPS), IEEE, Aug. 2020, pp. 1–6. doi: 10.1109/PMAPS47429.2020.9183582.

[4] M. Putri, I. Hajar, Trahman and M. Husna, "Overcome voltage drop by uprating conductors using ETAP software," International Journal of Performability Engineering, vol. 9, pp. 1–5, Dec. 2021.

[5] C. K. Wachjoe and H. Zein, "A method for voltage drop monitoring on load sides in medium voltage feeder," in 2020 7th International Conference on Control, Decision and Information Technologies (CoDIT), IEEE, Jun. 2020, pp. 1215–1220. doi: 10.1109/CoDIT49905.2020.9263852.

[6] A. S. Saidi, "Impact of grid-tied photovoltaic systems on voltage stability of Tunisian distribution networks using dynamic reactive power control," Ain Shams Engineering Journal, vol. 13, no. 2, p. 101537, Mar. 2022, doi: 10.1016/j.asej.2021.06.023.

[7] O. A. Osahenvemwen and O. Omorogiuwa, "Parametric modeling of voltage drop in power distribution networks ," International Journal of Technical Research and Applications, vol. 3, no. 3, pp. 356–359, 2015.

[8] A. Deshmukh, M. R. Ur Rahman and V. Aravinthan, "Feeder level linear voltage drop model for active radial distribution system operation in the presence of distributed generation," in 2019 North American Power Symposium (NAPS), IEEE, Oct. 2019, pp. 1–6. doi: 10.1109/NAPS46351.2019.9000390.

[9] M. L. Woldesemayat, D. B. Biramo and A. T. Tantu, "Assessment of power distribution system losses and mitigation through optimally placed D-STATCOM," Cogent Eng, vol. 11, no. 1, Dec. 2024, doi: 10.1080/23311916.2024.2330824.

[10] L. R. Visser, E. M. B. Schuurmans, T. A. AlSkaif, H. A. Fidder, A. M. van Voorden and W. G. J. H. M. van Sark, "Regulation strategies for mitigating voltage fluctuations induced by photovoltaic solar systems in an urban low voltage grid," International Journal of Electrical Power & Energy Systems, vol. 137, p. 107695, May 2022, doi: 10.1016/j.ijepes.2021.107695.

[11] Umar and N. A. Murtadho, "Analysis voltage drop and alternative network manuvers in BRG-4 recovery PT. PLN (Persero) Salatiga service unit using ETAP power station 12.6," 2019, p. 050021. doi: 10.1063/1.5112465.

[12] O. AlAhmad and M. AlDahmi, "Voltage profile improvement analysis of 11 kV feeders using capacitor banks," in 2021 International Conference on Electrotechnical Complexes and Systems (ICOECS), IEEE, Nov. 2021, pp. 83–87. doi: 10.1109/ICOECS52783.2021.9657351.

[13] T. P. M. Mtonga, K. K. Kabere and G. K. Irungu, "Optimal shunt capacitors' placement and sizing in radial distribution systems using multiverse optimizer," IEEE Canadian Journal of Electrical and Computer Engineering, vol. 44, no. 1, pp. 10–21, 2021.

[14] Khairudin, L. Hakim, A. A. S. Saputra and A. Alhasewi, "Dynamic voltage restorer for the voltage drop compensation in long rural distribution feeder application," J Phys Conf Ser, vol. 1376, no. 1, p. 012021, Nov. 2019, doi: 10.1088/1742-6596/1376/1/012021.

[15] M. Putri, A. Ramadhan and M. Hasanah, "Utilization of an Electrical Transient Analyzer Program (ETAP) in calculating power optimization for fuel cost efficiency," International Journal of Engineering Trends and Technology, vol. 71, no. 7, pp. 85–93, Jul. 2023, doi: 10.14445/22315381/IJETT-V71I7P209.

[16] J. Lopez-Lorente, X. A. Liu, R. J. Best, G. Makrides and D. J. Morrow, "Techno-economic assessment of grid-level battery energy storage supporting distributed photovoltaic power," IEEE Access, vol. 9, pp. 146256–146280, 2021, doi: 10.1109/ACCESS.2021.3119436.

[17] V. Lokesh and A. Q. H. Badar, "Optimal sizing of RES and BESS in networked microgrids based on proportional peer-to-peer and peer-to-grid energy trading," Energy Storage, vol. 5, no. 7, Oct. 2023, doi: 10.1002/est2.464.

[18] N. Belbachir, M. Zellagui, A. Lasmari, C. Z. El-Bayeh and B. Bekkouche, "Optimal integration of photovoltaic distributed generation in electrical distribution network using hybrid modified PSO algorithms," Indonesian Journal of Electrical Engineering and Computer Science, vol. 24, no. 1, p. 50, Oct. 2021, doi: 10.11591/ijeecs.v24.i1.pp50-60.

[19] M. Z. Ghorbani-Juybari, H. Gholizade-Narm and Y. Damchi, "Optimal recloser placement in distribution system considering maneuver points, practical limitations, and recloser malfunction," International Transactions on Electrical Energy Systems, vol. 2022, pp. 1–12, Apr. 2022, doi: 10.1155/2022/5062350.

[20] A. Razmjoo, L. G. Kaigutha, M. A. Vaziri Rad, M. Marzband, A. Davarpanah and M. Denai, "A Technical analysis investigating energy sustainability utilizing reliable renewable energy sources to reduce CO2 emissions in a high potential area," Renew Energy, vol. 164, pp. 46–57, Feb. 2021, doi: 10.1016/j.renene.2020.09.042.

[21] A. Hasibuan, F. Dani, and I. M. A. Nrartha, "Simulation and analysis of distributed generation installation on a 20 kV distribution system using ETAP 19.0," Bulletin of Computer Science and Electrical Engineering, vol. 3, no. 1, pp. 18–29, 2022.

[22] A. Z. Abass, D. A. Pavlyuchenko, and Z. S. Hussain, "Survey about impact voltage instability and transient stability for a power system with an integrated

International Journal of Electrical and Electronics Research (IJEER)
Research Article | Volume 12, Issue 3 | Pages 1060-1066| e-ISSN: 2347-470X

solar combined cycle plant in Iraq by using ETAP," Journal of Robotics and Control (JRC), vol. 2, no. 3, pp. 134–139, 2021, doi: 10.18196/jrc.2366.

[23] V. V. Mehtre and A. Dubey, "A case study for optimization of power system load flow analysis using ETAP software," World Journal of Advanced Engineering Technology and Sciences, vol. 11, no. 2, pp. 476–492, Apr. 2024, doi: 10.30574/wjaets.2024.11.2.0121.

[24] G. Mujtaba, Z. Rashid, F. Umer, S. K. Baloch, G. A. Hussain, and M. U. Haider, "Implementation of distributed generation with solar plants in a 132 kV grid station at Layyah using ETAP," International Journal of Photoenergy, pp. 1–14, Jun. 2020, doi: 10.1155/2020/6574659.

[25] X. Wang, X. Sheng, W. Qiu, W. He, J. Xu, Y. Xin and J. Jv, "Fault reconfiguration strategies of active distribution network with uncertain factors for maximum supply capacity enhancement," IEEE Access, vol. 10, pp. 72373–72380, 2022, doi: 10.1109/ACCESS.2021.3051230.

[26] D. Enescu, P. Colella and A. Russo, "Thermal assessment of power cables and impacts on cable current rating: An overview," Energies (Basel), vol. 13, no. 20, p. 5319, Oct. 2020, doi: 10.3390/en13205319.

[27] Ashley Edison, "Voltage Drop Compensators for Long Cable Runs," Ashley Edison, Surrey, 2021.

[28] IEEE, 141-1993 - IEEE Recommended Practice for Electric Power Distribution for Industrial Plants. 1994.

[29] A. Hasibuan, K. Kartika and S. Mahfudz, "Reconfiguration of 20 kV substance connection network LG-04 Lhokseumawe City using Digsilent Power Factory 15.1 software simulation," International Journal of Advances in Data and Information Systems, vol. 3, no. 1, pp. 19–28, Apr. 2022, doi: 10.25008/ijadis.v3i1.1232.

[30] S. Sivanagaraju, N. Sreenivasulu, M. Vijayakumar, and T. Ramana, "Optimal conductor selection for radial distribution systems," Electric Power Systems Research, vol. 63, no. 2, pp. 95–103, Sep. 2002, doi: 10.1016/S0378-7796(02)00081-0.

[31] N. J. Milardovich, L. Prevosto, and M. A. Lara, "Calculation of harmonic losses and ampacity in low-voltage power cables when used for feeding large LED lighting loads," Advanced Electromagnetics, vol. 3, no. 1, pp. 50–56, Oct. 2014, doi: 10.7716/aem.v3i1.258.

[32] A. Jaya, Wirentake, and M. Priyanto, "Analisis rugi daya dan rekonsiliasi energi jaringan distribusi tegangan menengah 20 kv pada penyulang Nijang," Jurnal TAMBORA, vol. 4, no. 3, pp. 34–40, Oct. 2020, doi: 10.36761/jt.v4i3.790.

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