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Research Original Article

Planning to Reconfigure the 150 kV Transmission Network at PT. PLN (Persero) Tualang Cut Network and Substation

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Abstract
System condition at PT. PLN (Persero) Tualang Cut Substation where the reliability of the 150 kV system depends on the Langsa Substation, which we will reconfigure on the Lgs-P.B and Lgs-T.C channels to P.B-T. C and T.C-Lgs. The planning for the reconfiguration of the 150 kv transmission network of the Tualang Cut Substation was carried out by estimating the distance of the transmission line and the constraints that occurred. The condition of the electric power system that is currently operating at PT. PLN (Persero) Tualang Cut Substation is considered less efficient in receiving power from the 150 kV SUTT interconnection. The SUTT in Tualang Cut currently receives electrical power from the Langsa Substation with a Losses value on lines 1 and 2 of 771,4142474 kW and experiences a Voltage Drop on lines 1 and 2 of 4,38 kV. After we reconfigured the channel, from the results of the reconfiguration there was a decrease in Losses on channels 1 and 2 by 311,298581 kW which before the reconfiguration of power losses on the line amounted to 771,4142474 kW and after being reconfigured to 460,1156668 kW there was a decrease in Voltage Drop on channels 1 and 2 by 1,44 kV, before the reconfiguration of the voltage drop on the line of 4,38 kV and after the reconfiguration to 2,94 kV, the reconfiguration carried out is the best solution to reduce losses and voltage drops.
Keywords: Reconfiguration; Losses; Voltage Drop

Introduction
The distribution of electrical energy from the generating center to the customer involves several important stages, namely generation, transmission, and distribution (Arnawan et al., 2021) (Binilang et al., 2017). As a result, the state electricity company must not stop distributing electricity for more than 24 hours (Arifin, 2017) (Aribowo et al., 2021). Substations as components of the electric power system play an important role in the continuity of electricity supply to consumers (M et al., 2015). With the increasing consumer demand for electrical energy, the burden borne by substations is also getting bigger (Rajagukguk et al., 2015).

Network reconfiguration is the process of changing the form of transmission network configuration using switches to reduce power losses on the transmission network and increase the reliability of the transmission and distribution system (Saputra, 2019) (Hasibuan et al., 2022) (Kartoni & Ervianto, 2016). The goal is to improve the efficiency of electrical power senders and ensure optimal service to consumers (Talaat et al., 2021)(Musdir et al., 2022). This configuration change occurs at PT. PLN (Persero) Network and Substation 150kV Langsa to Substation 150 kV Pangkalan Berandan and Substation 150 kV Tualang Cut (Ismail et al., 2020) (Syukri et al., 2022). At PT. PLN (Persero) Network and Substation Tualang Cut Where the reliability of its 150 kV system depends on PT. PLN (Persero) Network and Langsa Substation, which at the Langsa Substation get electricity supply from the Pangkalan Beranda Substation and Lhokseumawe Substation (Hasibuan et al., 2019).

In this research, planning will be carried out to reconfigure the 150 kV transmission network at the Tualang Cut Substation (Nasution, 2019). One of the steps to be taken is the withdrawal of the SUTT (High Voltage Air Line) network by connecting directly to the Pangkalan Berandan Substation, without passing through the Langsa Substation transmission network (Wantouw & Mandagi, 2014). The purpose of this reconfiguration is to improve the reliability of the transmission network in Aceh Tamiang District. In this scenario, the power supply from Tualang Cut Substation will be channeled directly to Langsa Substation. For this reason, researchers are interested in conducting a study entitled, "Planning for the Reconfiguration of the 150 Kv Transmission Network at PT. PLN (Persero) Network and Tualang Cut Substation".

The purpose of this study is to determine the condition of the electric power system at PT. PLN (Persero) Tualang Cut Network and Substation and know the Tualang Cut Substation Transmission Network Reconfiguration Planning system, the operating pattern from the results of the ETAP (Electrical Transient Analyzer Program) simulation version 12.6.0. (Hanung Yoba Abriyantoa, Fardhan Arkan, 2017) with the formulation of the problem, namely how the condition of the electric power system that is operating at PT. PLN (Persero) Tualang Cut Network and Substation and How the impact occurred after the Reconfiguration of the 150 KV Transmission Network Tualang Cut Substation and changes in operating patterns from the results of the ETAP (Electrical Transient Analyzer Program) simulation version 12.6.0. to reduce power losses and voltage drops after network reconciliation (Putranti & Setiono, 2014). In contrast to other studies, where the analysis of power flow in this study uses the Newton-Raphson method (Hasibuan et al., 2019) (Hasibuan et al., 2020) (Indah Permata Sari, Wahri Sunanda, 2017). This research was simulated in ETAP (Electrical Transient Analyzer Program) 12.6.0 to observe and model the maneuver process, as well as obtain data on power loss and voltage drop before and after network reconfiguration (Tanjung, 2014). This research is only on the scope of the 150 kv transmission network of Langsa-Tualang Cut Substation.

Research Methodology

A. Research Flow Chart

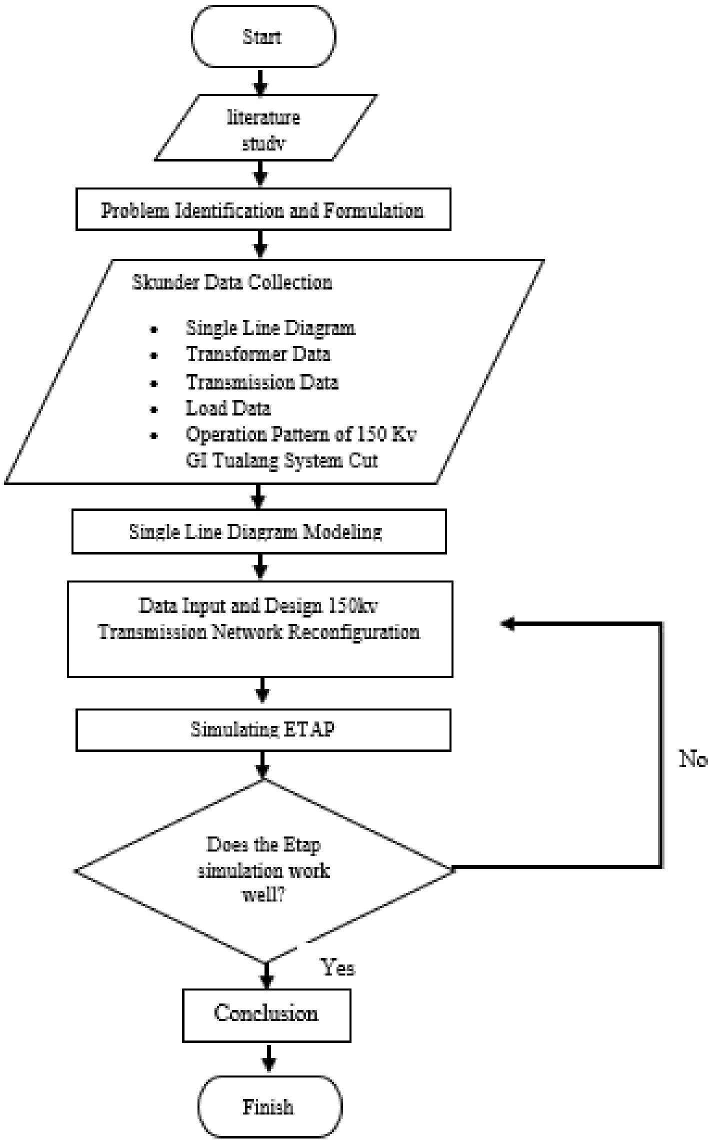

Figure 1. Research Flow Chart

B. Place And Time of Research

Data collection for research is carried out at PT. PLN (Persero) Tualang Cut Network and Substation, Manyak Payet District, Aceh Tamiang Regency, Aceh Province. While the place of research is carried out in the Electrical Engineering Laboratory, Electrical Engineering Study Program, Department of Electrical Engineering, Faculty of Engineering, Malikussaleh University. The time for this research to be carried out temporarily starts from January 2023. Within a few months of this research, several stages of research were carried out, namely the stage of preparing proposals, searching for literature studies and other reviews.

C. Data Collection

The data source is the subject of data that can be obtained from the electricity system contained in the 150 Kv transmission at the Tualang Cut Substation, namely the 150 Kv Tualang Cut transmission line with Langsa (LGS). The data needed in this study are as follows. Power source (Rahmadhani, 2018) at Induk Substation (Power gird 150Kv, incoming bus 150 Kv and frequency 50 Hz).

Table 1. Transmission Line Distance between Substations

No	Lines	Line	Conductor	Length (km)
1	Lgs–P.B	1	AC3 Lisbon 1 x 310 mm^2	78,47
2	Lgs–P.B	2	AC3 Lisbon 1 x 310 mm^2	78,47
3	Lgs–T.C	1	ACSR 1 x 240 mm^2	24,07
4	Lgs–T.C	2	ACSR 1 x 240 mm^2	24,07

Table 2. Substation Line Load Data

No	Lines	Load Data (MW)
1	Langsa – Pangkalan Brandan 1	37
2	Langsa – Pangkalan Brandan 2	38,897
3	Langsa - Tualang Cut 1	8,802
4	Langsa - Tualang Cut 2	8,802

Table 3. Substation Line Current Data

No	Lines	Flow data (kA)
1	Langsa – Pangkalan Brandan 1	145
2	Langsa – Pangkalan Brandan 2	152,4
3	Langsa - Tualang Cut 1	34,5
4	Langsa - Tualang Cut 2	34,5

D. Description of Research Variables

The variables of this study include data obtained at the time of observation on the transmission channel concerned with the study. This research data is in the form of a configuration between Langsa Substation, Tualang Cut Substation, and Pangkalan Brandan Substation.

Analysis and Discussion

A. Transmission Line Power Losses Before Reconfiguration

Analysis of transmission lines before reconfiguration is carried out by calculating power losses (Listin et al., 2021), voltage drops (Utomo & Haddin, 2019) and simulations are carried out on ETAP which will be explained in the points below.

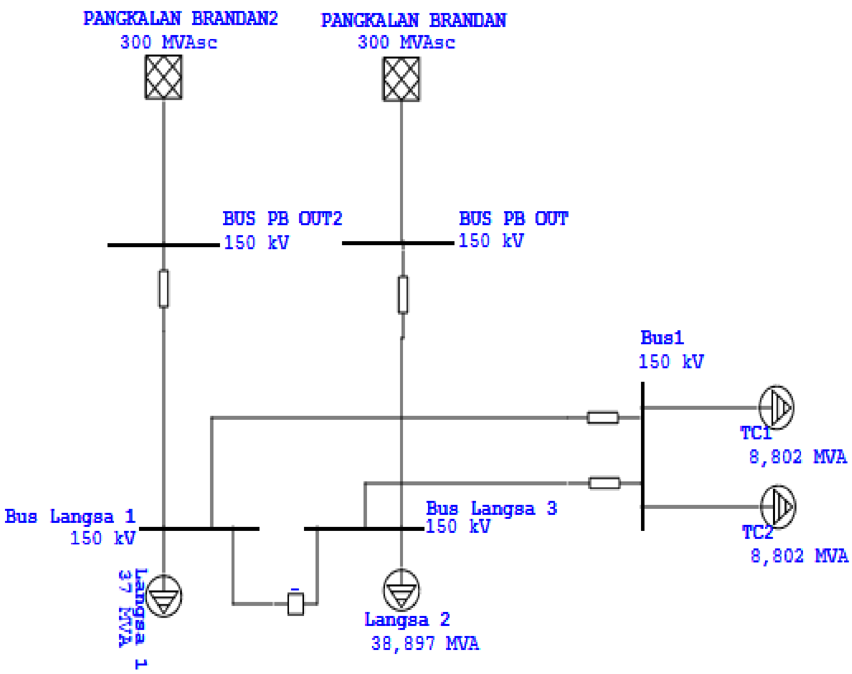

Figure 2. Transmission Line Before Reconfiguration

In figure 1.2 The Lgs-P.B channel has a length of 78,47 km and the Lgs-T.C has a length of 24,07 km, each of which has 2 channel lines directly attached to the network itself.

1) Calculation of Losses Before Reconfiguration

Table 4. Manual calculation of power losses from each transmission line

No	*Line*	Active Power (kW)
1	Langsa – Pangkalan Brandan 1	771,4142474
2	Langsa – Pangkalan Brandan 2	771,4142474
3	Langsa – Tualang Cut 1	9,884014538
4	Langsa – Tualang Cut 2	9,884014538
	Total	**1.562,597**

In table 4 above, it can be concluded that in manual calculations the smallest power loss occurs in the Langsa - Tualang Cut Line 1 and 2 channels with 9,884014538 kW, and the largest losses are found in the Langsa - Pangkalan Berandan line 1 and 2 channels of 771,4142474 kW, this is caused by several factors, namely the current flowing on the line is quite large and the length of the channel is quite long. the result of manual calculations if added together then obtained a loss value of 1.562,597 kW.

2) Voltage Drop Calculation Before Reconfiguration

Table 5. Manual Calculation of Voltage Drop Value

No	*Line*	Long (km)	*Voltage Drop* (kV)
1	Lgs - P.B 1	78,47	4,9022
2	Lgs - P.B 2	78,47	5,1524
3	Lgs – T.C 1	24,07	0,3675
4	Lgs – T.C 2	24,07	0,3675
	Total		10,78983

In table 5 above, it can be concluded that in manual calculations, the smallest Voltage Drop is found on lines 1 and 2 Langsa - Tualang Cut of 0,3675 kV, and the largest Voltage Drop is found on line 2 Langsa - Pangkalan Berandan of 5,1524 kV, this is caused by several factors such as the length of the channel that is long enough and the value of resistance and reactance on the feeder conductor itself. Total Voltage Drop of 10,78983 KV.

3) Comparison of Manual Calculations with Software Simulation

Table 6. Comparison of the value of losses on the channel

No	*Line*	Active Power (kW)	
		Manual	Software
1	Lgs - P.B 1	771,4142474	846,6
2	Lgs - P.B 2	771,4142474	846,6
3	Lgs – T.C 1	9,884014538	12,1
4	Lgs – T.C 2	9,884014538	12,1
	Total	1.562,597	1.717,4

In table 6 above, it can be concluded that in manual calculations the smallest power loss occurs in the Langsa - Tualang Cut line 1 and 2 channels with 9.884014538 kW, and the largest losses are found in the Langsa - Pangkalan Berandan line 1 and 2 channels of 771.4142474 kW, this is caused by several factors, namely the current flowing on the line is quite large and the length of the channel is quite long. Total losses on the transmission line of 150 kv if from software amounted to 1,717.4 kW, while the results of manual calculations if added together, a loss value of 1,562.597 kW was obtained, then the difference between manual calculations and software was 154,803 kW.

Table 7. Comparison of Voltage Drop Values on channels

No	*Line*	*Voltage Drop* (kV)	
		Manual	Software
1	Lgs - P.B 1	4,9022	4,38
2	Lgs - P.B 2	5,1524	4,38
3	Lgs – T.C 1	0,3675	0,33
4	Lgs – T.C 2	0,3675	0,33
	Total	10,78983	9,42

In table 7 above, it can be concluded that in manual calculations the smallest Voltage Drop occurs in the Langsa - Tualang Cut line 1 and 2 channels with a result of 0,3675 kV, and the largest Voltage Drop is found in the Langsa - Pangkalan Brandan line 2 channel of 5,1524 kV, this is caused by several factors such as a fairly long channel length and the value of reistance and reactance on the feeder conductor itself. The Total Voltage Drop on the transmission line is 150 kv if the software is 9,42 kV, while the results of manual calculations if added together, the Voltage Drop value of 10,78983 KW is obtained, then the difference between the calculation and the Software is 1,36983 kV.

B. Cable Cross-sectional Area

In the calculation above, we get the cable resistance on the transmission line (Tenda et al., 2016) that we will reconfigure, namely Berandan - Tualang Cut which has a channel length of 48,21 km using the ACCC type 3 x 310 mm^2 of 0,097 Ω / km (Azizurrohman & Fadlun, 2019) and the Tualang Cut - Langsa channel has a channel length of 24,07 km using an ACSR cable type of 3 x 240 mm^2 of 0,015 Ω / km (Catra Indra Cahyadi,Kurniaty Atmia, 2022).

C. Transmission Line After Reconfiguration

Analysis of transmission lines after reconfiguration is carried out by calculating power losses, voltage drops and simulations are carried out on ETAP which will be explained in the points below.

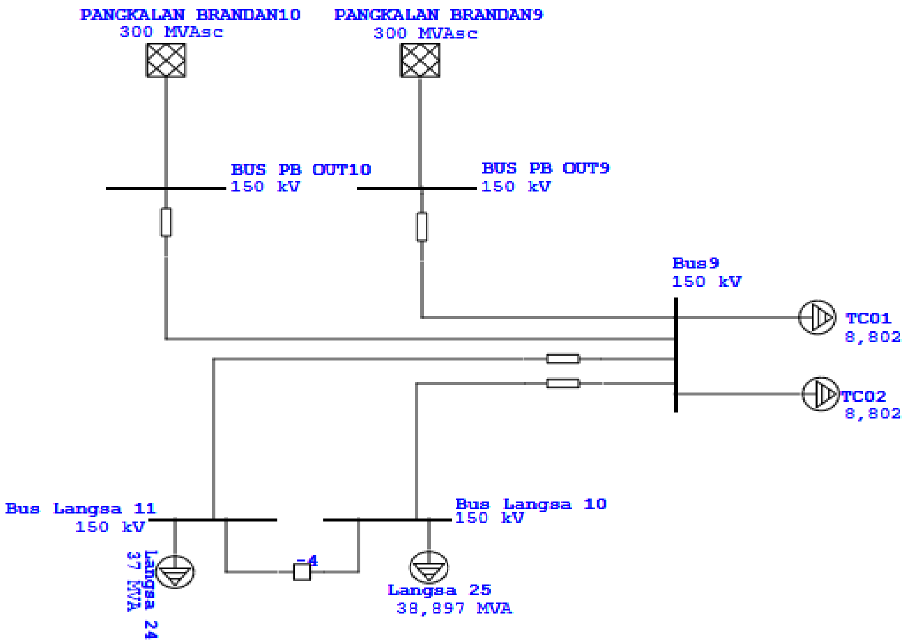

Figure 3. Transmission Line After Reconfiguration

In figure 1.3 is a way to reconfigure the Langsa – Pangkalan Brandan transmission network to Pangkalan Brandan – Tualang Cut which has a network length of 48,21 km.

1) Calculation of Losses After Reconfiguration

Table 8. Manual calculation of power loss after reconfiguration

No	*Line*	Active Power (kW) Manual
1	Pangkalan Brandan – Tualang Cut 1	460,1156668
2	Pangkalan Brandan – Tualang Cut 2	460,1156668
3	Tualang Cut – Langsa 1	208,6189323
4	Tualang Cut – Langsa 2	208,6189323
	Total	1.337,5

In table 8 above, it can be concluded that after reconfiguration in the Manual Calculation, the smallest power loss occurred in the Tualang Cut - Langsa line 1 and 2 channels with 208,6189323 kW, and the largest losses were found in the Pangkalan Brandan - Tualang Cut channel of 460,1156668 kW, the results of the simulation results if added together, the loss value of 1.337,5 kW was obtained.

2) Calculation of *Voltage Drop* After Reconfiguration

Table 9. Manual Calculation of Voltage Drop Value After Reconfiguration

No	*Line*	Long (km)	*Voltage Drop* (kV)
1	T.C – P.B 1	48,21	3,0118
2	T.C – P.B 2	48,21	3,1655
3	T.C - Lgs 1	24,07	0,3654
4	T.C - Lgs 2	24,07	0,3654
	Total		6,9081

In table 9 above, it can be concluded that after Reconfiguration in manual calculations, the smallest Voltage Drop is found on the Tualang Cut - Langsa line with 0,3654 kV, and the largest Voltage Drop is found on the Pangkalan Brandan - Tualang Cut 2 line of 3,1655 kV. Total Voltage Drop of 6,9081 kV.

D. Analysis

A transmission system is a system for distributing electricity from a power plant to distribution known as a transmission system. Conducting materials are used to conduct electric power, which then flows through a type of electrical transmission line. The transmission system provides high-voltage power that is used to reduce power loss caused by voltage drops. The distribution distance between the generating center and the load center and the amount of power that must be delivered from the generating center to the load center determine the application of the transmission system. Namely the primary voltage (150,000 Volts) and the secondary voltage (20,000 Volts).

Simulation data taken from PT. PLN (Persero) Tualang Cut Substation (Aceh Tamiang) namely Langsa - Pangkalan Brandan, Langsa - Tualang Cut transmission line to analyze the transmission network used Elektrical Transien Analiyzer program 12.6.0 (ETAP12.6.0) software which results to determine the amount of voltage drop, as well as power losses on each feeder line before reconfiguration and also after reconfiguration.

Table 10. Comparison of Manual Calculation of Voltage Drop

No	Lines	*Voltage Drop* (kV)		Difference (kV)
		Before Reconfiguration	After Reconfiguration	
1	Lgs–P.B with P.B–T.C 1	4,9022	3,0118	1,8904
2	Lgs–P.B with P.B–T.C 2	5,1524	3,1655	1,9869
3	Lgs–T.C with T.C–Lgs 1	0,3675	0,3654	0,0021
4	Lgs–T.C with T.C–Lgs 2	0,3675	0,3654	0,0021

Table 10 above is a comparison of manual calculations of voltage drop values on the Langsa-Pangkalan Berandan network both before being reconfigured and after being reconfigured, it can be seen that if channels 1 and 2 Langsa-Pangkalan Berandan are reconfigured with channels 1 and 2 Pangkalan Berandan-Tualang Cut, the voltage drop on channels 1 and 2 Pangkalan Berandan-Tualang Cut will decrease on channel 1 from 4,9022 kV to 3,0118 kV with a decrease of 1,8904 kV and on channel 2 from indigo of 5,1524 kV to 3,1655 kV with a decrease of 1,9869 kV. this also indicates that the Langsa-Pangkalan Berandan channel reconfigured to the Pangkalan Berandan – Tualang Cut channel is the best solution to reduce the voltage drop in the Langsa – Pangkalan Berandan feeder network.

In the Langsa - Tualang Cut network both before being reconfigured and after being reconfigured, it can be seen that if the Langsa-Tualang Cut channel is reconfigured with the Tualang Cut-Langsa channel, the voltage drop on the Tualang Cut-Langsa channel will increase from a value of 0.3675 kV to 0.3654 kV with an increase of 0.0021 kV. The increase that occurs due to the current flowing to the prey is very large, causing exponential changes in the current. This change occurred when the reconfiguration was carried out and it can be seen that the increased voltage drop in the Tualang Cut Substation channel leading to the Langsa Substation is not too large.

Table 11. Voltage Drop Software Simulation Comparison

No	Channels	*Voltage Drop* (kV)		Difference (kV)
		Before Reconfiguration	After Reconfiguration	
1	Lgs–P.B with P.B–T.C 1	4,38	2,94	1,44
2	Lgs–P.B with P.B–T.C 2	4,38	2,94	1,44
3	Lgs–T.C with T.C–Lgs 1	0,33	0,75	0,42
4	Lgs–T.C with T.C–Lgs 2	0,33	0,75	0,42

Table 11 above is a software simulation comparison of voltage drop values on the Langsa – Pangkalan Berandan network both before being reconfigured and after being reconfigured, it can be seen that if channels 1 and 2 Langsa – Pangkalan Berandan are reconfigured with channels 1 and 2 Pangkalan Berandan – Tualang Cut, the voltage drop on channels 1 and 2 Pangkalan Berandan – Tualang Cut will decrease from 4,38 kV to 2,94 kV with a decrease of 1,44 kV. this also indicates that the Langsa - Pangkalan Berandan channel is reconfigured to the Pangkalan Berandan - Tualang Cut channel is the best solution to reduce the voltage drop in the Langsa - Pangkalan Berandan feeder network.

In the Langsa – Tualang Cut network both before being reconfigured and after being reconfigured, it can be seen that if the Langsa – Tualang Cut line is reconfigured with the Tualang Cut – Langsa channel, the voltage drop on the Tualang Cut – Langsa line will increase from a value of 0,33 kV to 0,75 kV with an increase of 0,42 kV. The increase that occurs due to the current flowing to the prey is very large, causing exponential changes in the current. This change occurred when the reconfiguration was carried out and it can be seen that the increased voltage drop in the Tualang Cut Substation channel leading to the Langsa Substation is not too large.

Table 12. Comparison of Manual Calculation of Losses on Channels

No	Channel	Channel Losses (kW)		Difference (kW)
		Before Reconfiguration	After Reconfiguration	
1	Lgs–P.B with P.B–T.C 1	771,4142474	460,1156668	311,298581
2	Lgs-P.B with P.B–T.C 2	771,4142474	460,1156668	311,298581
3	Lgs–T.C with T.C–Lgs 1	9,884014538	208,6189323	198,734918
4	Lgs–T.C with T.C–Lgs 2	9,884014538	208,6189323	198,734918

In table 12 above is a comparison table of manual calculation of active power losses (kW) on each channel on the Langsa - Pangkalan Berandan feeder both before being reconfigured and after being reconfigured with the Pangkalan Berandan - Tualang Cut line table 1.12 shows that the decrease in losses occurred on the Langsa - Tualang Cut line, which was 460,1156668 KW, this also affects power losses before reconfiguration which is 771,4142474 kW and after reconfiguration losses decrease to 460.1156668 kW with a decrease of 311,298581 kW. This also indicates that the Lgs – P.B channel is reconfigured to the P.B – T.C channel is the best solution to reduce power losses in the Langsa – Pangkalan Berandan feeder network.

When configured and reconfigured, the power losses that occur in GI Langsa and GI Tualang Cut have significantly different values. At the configuration stage, the power losses obtained were 9,884014538 kW while after reconfiguring the power losses obtained increased to 208,6189323 kW. A significant difference occurs because the current flowing to the prey is very large, causing exponential changes in the current. This change occurred when the reconfiguration was carried out and it can be seen that power losses have increased in the Tualang Cut Substation channel leading to the Langsa Substation.

Table 13. Comparison of Software Simulation Results on Channels

No	Channel	Channel Losses (kW)		Difference (kW)
		Before Reconfiguration	After Reconfiguration	
1	Lgs–P.B with P.B–T.C 1	846,6	549,2	297,4
2	Lgs–P.B with P.B–T.C 2	846,6	549,2	297,4
3	Lgs–T.C with T.C–Lgs 1	12,1	220,8	208,7
4	Lgs–T.C with T.C–Lgs 2	12,1	220,8	208,7

In table 13 above is a comparison table of active power losses (kW) in software simulations on each channel on the Langsa – Pangkalan Berandan feeder both before being reconfigured and after being reconfigured with the Pangkalan Brandan – Tualang Cut channel. Table 1.13 shows that the decrease in losses occurred on the Langsa – Tualang Cut line, which was 549,2 kW, This also affected the power losses before the reconfiguration which was 846,6 kW and after the reconfiguration losses decreased to 549,2 kW with a decrease of 297,4 kW. this also indicates that the Langsa – Pangkalan Berandan channel reconfigured to the Pangkalan Berandan – Tualang Cut channel is the best solution to reduce power losses in the Langsa – Pangkalan Berandan feeder network.

When configured and reconfigured, the power losses that occur in GI Langsa and GI Tualang Cut have significantly different values. Which at the configuration stage, the power losses obtained were valued at 12,1 kW while after reconfiguration the power losses obtained increased to 220,8 kW. A significant difference occurs because the current flowing to the prey is very large, causing exponential changes in the current. This change occurred when the reconfiguration was carried out and it can be seen that power losses have increased in the Tualang Cut Substation channel leading to the Langsa Substation.

Conclusion

As for the analysis and discussion of this final project, we can draw several conclusions, including the following:

1. The condition of the electric power system that is currently operating at PT. PLN (Persero) Network and Tualang Cut Substation are considered less efficient in receiving power from the 150 kV SUTT interconnection. The high-voltage overhead line in Tualang Cut currently receives electrical power from the Langsa Substation with power losses on lines 1 and 2 of 771,4142474 kW and experiencing a voltage drop on lines 1 and 2 of 4,38 kV.
2. The impact that occurs if reconfiguration is carried out on the 150 kV transmission line of Tualang Cut Substation is the occurrence of technical changes in the transmission line. From the results of the reconfiguration, there was a decrease in power losses on channels 1 and 2 of 311,298581 kW which before the reconfiguration of power losses on the lines amounted to 771,4142474 kW and after reconfiguration became 460,1156668 kW and there was a voltage drop on lines 1 and 2 by 1.44 kV which before the reconfiguration dropped voltage on the line by 4,38 kV and after being reconfigured to 2,94 kV.

At the time of reconfiguration of the Langsa - Tualang Cut channel to Tualang Cut - Langsa experienced an increase in power losses (Losses) which at the configuration stage, the power losses obtained were 9,884014538 kW while after being reconfigured the power losses obtained increased to 208,6189323 kW and experienced an increase in voltage drop (Voltage Drop) which at the configuration stage, the voltage drop obtained was 0,3675 kV while after being reconfigured the voltage drop obtained increased to 0,3654 kV. A significant difference occurs because the current flowing to the prey is very large, causing exponential changes in the current. This change occurs at the time the reconfiguration is performed.

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