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The Reconfiguration of Network at 20 kV Distribution System Nagan Raya Substation with the Addition of the Krueng Isep Hydroelectric Power Plant

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A B S T R A C T

Switching substations are usually supplied from one express feeder which can cause a low level of reliability due to disruption or outage on the express feeder. Also, the lack of power supply at the ends of the network causes voltage drops. One way to solve this problem is to reconfigure the network. In this study, testing was carried out on a distribution system in the Nagan Raya Regency, namely the distribution system of PT. PLN (Persero) ULP Jeuram originally had a radial system. Furthermore, the distribution system was reconfigured with the Krueng Isep hydroelectric power plant which was included in the PLN ULP Jeuram grid so that the system that was originally radial became a loop configuration. The method used in analyzing the network reconfiguration process is to use the ETAP 12.6 application. As a result, after reconfiguring the network the voltage increased from 19.2 kV to 20.7 kV, the highest increase was at the Beutong Substation which reached 1.5 kV and decreased power losses in the network with a total of 188.2 kW and 263.1 kVAR. Furthermore, before the network reconfiguration, ULP Jeuram SAIFI value was 22.25 times/customers and SAIDI values 1337.74 minutes/ customers. However, after reconfiguring the network, ULP Jeuram SAIFI value fell to 15.39 times/customers and SAIDI to 945.6 minutes/customers, resulting in an increase in system reliability by 70.69%.

INTRODUCTION

Currently, as mandated by the Rencana Umum Energi Nasional (RUEN), the Government continues to strive to accelerate the development of new and renewable energy to achieve the target of at least 23% of the total primary energy mix by 2025. The state electricity company or PT. PLN (Persero) also participates in encouraging the use of low-carbon energy that is environmentally friendly, in particular by utilizing new and renewable energy in the supply of electrical energy. One of its main aspirations is "green".

The Aceh Provincial Government through the relevant agencies also does not remain silent about this opportunity, promoting the potential for new and renewable energy in Aceh according to data from the Dinas Pertambangan dan Energi Aceh Province of 3,978 MW from various sources including hydro, geothermal, wind, biogas and biomass, solar radiation, ocean currents and others. Of the many potential sources that exist, one of the potential sources of NRE that has been utilized is the Krueng Isep Hydroelectric Power Plant.

The Krueng Isep hydroelectric power plant is a power plant that uses hydropower potential as primary energy sourced from the water flow of the Krueng Isep river. The Krueng Isep hydroelectric power plant is located in Krueng Isep Village, Beutong District, Nagan Raya Regency with a capacity of 20 MW. Before the entry of power from the Krueng Isep hydroelectric power plant, the Unit Pelaksana Pelayanan Pelanggan (UP3) Meulaboh electricity system was supplied from the Northern Sumatra transmission system (grid) through the Nagan Raya substation and the Meulaboh substation with a medium voltage distribution of 20 kV and has several interconnected sub-systems. With the entry of power from the Krueng Isep hydroelectric power plant, the UP3 Meulaboh electricity system already has two main energy sources. The system also has several load centres. One of the load centre points that are far from the centre of the power plant and substation at UP3 Meulaboh is the Beutong Bawah and Alue Bilie areas in the Nagan Raya Regency, so that the area has a low operating voltage supply, resulting in power losses in the network.

The distribution system network is a network that connects distribution transformers with low voltage consumers or also known as low voltage networks. The network usually uses a three-phase four-wire network with an inter-phase voltage of 380

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Volts [1][2]. The distribution system network is characterized by a radial topological structure and poor stress regulation. In the radial distribution network, substations are used to serve many loads through several feeders, where each feeder is not interconnected. The weakness is that the continuity of service is not good, because if there is a disturbance in the feeder which results in damage, all connected loads are not served [3][4]. Furthermore, the weakness in the radial system can be overcome by using a loop system that is connected between feeders close to each other. If there is a disturbance in one of the feeders, the load can be transferred to another adjacent feeder by opening/closing the separator switch [5][6]. Therefore, it is necessary to reconfigure the network in the distribution system to minimize the duration and frequency of service interruptions, to reduce voltage drop, power losses and increase system reliability [7][8][9]. Distribution network reconfiguration is to create a distribution network operating mode by having several feeders and buses on the distribution network [10][11].

There has been a lot of research done on reconfiguring distribution system networks. Research [12] describes a simple reconfiguration method to minimize power losses in an unbalanced radial distribution system. In research [13][14], reconfiguration was carried out by assuming that the distribution network is equipped with switches that can be operated remotely. Furthermore, other studies to improve the quality of network reconfiguration power is also carried out by placing capacitors [15][16].

Based on the background problems in the Nagan Raya distribution system network and some of the results of the review, with the addition of the Krueng Isep hydroelectric power plant, the author wants to get the number of power losses, voltage drop, SAIDI and SAIFI from the results of reconfiguring the distribution system network of the Nagan Raya substation and to determine the effect of the network reconfiguration on the value of the existing voltage at the Beutong substation.

METHOD

In this study, the location taken for network reconfiguration planning is at the PLN UP3 Meulaboh radial system feeder, Unit Pelayanan Pelanggan (ULP) Jeuram located at Simpang Peut, Nagan Raya Regency. At ULP Jeuram itself, it is divided into 6 (six) working areas, namely Simpang Peut, Jeuram, Beutong Bawah, Beutong Ateuh, Langkak, and Alue Bilie work areas, all of which are part of Nagan Raya.

Research Flowchart

This research was conducted using simulation using ETAP 12.6 software. The first step is to start the stages by collecting data in the form of data on generators, transformers, distribution channels, and loads. Modelling the electric power system using ETAP 12.6 software. The ETAP program is software that is used for power systems that work based on planning [17]. ETAP software can also depict a one-line diagram graphically and analyze power flow (load flow), short circuit, motor starting, harmonics power system, transient stability, and protective device coordination [18].

Next, perform a single line simulation to determine the power flow in the radial network of the Nagan Raya distribution system before the addition of the Krueng Isep hydroelectric power plant and to determine the power flow in the reconfiguration of the Nagan Raya distribution system network after the addition of the Krueng Isep hydroelectric power plant. Then the data is tested in the form of simulation results whether it is appropriate or not with the exiting state. If the results are appropriate, the next step is an analysis by comparing the simulation results of the Nagan Raya radial distribution system with the network that has been reconfigured for power losses, voltage drop, and system reliability. The complete research flow chart is shown in Figure 1.

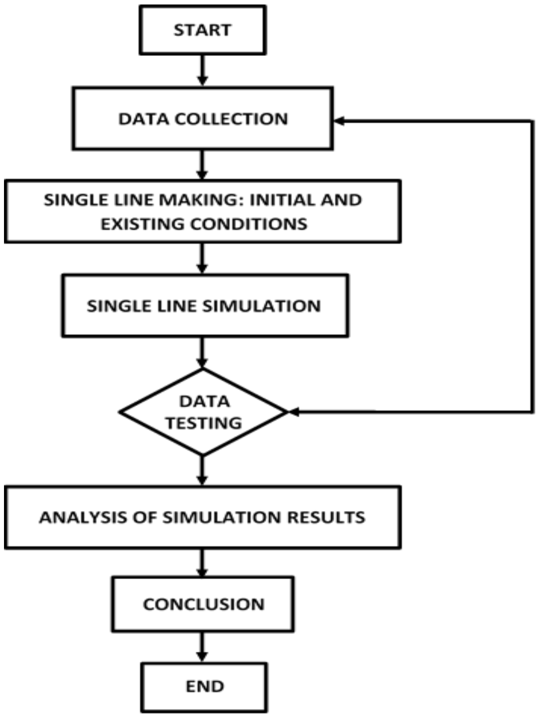

Figure 1. Research Flow Chart

In this study, the system reliability index used is SAIDI and SAIFI. The index was chosen because it focuses more on customers, the frequency of blackouts, and the duration of power outages in the 20 kV distribution system of the GI. Nagan Raya.

SAIDI

SAIDI is an indicator of the average duration of a permanent blackout (>5 minutes) felt by the customer at a certain service unit during a certain period of time, which is calculated in units (minutes/customer). For performance monitoring, the unit of calculation period can be done every month, quarter, semester and yearly. The SAIDI formula used is as follows [19][20][21]:

$$\text{SAIDI} = \frac{\sum_{n}^{i}\left(\delta_i x N_i\right)}{N_t} \quad (1)$$

where:

i = Outages to i

n = Number of outages

δi = Length (duration) of interruption to i

Ni = Number of customers outages to i

Nt = Total customers in one service unit

SAIFI

SAIFI is an indicator of the frequency of permanent power outages (>5 minutes) in a certain service unit, which is calculated in units (times/customer). The SAIFI formula used is as follows [19][20][21]:

$$\text{SAIDI} = \frac{\sum_{n}^{i} (\lambda_i x N_i)}{N_t} \quad (2)$$

where:

i = Outages to i
n = Number of outages
λi = Outages to i
Ni = Number of customers outages to i
Nt = Total customers in one service unit

RESULTS AND DISCUSSION

In this study, to obtain precise analysis results on the effect of the network reconfiguration system, the authors performed a power flow simulation before and after the network reconfiguration using the Electrical Transient Analyzer Program (ETAP) application.

Power Flow Simulation before Reconfiguration

A one-line diagram of the ULP Jeuram distribution system before reconfiguration is shown in Figure 2.

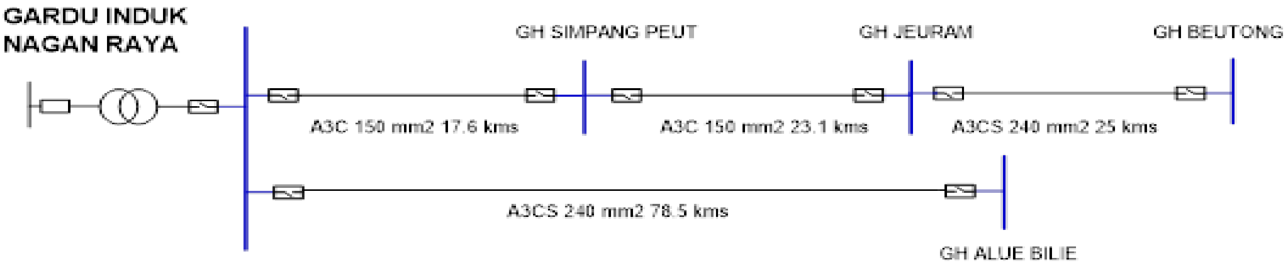

Figure 2. One-Line Diagram of the ULP Jeuram Distribution System before Reconfiguration

In Figure 2, the ULP Jeuram distribution system consisting of GH. Simpang Peut, GH. Jeuram, GH. Beutong, and GH. Alue Bilie is only supplied from one express feeder, causing power losses and voltage drop so that the quality of the voltage received by customers in the Beutong area is reduced. This is inseparable from the length of the medium voltage network from the GI. Nagan Raya to customers in the Beutong area which reaches 109.3 kms. Furthermore, the ULP Jeuram distribution system before reconfiguration was simulated using ETAP software to determine power losses, voltage drop, and system reliability. The ULP Jeuram power flow simulation before complete reconfiguration is shown in Figure 3.

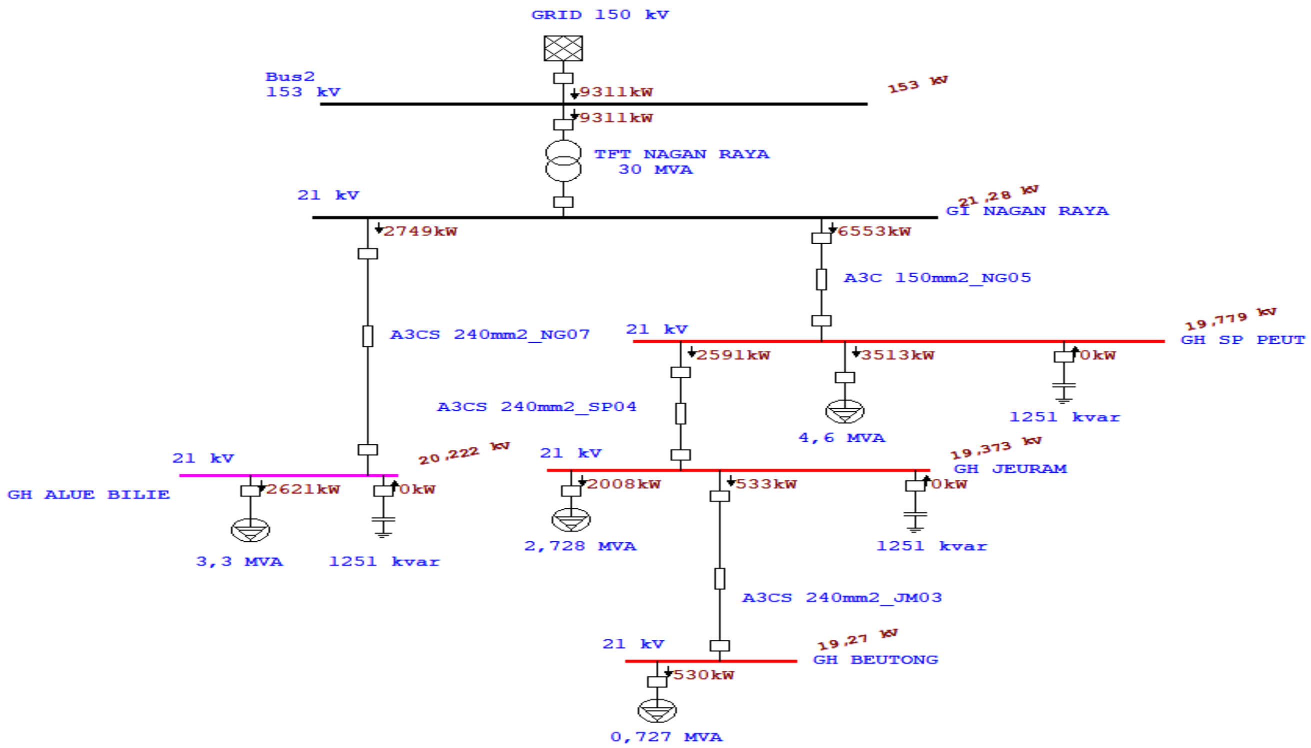

Figure 3. Simulation of the ULP Jeuram Power Flow before Reconfiguration

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At this stage, testing is carried out to determine the effect of system configuration on power losses, voltage drop, and system reliability. The results of the simulation of power flow in the ULP Jeuram electric power distribution system before the addition of the Krueng Isep hydroelectric power plant (reconfiguration), can be seen in Figure 3 that the system still has a radial configuration. This configuration has an impact on the low value of the voltage at the end of the network and the lack of system reliability in the event of a disturbance in one of the express feeders. The results of operating voltage efficiency before complete reconfiguration are shown in Table 1.

Table 1. Operating voltage efficiency before reconfiguration

Substation (GH)	Voltage Limit (kV)	Operating Voltage (kV)	η Operating (%)
GH. Beutong	21	19,2	91,8
GH. Jeuram	21	19,3	92,3
GH. Sp. Peut	21	19,7	94,2
GH. Alue Bilie	21	20.2	96,3

Based on the results of the power flow analysis using the ETAP 12.6 application (Table 1), it shows that the value of the operating voltage on the GH. Beutong is 19.2 kV with an operating efficiency of 91.8%. At GH. Jeuram the value of the operating voltage is 19.3 kV with an operating efficiency of 92.3%, at GH. Sp. Peut operating voltage value is 19.7 kV with an operating efficiency of 94.2%. Next on GH. Alue Bilie received an operating voltage is 20.2 kV with an operating efficiency of 96.3%. So, the average value of operating voltage on the radial configuration of ULP Jeuram is 19.6 kV with an average operating efficiency of 93.65%. This value is almost close to the standardized voltage limit of 21 kV. The impact resulting from all low operating voltage values is that it can cause power losses in the network so that the power supply to consumers is not optimal. These conditions can also result in customers who are on GH. Beutong often experiences voltage flicker, especially at peak load times. This is due to GH. Beutong is located at the very end of the network.The results of the recapitulation of power losses and voltage drop on the system network before reconfiguration are shown in Table 2.

Table 2. Recapitulation of Power Losses and Voltage Drop (Vd) on the System Network before Reconfiguration

System Network (Express Feeder)	Power From-To Bus		Power To-From Bus		Losses		Bus Voltage (%)		Vd
	MW	MVAR	MW	MVAR	kW	kVAR	From	To	(%)
TFT Nagan Raya	9,311	2,709	-9,302	-2,317	8,7	391,7	100,0	101,3	1,33
A3CS 240mm2_NG07	-2,621	-0,465	2,749	0,539	127,6	74,9	96,3	101,3	5,04
A3CS 240mm2_JM03	-0,530	-0,329	0,533	0,330	2,9	1,7	91,8	92,3	0,49
A3CS 240mm2_SP04	-2,541	-0,510	2,591	0,539	49,4	29,0	92,3	94,2	1,93
A3C 150mm2_NG05	-6,103	-1,606	6,553	1,778	449,9	171,4	94,2	101,3	7,15
Total					638,6	668,7			

From Table 2 it can be seen that the amount of power losses generated in the ULP Jeuram distribution system network (express feeder) is relatively high, with total of 638.6 kW and 668.7 kVAR. The table also shows that the express feeder (A3CS 240mm2_NG07) and (A3C 150mm2_NG05) have larger voltage drop compared to the other express feeders, which are 5.04% and 7.15%, respectively. Furthermore, for recapitulation of the total load on the ULP Jeuram bus, it can be seen in Table 3.

Table 3. Recapitulation of the Total Load on the ULP Jeuram Distribution System before Reconfiguration

Bus and Substation	Voltage (kV)	Directly Connected Load				Total Load on Bus		
		Constant kVA		Constant Z				
		MW	MVAR	MW	MVAR	MVA	Cos ϕ	I (Amp)
Bus2	153	0	0	0	0	9,697	0,96	36,6
GH. Alue Bilie	21	0,281	0,174	2,341	0,291	3,084	0,85	88,1
GH. Beutong	21	0,062	0,038	0,469	0,290	0,624	0,85	18,7
GH. Jeuram	21	0,232	0,144	1,776	0,036	2,990	0,85	89,1
GH. Sp. Peut	21	0,391	0,242	3,122	0,825	6,680	0,914	195,0
GI. Nagan Raya	21	0	0	0	0	9,587	0,97	260,1

Table 3 shows that the total load on the ULP Jeuram distribution system varies widely. This is influenced by a large number of customers from each substation. The highest total load is on Bus 2 and GI. Nagan Raya is respectively 9.697 MVA with a power factor of 0.96 and 9.587 MVA with a power factor of 0.97. Furthermore, the lowest total load is found in GH. Beutong is 0.624 MVA with a power factor of 0.85. Low load on GH. Beutong is caused by the not yet dense population inhabiting the area so that the amount of customer power consumption is also still small.

Power Flow Simulation after Reconfiguration

At this stage, testing is carried out to determine the effect of network reconfiguration on power losses, voltage drop, and reliability of the ULP Jeuram distribution system. One-line diagram of ULP Jeuram distribution system after reconfiguration is shown in Figure 4.

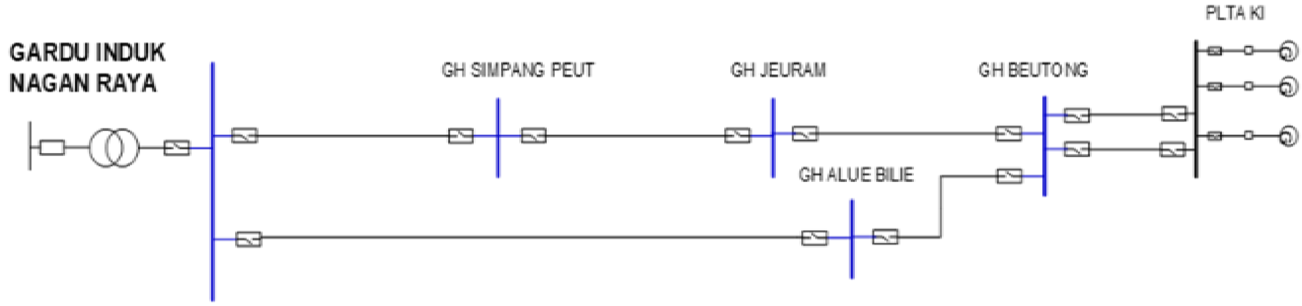

Figure 4. One-line Diagram of ULP Jeuram Distribution System after Reconfiguration

Furthermore, after reconfiguration, the ULP Jeuram electric power distribution system was simulated to see power losses, voltage drop, and system reliability. This system already has a loop configuration due to the addition of the Krueng Isep hydroelectric power plant so that it has an impact on improving the voltage value, especially at locations that were previously located at the end of the radial configuration. The addition of the Krueng Isep hydroelectric power plant also causes the ULP Jeuram power distribution system to have two incoming feeders so that it can increase system reliability in the event of a disturbance in one of the express feeders. The ULP Jeuram power flow simulation after reconfiguration is shown in Figure 5.

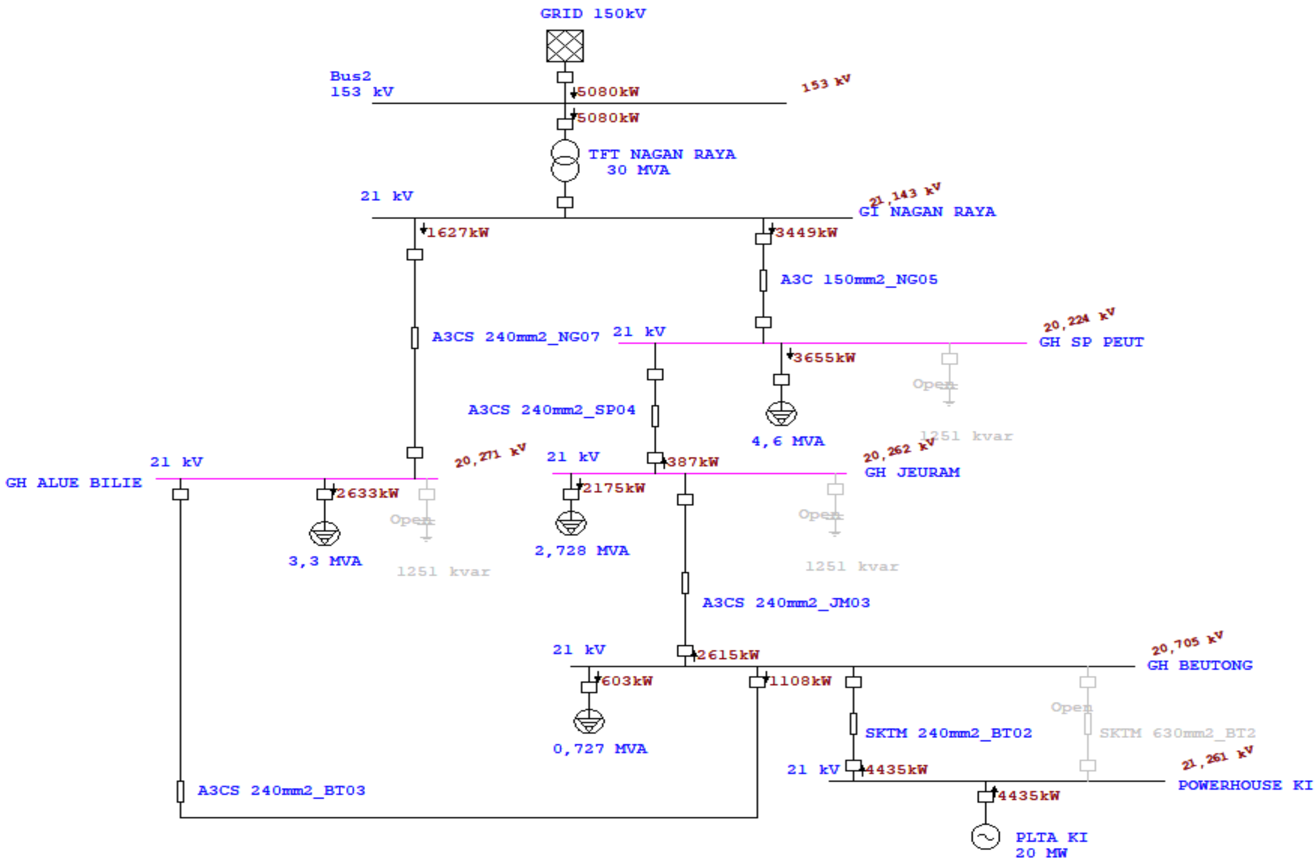

Figure 5. Simulation of the ULP Jeuram Power Flow after Reconfiguration

Figure 5 shows that the system of the Krueng Isep hydroelectric power plant is connected to the 20 kV GI. Nagan Raya system through two incoming feeders, namely BT-01 and BT-02 located at GH. Beutong. GH. Beutong was initially only supplied from one express feeder, namely JM-03. Since the interconnection system has become more reliable because it has another express feeder connected to GH. Alue Bilie, namely BT-03. The results of operating voltage efficiency after complete reconfiguration are shown in Table 4.

Table 4. Operating Voltage Efficiency after Reconfiguration

Substation (GH)	Voltage Limit (kV)	Operating Voltage (kV)	η Operating (%)
GH. Beutong	21	20,705	98,5
GH. Jeuram	21	20,262	96,5
GH. Sp. Peut	21	20,224	96,3
GH. Alue Bilie	21	20.271	96,5

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Table 4 shows that the value of the operating voltage on GH. Beutong is 20.7 kV with an operating efficiency of 98.5%. This result has increased when compared to the results before reconfiguration of the distribution system network, which is 1.5 kV. Furthermore, with the reconfiguration, during peak load conditions it does not require the installation of capacitors to operate so that it can economically reduce operational costs in the ULP Jeuram power distribution system. At GH. Jeuram, GH. Sp. Peut, and GH. Alue Bilie operating voltage tends to be more stable which is about 20.2 kV each with an efficiency of 96.3% to 96.5%. The influence of the reconfiguration of the ULP Jeuram electricity distribution network system, especially on power losses and voltage drops that arise in the network. The results of the recapitulation of power losses and voltage drop on the distribution system network after complete reconfiguration are shown in Table 5.

Table 5. Recapitulation of Power Losses and Voltage Drop (Vd) on the System Network after Reconfiguration

System Network (Express Feeder)	Power From-To Bus		Power To-From Bus		Losses		Bus Voltage (%)		Vd
	MW	MVAR	MW	MVAR	kW	kVAR	From	To	(%)
TFT Nagan Raya	5,080	4,195	-5,076	-4,014	4,0	180,8	100,0	100,7	0,68
A3CS 240 mm2_BTO3	-1,086	-0,180	1,108	0,193	21,7	12,7	95,5	98,6	2,06
A3CS 240 mm2_NG07	-1,547	-1,452	1,627	1,499	80,6	47,3	96,5	100,7	4,15
A3CS 240 mm2_JM03	2,615	1,198	-2,562	-1,167	53,3	31,3	98,6	101,2	2,65
A3CS 240 mm2_SP04	0,387	-0,181	-0,386	0,182	1,2	0,7	96,5	96,3	0,18
A3C 150 mm2_NG05	-3,269	-2,447	3,449	2,515	180,1	68,6	96,3	100,7	4,38
Total					450,4	405,6			

The results in Table 5 show that there are improvements to the power losses that arise in the system network, namely 450.4 kW and 405.6 kVAR. This is influenced by the reconfiguration performed on the distribution system network. So, if these results are compared with the results before the reconfiguration of the 20 kV distribution system network at GI Nagan Raya, then these results indicate that it can improve power losses of 188.2 kW and 263.1 kVAR.. Furthermore, in Table 5 it can also be seen that in the express feeder (A3CS 240 mm2_NG07) and (A3C 150 mm2_NG05), the resulting voltage drop is also smaller than before the reconfiguration, which is 4.15% and 4.38%, respectively. The lowest voltage drop is found in the express feeder (A3CS 240 mm2_SP04) and (TFT Nagan Raya), which are 0.18% and 0.68%, respectively. Furthermore, the results of the recapitulation of the total load on the ULP Jeuram distribution system after complete reconfiguration are shown in Table 6.

Table 6. Recapitulation of the Total Load on the ULP Jeuram Distribution System after Reconfiguration

Bus and Substation	Voltage (kV)	Directly Connected Load				Total Load on Bus		
		Constant kVA		Constant Z				
		MW	MVAR	MW	MVAR	MVA	Cos ϕ	I (Amp)
Bus2	153	0	0	0	0	6,588	0,771	24,9
GH. Alue Bilie	21	0,281	0,174	2,352	0,458	3,097	0,85	88,2
GH. Beutong	21	0,062	0,038	0,541	0,335	4,672	0,926	130,3
GH. Jeuram	21	0,232	0,144	1,943	1,204	2,895	0,885	82,5
GH. Sp. Peut	21	0,391	0,242	3,264	2,023	4,398	0,831	125,6
GI. Nagan Raya	21	0	0	0	0	6,472	0,784	176,7
Power House KI	21	0	0	0	0	4,797	0,925	130,3

From Table 6, the results of the recapitulation of the total load on the Jeuram ULP distribution system after reconfiguration shows that the highest total load is on Bus 2 and GI Nagan Raya, which are 6.588 MVA with a power factor of 0.771 and 6.472 MVA with a power factor of 0.784. Furthermore, for the lowest total load, GH Jeuram is 2.895 MVA with a power factor of 0.885. So, it can be concluded that the reconfiguration of the system network at ULP Jeuram, namely by adding the Krueng Isep hydroelectric power plant, can have a positive impact on network reliability, voltage improvement, and power losses in the Nagan Raya distribution system network.

The Effect of Reconfiguration of the Nagan Raya Distribution Network on Reliability

The ULP Jeuram system which has a radial configuration has the potential to be widely extinguished if there is a disturbance in one of the express feeders. This is because the electricity supply is only supplied from one source, namely the GI. Nagan Raya.

So, with the addition of the Krueng Isep hydroelectric power plant, the ULP Jeuram system has a loop configuration so that if there is a disturbance in one of the express feeders, it does not cause widespread outages in the GH at ULP Jeuram. In this study to determine the level of reliability, the disturbance data taken is data before network reconfiguration, namely data disturbances that occurred during 2019 and disturbance data after network reconfiguration, namely data disturbances that occurred during 2020. The number of blackouts due to disturbances in the express feeder is shown in Table 7.

Table 7. Number of Blackouts Due to Disturbances in Express Feeders

No	Feeders	Number of Disturbances	Outage Duration (Minutes)	Number of Outages	Duration x Number of Outages (Minutes)	Average Load (kW)	Energy Not Served (kWh)
1	NG 05/Exp. SP Peut	18	217	21865	4744705	4633	16756,02
2	SP 04/Exp. Jeuram	6	61	11796	719556	2092	2126,87
3	JM 08/Exp. Beutong	68	1057	5166	5460462	592	10429,07
4	NG 07/Exp. Alue Bilie	19	134	6890	923260	3346	7472,73
	Total	111			11.847.983		36784,69

Table 7 shows that the number of blackouts due to disturbances at express feeders (NG-05, SP-04, JM-08, and NG-07) during 2019 was 111 times. This has an impact on customer outages with a total duration multiplied by the number of customer outages of 11,847,983 minutes, and total energy not served of 36,784.69 kWh due to the absence of a backup electrical energy source if one express feeder is disturbed. So, for the reliability index of the Nagan Raya distribution system based on the comparison of the SAIDI and SAIFI ULP Jeuram index values, it can be determined by calculation.

Calculation of SAIDI and SAIFI Index Values in 2019

Based on data from the Aplikasi Pengaduan dan Keluhan Terpadu (APKT) of PLN Meulaboh, it is known that the total ULP Jeuram customers are 49556 customers, the number of interruptions in 1 (one) year is 681 times, and the length of outage in 1 (one) year is 477.52 hours.

So, the number of permanent customer outages in 1 (one) year is:

$$= \left(\sum_{n}^{i} \left(\lambda_i x N_i \right) \right)$$

= 1102934 (customers outage)

The number of permanent costumer outages in 1 (one) year are:

$$= \left(\sum_{n}^{i} \left(\delta_i x N_i \right) \right)$$

= 1105102,95 (hours/customers)

Then, based on equations (1) and (2), the SAIDI and SAIFI index values can be calculated as follows:

a. $\text{SAIDI} = \dfrac{\sum_n^i \left(\delta_i x N_i \right)}{N_t}$

$\text{SAIDI} = \dfrac{1105102{,}95}{49556}$

= 22,3 hours/customers

= 1337,74 minutes/customer

b. $\text{SAIFI} = \dfrac{\sum_n^i \left(\lambda_i x N_i \right)}{N_t}$

$\text{SAIFI} = \dfrac{1102934}{49556}$

= 22,25 times/customers

Calculation of SAIDI and SAIFI Index Values in 2020

Based on data from the Aplikasi Pengaduan dan Keluhan Terpadu (APKT) of PLN Meulaboh, it is known that the total ULP Jeuram customers are 51331 customers, the number of interruptions in 1 (one) year is 1171 times, and the length of outage in 1 (one) year is 649.93 hours.

So, the number of permanent customer outages in 1 (one) year is:

$$= \left(\sum_{n}^{i} \left(\lambda_i x N_i \right) \right)$$

= 789792 (customers outage)

The number of permanent costumer outages in 1 (one) year are:

$$= \left(\sum_{n}^{i} \left(\delta_i x N_i \right) \right)$$

= 808975,68 (hours/customers)

Then, based on equations (1) and (2), the SAIDI and SAIFI index values can be calculated as follows:

a. $\text{SAIDI} = \dfrac{\sum_n^i \left(\delta_i x N_i \right)}{N_t}$

$\text{SAIDI} = \dfrac{808975{,}68}{51331}$

= 15,76 hours/customers

= 945,6 minutes/customer

b. $\text{SAIFI} = \dfrac{\sum_n^i \left(\lambda_i x N_i \right)}{N_t}$

$\text{SAIFI} = \dfrac{789792}{51331}$

= 15,39 times/customers

For the reliability index of the Nagan Raya distribution system based on the comparison of the SAIDI and SAIFI ULP Jeuram index values, it can be seen in Table 8 below:

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Table 8. SAIDI and SAIFI Index Values on ULP Jeuram before and after Reconfiguration

No	Index	Before and After Reconfiguration		Achievement (%)
		Year 2019	Year 2020	
1	SAIFI (Times/cst)	22,25	15,39	69,17 %
2	SAIDI (Minutes/cst)	1337,74	945,6	70,69 %

Table 8 shows that in 2019, the SAIFI ULP Jeuram index value was 22.25 times/customer and the SAIDI index value was 1337.74 minutes/customer. In 2020, the value of SAIFI ULP Jeuram fell to 15.39 times/customer and SAIDI to 945.6 minutes/customer. This is directly proportional to the reconfiguration of the Nagan Raya distribution network at ULP Jeuram. So, it can be concluded that based on the SAIFI and SAIDI index values, after the addition of the Krueng Isep hydroelectric power plant, it can increase the reliability of the Nagan Raya distribution system.

CONCLUSIONS

From the results of the study, it can be concluded that the reconfiguration of the Nagan Raya distribution system network can have a positive impact on the 20 kV distribution network at ULP Jeuram because with the addition of the Krueng Isep hydroelectric power system to the 20 kV GI Nagan Raya system, then the reconfiguration of the Nagan Raya distribution network changes shape which initially had a radial configuration changed to a loop configuration. Before network reconfiguration, the voltage at the end of the low-voltage distribution network in the Beutong area was 19.2 kV. However, after reconfiguring the network, the voltage increased to 20.7 kV. Furthermore, there was an improvement in the voltage across all substations at ULP Jeuram, with the highest increase being at the Beutong substation, which reached 1.5 kV and a decrease in power losses in the network with a total of 188.2 kW and 263.1 kVAR. Network reconfiguration can also minimize the number and duration of outages on the customer side and financial losses for the company due to unsold energy in the event of a disruption to the express feeder. In 2019, the SAIFI ULP Jeuram index value was 22.25 times/customer and the SAIDI value was 1337.74 minutes/customer while in 2020, the SAIFI ULP Jeuram index value fell to 15.39 times/customer and SAIDI to 945.6 minutes/customer.

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