THE STUDY OF THE LOAD FLOW AFTER THE ADDITION OF MOUTONG'S MAIN SUBSTATION IN THE ISOLATED SYSTEM OF KOTARAYA

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***Abstract* - PT. PLN (Persero) UP3 Tolitoli consists of four customer service units, namely ULP Leok, ULP Bangkir, ULP Moutong, and ULP Kotaraya. The electricity supply in ULP Kotaraya comes from an isolated system supported by PLTD Kotaraya, PLTD Tomini, and PLTD Palasa. During the dry season from September to November 2023, the power deficit at the power plants reached 950 kW, causing rolling blackouts. In order to overcome this problem, PLN UP3 Tolitoli plans to build a substation near Ongka Malino District to supply the Kotaraya system, which will improve flexibility and customer satisfaction. This study aims to implement the system condition through system testing based on the design of the Kotaraya isolated system after the operation of the Moutong Substation using software. The results of this study show that after the Moutong Substation operates, the functions of PLTD Kotaraya and PLTD Palasa change into voltage controllers, resulting in a power system with medium-voltage busbar voltage values that are more stable based on the standards used by PLN, with a nominal range of +5% and -10% against 20 kV.**

Keywords- Isolated System , New Main Substation , Load Flow

I. Introduction

Electrical energy is a secondary form of energy that is very important for human life, so the demand for electricity continues to increase and must be supported with good quality [5].

ULP Kotaraya is supplied by the Kotaraya–Moutong interconnection system through a medium-voltage overhead line (MVOL) stretching 315.367 km with a power capacity of 12,255 kVA distributed to 235 distribution substations. It serves around ±27,364 customers across Ongka District, Mepanga District, Tomini District, Palasa District, and Tinombo District. However, the electricity supply of the Kotaraya system comes from the Kotaraya isolated system, which is a stand-alone or separated system, disconnected from transmission and supplying power from its own generating units. The Kotaraya isolated system at ULP Kotaraya is supported by several power plants, namely PLTD Kotaraya with a maximum capacity of 2,650 kW, PLTD Tomini with a maximum capacity of 2,000 kW, and PLTD Palasa with a maximum capacity of 1,050 kW [1].

Under these system conditions, combined with the impact of the prolonged dry season from September to November 2023, a generation capacity deficit occurred, forcing rolling blackouts [2]. Therefore, PLN UP3 Tolitoli plans to build a centralized substation in Moutong to supply the Kotaraya–Moutong interconnection system. This substation will provide greater flexibility in electricity supply, thereby increasing customer satisfaction at ULP Kotaraya. The construction of this new substation will change the operating pattern of the existing power system.

The functions of the main substation include:

1. As a center for receiving and distributing electrical power according to demand at different voltages (stepping down or stepping up system voltage). The power may come from a generating unit or another substation.
2. As a measurement, operational monitoring, and system security control (disconnecting or connecting the network).
3. As a power regulator to other substations via high-voltage lines and to distribution substations via medium-voltage feeders (serving loads around the substation) [4].

Power flow studies are a method used to obtain information about active power, reactive power, voltage, current, and power factor in a power network. The main purpose is to represent the performance and

flow of active and reactive power under certain conditions in the system operating in steady-state balance, as well as to improve the system's voltage profile [6]. Because manual power flow calculations are quite complex, software is used as an analytical tool. Electrical power will always flow toward the load, which is why it is also referred to as power flow.

Power flow studies are also used for planning the development of power systems and evaluating the condition of electrical systems within the network. This study is crucial to ensure that the power system can operate optimally, efficiently, and reliably [5].

II. Research methodology

A. Method

The general location of activities has been carried out at PT. PLN (Persero) ULP Kotaraya , Jalan Trans Sulawesi Kotaraya Village, District Mepanga, Parigi Moutong Regency, Central Sulawesi Province. This research began in November 2023 and lasted until January 2024.

The research procedure can be detailed as follows:

1. Collecting Kotaraya system data in the form of feeder single line diagrams, line lengths, and loads.
2. Designing the Kotaraya isolated system after the operation of the Moutong Substation.
3. Simulating the system based on the design of the Kotaraya isolated system after the operation of the Moutong Substation using software.
4. Preparing a report on the changes in the operating pattern after the construction of the Moutong Substation and its impact on feeder protection coordination in the Kotaraya isolated system.

B. Figures and Tables

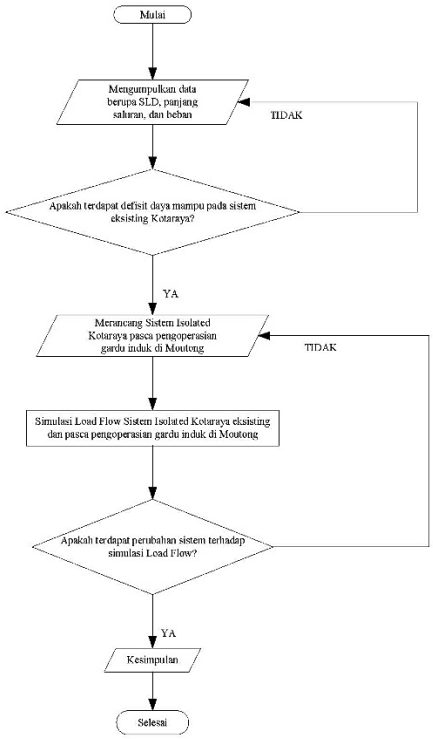

Figure 1. Research *Flowchart*

The data collected will be analyzed through simulation of the single line diagram of the Kotaraya isolated system after the operation of the new substation using software. Data analysis is the core of this research since the conclusions and evaluations will be drawn from the system simulation results for the Kotaraya isolated system after changes in the operating pattern.

III. Results and Discussion

The power system at ULP Kotaraya receives electricity supply from two Diesel Power Plants (PLTD), one Microhydro Power Plant (PLTM), and is also equipped with one Switching Substation (GH). The operating generating units include: PLTD Kotaraya with 8 installed units, of which only 5 units are operating with a total capacity of 5,000 kW, PLTD Palasa consists of 3 rented units with a total capacity of 1,050 kW, PLTM Tomini which has 2 units capable of producing up to 2,000 kW during the rainy season [1].

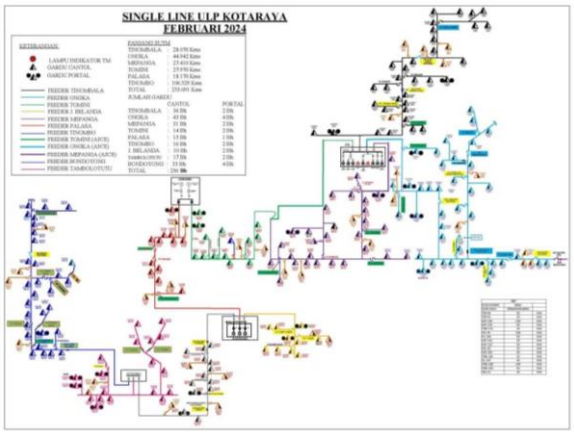

Figure 2. *Single Line Diagram* of the System Kotaraya
* Source : PT. PLN (Persero) ULP Kotaraya

The machine data for PLTD Kotaraya, PLTM Tomini, and PLTD Palasa are shown in Tables 1, 2, and 3.

Table 1. Kotaraya PLTD Machine Data

NO.	NAMA SENTRAL PLTD	NO.URUT MESIN	RATING DAYA MAMPU (kW)	STATUS
1	PLTD KOTARAYA	1	1.000	*AKTIF*
2	PLTD KOTARAYA	2	1.000	*AKTIF*
3	PLTD KOTARAYA	3	1.000	*AKTIF*
4	PLTD KOTARAYA	4	1.000	TIDAK AKTIF
5	PLTD KOTARAYA	5	1.000	*AKTIF*
6	PLTD KOTARAYA	7	1.000	TIDAK AKTIF
7	PLTD KOTARAYA	8	1.000	TIDAK AKTIF
8	PLTD KOTARAYA	10	1.000	*AKTIF*

Table 2. Tomini PLTM Machine Data

NO.	NAMA SENTRAL PLTM	NO.URUT MESIN	RATING DAYA MAMPU (kW)	STATUS
1	PLTM TOMINI	1	1.000	*AKTIF*
2	PLTM TOMINI	2	1.000	*AKTIF*

Table 3. Palasa PLTD Engine Data

NO.	NAMA SENTRAL PLTD	NO.URUT MESIN	RATING DAYA MAMPU (kW)	STATUS
1	PLTD PALASA	1	350	*AKTIF*
2	PLTD PALASA	2	350	*AKTIF*
3	PLTD PALASA	3	350	*AKTIF*

In the existing condition, the generating units PLTD Kotaraya and PLTD Palasa operate in swing mode, where their main function is to supply power flow to the electrical system while maintaining voltage angle stability at the 20 kV medium-voltage network within a tolerance of –10% to +5% from the nominal value, in accordance with SNI 04-0225-2000 applied by PT PLN (Persero). Meanwhile, PLTM Tomini operates as a voltage control unit, playing a role in regulating and controlling system voltage to minimize the risk of undervoltage.

Power flow analysis on the Kotaraya isolated system was carried out based on this actual condition, i.e., before the addition of the planned Moutong Substation, which is expected to be connected to the Ongka feeder.

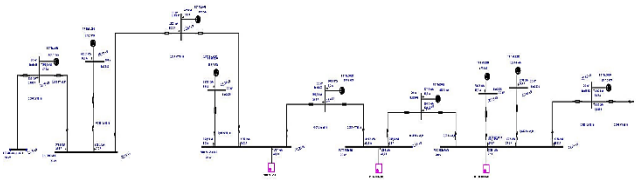

Figure 3. *Load Flow Simulation of Kotaraya System in Existing Condition (using software)*

Table 4. Simulation Results of Kotaraya Isolated System

No.	PLTD dan GH	Tegangan (kV)	Arus (A)	Daya Aktif (kW)	Tegangan busbar terhadap tegangan nominal
1	PLTD KOTARAYA	21,24	77	2.283	106%
2	PLTM TOMINI	21,55	42,70	1.593	107,7%
3	PLTD PALASA	21,33	48,40	1.292	106,6%
4	GH TINOMBO	20,15	-	-	100,8%

Based on the information in Table 1, the average voltage at the PLTD Kotaraya, PLTD Palasa, and PLTM Tomini busbars was recorded at above 21 kV, while the GH Tinombo busbar remained within the ideal range, close to the nominal 20 kV voltage. From the calculations, only the GH Tinombo busbar was considered safe with a percentage of 100.8%, while the average voltage percentage at the PLTD Kotaraya, PLTD Palasa, and PLTM Tomini busbars reached 106.6%. This condition indicates that voltage magnitude control requires special attention in unit operations. In addition, at the GH Tinombo busbar, no current or active power values were recorded because it was not connected to a generator.

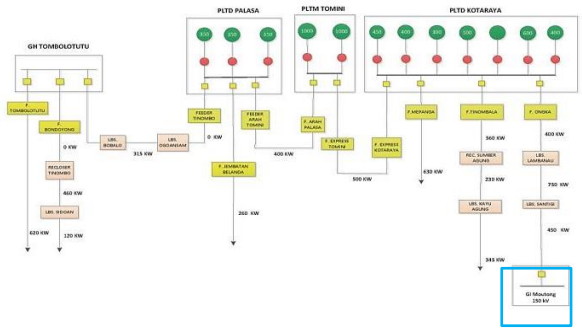

Figure 4. *Single Line Diagram of Kotaraya Isolated System After Moutong Substation Operation*

The Kotaraya isolated system is projected to undergo a configuration change following the construction of the Moutong Substation (GI Moutong), located at the end of the ULP Kotaraya network. The presence of GI Moutong will serve as the upstream of the ULP Kotaraya power system, potentially influencing the overall system operation pattern. In this isolated system plan, GI Moutong is planned to be connected with the Santigi Load Break Switch (LBS) through the nearest feeder, namely the Ongka feeder.

A power flow simulation was conducted after GI Moutong was connected to the Kotaraya isolated system, as shown in Figure 5.

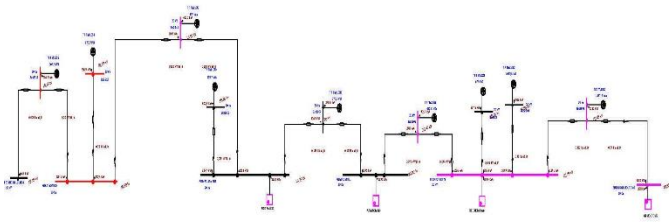

Figure 5. Load Flow Simulation of Kotaraya System After GI Moutong Operation

Table 5. Simulation Results of Kotaraya Isolated System After GI Moutong Operation

No.	PLTD dan GH	Tegangan (kV)	Arus (A)	Daya Aktif (kW)	Tegangan busbar terhadap tegangan nominal
1	GI MOUTONG	20,95	31,4	74,1	104,7%
2	PLTD KOTARAYA	20,79	110,6	3.982	104%
3	PLTM TOMINI	20,32	52,70	267,8	101,6%
4	PLTD PALASA	19,75	36,00	1.232	98,75%
5	GH TINOMBO	18,58	-	-	92,92%

From Table 2, it is obtained that the average busbar voltages at PLTD Kotaraya, PLTD Palasa, and PLTM Tomini remain within the tolerance of +5% to –10% relative to the 20 kV nominal voltage. The highest voltage was measured at GI Moutong at 20.95 kV (104.7%), while the lowest voltage was found at the GH Tinombo busbar at 18.58 kV (92.92%). Similar to the previous condition, no current or active power values were recorded at the GH Tinombo busbar since it was not connected to any generator.

IV. Conclusion

Based on the load flow simulation of the Kotaraya isolated system using software in this study, it can be concluded that the condition of the Kotaraya power system after the operation of GI Moutong results in more stable busbar voltage values at the generating units and switching substations. This stability aligns with the standards of the 2000 General Electrical Installation Regulations, which serve as PLN's reference, where the medium-voltage busbar levels fall within the safe range of 92%–104.7% of the 20 kV nominal, i.e., between 18–21 kV.

Award

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