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Determination of Optimum Resources for the Blang Kejeren Electrical System Using PSS Sincal Application

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Abstract

Currently, the Customer Service Unit (ULP) of the Blang Kejeren State Power Company (PLN) uses the system of the Diesel Power Power Centre (PLTD). Sistem ini terdiri dari PLTD yang dimiliki PLN dan PLtD Lewa, serta beberapa PLTMH (Pusat Listrik Tenaga Mikro Hidro). Aim of the study is to assess the technical viability of the 20 kV ULP Blangkejeren system if supplied with the Kutacane GI and parallel with Distributed Generation (DG). This is because there is no distribution network that can connect the Blangkejeren ULP load centre to the Kutacane GI. Using the PSS Sincal Power System Analysis Application, load scenarios for power plants and distribution networks are modeled and simulated. The findings indicate that the 20kV Ulp Blangkjeren system provided by GI Kutacana, PLTMH, PLTM Lawe, and PLTD Rema is the most appropriate scenario. This situation is regarded as optimal, with a network voltage of 21.07 kV on the ULP Blangkejeren Connection Guard Bus.

***Keywords**: Isolated, GI, DG, power flow, PSS Sincal*

Abstrak

Saat ini, Unit Layanan Pelanggan (ULP) Perusahaan Listrik Negara (PLN) Blang Kejeren menggunakan sistem dari Pusat Listrik Tenaga Diesel (PLTD), yang terdiri dari PLTD milik PLN dan PLTD Sewa serta beberapa PLTMH (Pusat Listrik Tenaga Mikro Hidro). Tidak ada jaringan distribusi yang dapat menghubungkan pusat beban ULP Blangkejeren dengan GI Kutacane, karena jarak 109 kilometer. Untuk mencapai ini, simulasi aliran daya harus dilakukan. Tujuan dari penelitian untuk mengevaluasi kelayakan teknis sistem 20 kV ULP Blangkejeren jika disuplai dengan GI Kutacane dan paralel dengan Generasi Terdistribusi (DG). Metode yang digunakan adalah pemodelan dan simulasi skenario pembebanan pembangkit listrik dan jaringan distribusi menggunakan PSS Sincal Power System Analysis Application. Hasil penelitian menunjukkan bahwa skenario yang paling cocok adalah sistem 20 kV ULP Blangkejeren yang disuplai dari GI Kutacane, PLTMH, PLTM Lawe, dan PLTD Rema. Dengan tegangan jaringan 21,07 kV pada Bus Gardu Hubung ULP Blangkejeren, skenario ini dianggap sebagai yang terbaik.

***Kata kunci**: Isolated, GI, DG, aliran daya, PSS Sincal*

Introduction

It is difficult for PLN to fulfill government tasks to oversee Indonesia's electrical system, which includes everything from energy production and transmission to distribution and sales. Specifically, the Bukit Barisan Area and Gunung Leuser National Park, which have been designated as world heritage sites, are home to ULP Blangkejeren and Kutacane, which are situated in the Gayo Lues and Southeast Aceh districts. These two districts are located in the province of Aceh's isolated regions. Due to the areas' predominant mountain and protected forest landscapes, building power infrastructure in Gayo Lues and Southeast Aceh districts is a difficulty. Because this region has an abundance of river water resources that might be used to power a water-powered power plant, the possibility for the establishment of a renewable energy-based power plant demands attention. Although the Kutacane substation system is the nearest grid system to ULP Blangkejeren, it is still quite a distance, roughly 109 kilometers, between the load center and the substation. Therefore, technical investigations are required to ascertain if running the 20 kV interconnection network ULP Blangkejeren in parallel with the distributed generation in ULP Blangkejeren and with the Kutacane substation is feasible.

Numerous comparable experiments using different approaches and performance enhancements have been conducted. After first utilizing the Backward-Forward Sweep approach, it employs the Continuation Power Flow (CPF) method to examine the stability of the voltage in the microgrid system as a result of an ongoing rise in load. It is possible to rectify the voltage instability profile and see it both prior to and following the DG addition. Voltage stability can be examined and assessed using the Continuation Power Flow (CPF) approach [1]. The effects of using DG (PLTMH Aek Silang and Aek Sibundong) on voltage drop and losses in a 20 kV distribution system using ETAP software for network simulation. The results of the investigation show that DG implementation in feeders can improve the quality of power distribution [2].

Potential renewable energy sources, solar photovoltaics (PV) and biogas (Hybrid) off-grid systems, were employed in a study to look into a number of reliability issues with the electric power system. Using of natural energy will produce an unlimited source of electricity [3]. Utilize HOMER Pro to evaluate the system. The analysis's conclusions indicate that a hybrid power plant can theoretically supply a load during the project's 20-year lifespan if it has good technical and financial potential for future implementation [4]. Researchers at the Mrica Substation, which is connected to the Karangtengah and Singgih PLTMH, investigated the reliability of the MRA 01 Feeder. Testing with the ETAP 12.6.0 program and the Reliability Index Assessment (RIA) method. The SAIDI Performance Indicator (System Average Interuption Duration Index) showed improvements when the system was connected to DG, going from 18,327 hours/year to 12,228 hours/year, according to the research findings. The annual number of disruptions was 5,018 but it improved to 3,272 according to the SAIFI (System Average Interruption Frequency Index) and), ENS (Energy Not Sale) increased from 133.359 MWh/year to 86.392 MWh/year [5].

Using the ETAP 16.0.0 application, a study investigated the technical drawbacks of the Bau-Bau and Raha distribution network connected to DG. There are two scenarios in which technical losses are calculated. The 20 kV Bau-Bau Substation Bus is where DG is linked in the first instance. The second scenario involves the DG being linked to a 20 kV bus located at the feeder's terminus. It was discovered from the study findings that technical losses were 8.443% in the second scenario and 8.735% in the first[6]. Suprianto examined the voltage loss in the Rantau Prapat Area, Aek Kota Batu District's PLN 20 kV distribution network. On the main bus, sub main bus, and lateral bus, the voltage drop is examined. Simulation of power flow with ETAP application. The resulting results are then verified by contrasting them with Newton Raphson's formula. The analysis's findings indicate that, with the exception of those that are closest to the main and sub main buses, the biggest voltage loss at peak load—and not peak load time—generally happens on the lateral bus that is farthest from the sending voltage center [7]. In order to perform research, Asran, Misbahul Jannah, and Adi Setiawan used ETAP software to model the standard IEEE 34 bus and DG distribution system. The study's findings demonstrate that voltage dips improved to 0.19 kV and system power losses dropped to 17,703 kW [8]. Using MATLAB software, ETAP, genetic algorithm techniques, and conducted study on the proper placement of DGs. The objective of this study is to minimize network losses and acquire a voltage profile in compliance with technical specifications. As a result, the voltage profile is within the designated standard limits and energy losses drop from 54.6733 kW to 9.9447 kW [9].

Another study conducted study on the Watu Ulo Jember feeder's DG placement and capacity optimization using the Particle Swarm Optimization (PSO) algorithm. According to Fitriana, Wicaksono, Ariyani, and Setyawan (2022), optimization of Bus 58, which has a capacity of 3.15 MW and 0.64 MVAR, enhanced the loadability (SLI) value by 182%. Using ETAP, Wayan Mertayasa, Jondra, and Saputra studied the power flow of the 20 kV distribution network from the DG, or PLTM Muara, to the Pemaron Main Substation. As a result, losses drop by 33.33 percent and the end voltage increases by 1.09 percent, or 12 kW [10].

Method

a. Research Flowchart

Data on feeder loads, distribution networks, and generators were gathered for this study. The gathered information is utilized in modeling, simulation, and calculations. The PSS Sincal application is used in this work to model and simulate power flow. The simulation's outcomes are examined and assessed in order to be contrasted with current benchmarks. The technical standard for network operation in line with PLN Directors Decree No.0357.K/DIR/2014 specifies that the voltage should be 20 kV, the frequency should be between 49.5 and 50.5 Hz, and the minimum and maximum percentages should be -10% and +5%, respectively [11].

The research was conducted in the following stages:

1) Gathering data from the distribution network and generator
2) Examining literature from books and other media
3) Using PSS Sincal programs to model the 20 kV ULP Blangkejeren and ULP Kutacane systems
4) Compute technical data, including load and current
5) Using the PSS Sincal program to simulate distribution network and DG loading situations
6) Assess and examine the data from the simulation results.
7) Make inferences

The stages of the research flow are shown in Figure 1.

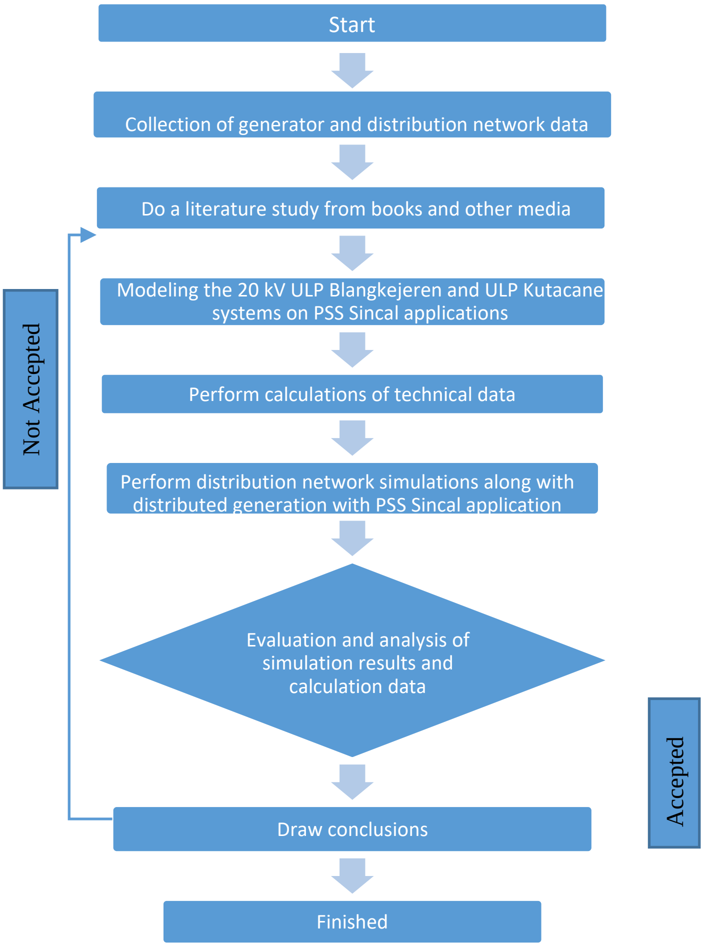

Figure 1. Research Flowchart

b. Drop Voltage

Drop voltage is the term used to describe the range of voltages that are lost or dropped in an electrical energy conductor. The cross-sectional area, load, and conductor length all have an impact on the voltage drop. There is a voltage condition decrease at the electrical conductor's terminus. If the load is reduced, the voltage at the receiving end will increase; if the load is increased, the voltage will decrease [12]. The power transfer diagram in Figure 2 below shows how the voltage drop equation has decreased.

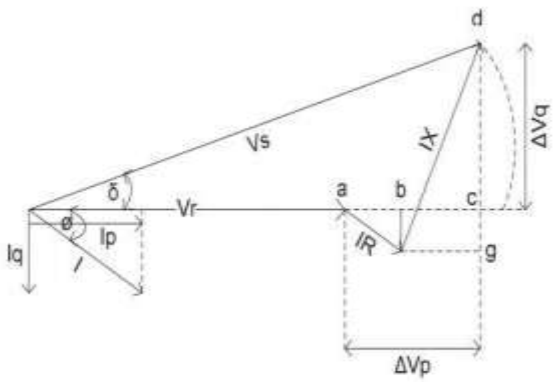

Figure 2. Power Transmission Diagram

Voltage drop can be made in the equation:

$INs^2 = (Vr + \Delta Vp)^2 + (\Delta Vq)^2$…………………………………..…… (1)

information:

Vs = sending end voltage

Vt = receiving end voltage

ΔVp = voltage drop = I.R cos ϴ + I.X sin ϴ = ab + bc, and

ΔVq = I.R cos ϴ - I.X sin ϴ

then the voltage at the sending end Vs can be made:

$INs^2 = (Vr + IR \cos\theta + IX \sin\theta)^2 + (IR \cos\theta - IX \sin\theta)^2$…………….. (2)

Because the value of ΔVq is very small and can be neglected, the sending end voltage becomes:

$$INs^2 = (Vr + IR\ Cos\ \theta + IX\ Sin\ \theta)^2 \quad \text{………………………} \quad (3)$$

$$\Delta Vp = IR\ Cos\ \theta + IX\ Sin\ \theta \quad \text{……………………………….} \quad (4)$$

$$\Delta Vp = R\frac{P}{Vr} + X\frac{Q}{Vr} \quad \text{…………………………………………} \quad (5)$$

Where:

R = Conductor resistance
X = Conductor reactance
P = Active power delivered
Q = Delivered reactive power

c. Drop Voltage

A program called PSS Sincal can simulate, analyze, and plan the building of electrical networks. The PSS Sincal application can also be used to do a number of analytical tasks, including power flow, short circuit, harmonic analysis, dynamics, distributed generator connectivity, and line diagram creation [13]. The PSS SINCAL Platform 16.0 is the application utilized in this study. In Figure 4, the application display is displayed.

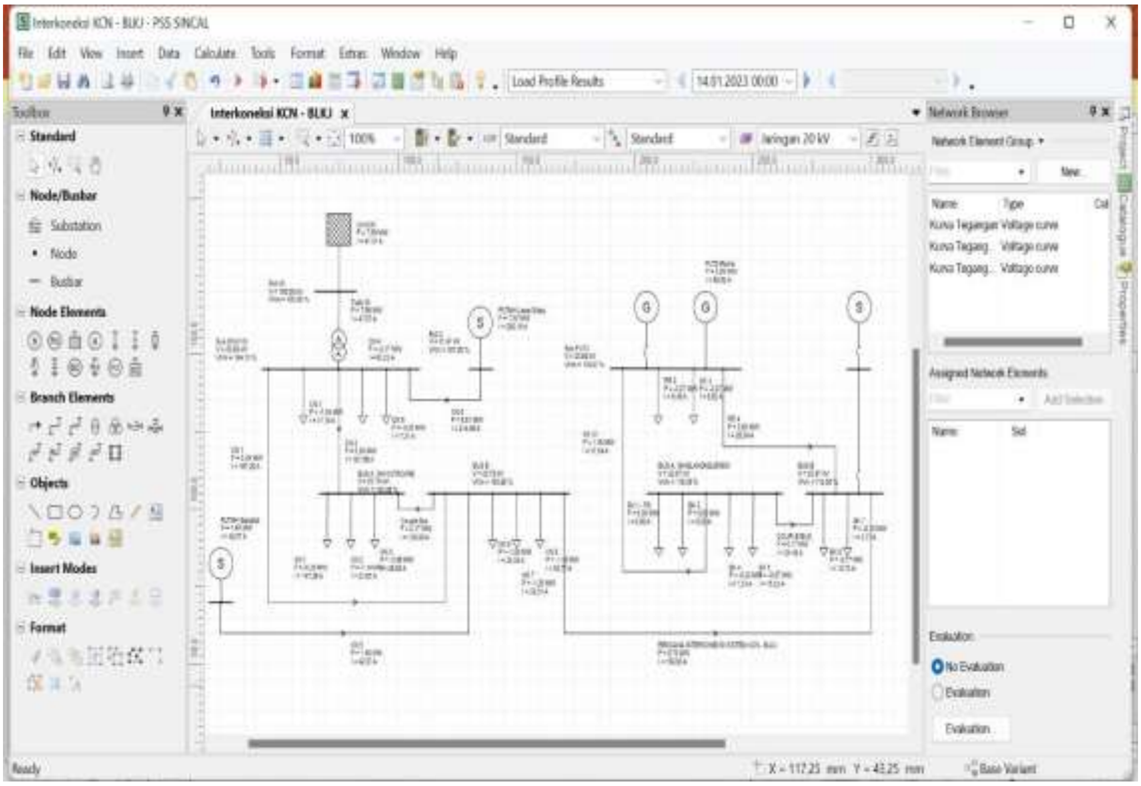

Figure 4: PSS Sincal Application Display

d. Distributed Generation (DG)

Different organizations have different definitions of distributed generation. All generating units connected to the distribution network with a maximum installed power of 50 MW are defined by CIGRE (Conseil International des Grands Reseaux Electriques). IEEE defines distributed generators as generators with less power than traditional generators that can be linked at any point in the electrical system. Distributed generation, on the other hand, refers to the energy that generators create for customers in the local distribution network (IEA / 2002). As depicted in Figure 5, it is quite feasible for the Kutacane substation system to supply the Blangkejeren ULP electrical system in parallel with the current dispersed generators. Blangkejeren ULP system and Kutacane ULP single line diagram.

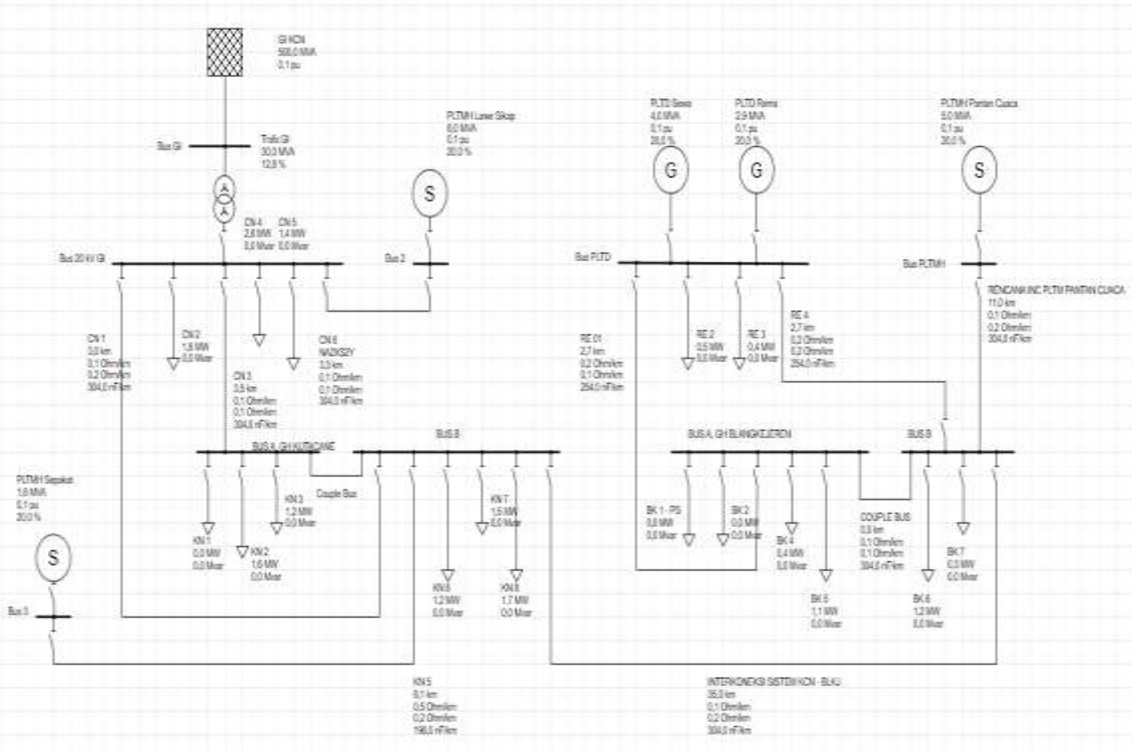

Figure 5. Single Line Diagram of the Blangkejeren ULP and Kutacane ULP systems

Results and Discussion

To find out the operational feasibility of the Kutacane substation interconnection network with DG to technically supply the Blangkejeren ULP system, technical data were collected for the Blangkejeren ULP and Kutacane ULP feeders for the purposes of the subsation interconnection simulation with DG using the PSS Sincal application. Following are the technical data of Blangkejeren ULP and Kutacane ULP feeders.

Table 1. Technical Data of Kutacane ULP Feeders

No	GI/ GH	Feeder	Length (Kms)	Peak Load (Kw)
1	GI	CN01/ Outgoing SUTM GH	3,52	
2	GI	CN02/ Semadam	29,52	1558,8
3	GI	CN03/ Outgoing SKTM GH	3,52	
4	GI	CN04/ Lawe Pakam	113,09	2556,4
5	GI	CN05/ Likat	19,23	1465,3
6	GH	KN01/ PS GH		
7	GH	KN02/ Lawe Alas	39,04	1597,8
8	GH	KN03/ Kuning	6,02	1210
9	GH	KN04/ Inc GI	3,52	
10	GH	KN05/ Inc. PLTMH	8,2	550,5
11	GH	KN06/ Peranginan	9,67	1303,8
12	GH	KN07/ City of Kutacane	27,64	1844,4
13	GH	KN08/ Ketambe		1812,6
14	GH	KN09/ Inc SKTM GI	3,52	

Table 2. Technical Data of Blangkejeren ULP Feeders

No	GH/PLTD	Feeder	Length (Kms	BP (Kw)
1	GH	BK01/ PS		
2	GH	BK02/ Pinding	73,41	159,7
3	GH	BK03/ Incoming SKTM PLTD Rema		
4	GH	BK04/ Rikit Gaib	52,49	445,2
5	GH	BK05/ City 2	5,99	604,2
6	GH	BK06/ City 1	30,65	1303,8
7	GH	BK07/ Putri Betung	62,3	349,8
8	GH	BK08/ Incoming SUTM PLTD Rema	62,3	
9	PLTD	RE01/ Outgoing SKTM GH	8,4	
10	PLTD	RE02/ Kuta Panjang	17,49	540,6
11	PLTD	RE03/ Trangon	82,8	443,01
12	PLTD	RE04/ Outgoing SUTM GH	8,42	

a. Perform Modelling and Calculation of Distribution Network Technical Data

For the PSS Sincal application, the distribution network modeling phases are as follows:

1. Using the network and generator element data, create a single line diagram of the Kutacane and Blangkejeren ULP 20 kV distribution network as follows:

Table 3. Data on Networks and Generators

No	Elements	Parameter
1	Grid	150 kV
2	Transformer GI	30 MVA, 150/20 kV
3	Bus	Bus GI = 150 kV GH/PLTD/PLTMH buses = 20 kV
4	Conductor	SUTM/SKTM cable 3x150 mm^2
5	Load	Cosphi = 0.9; 20 kV, Feeder Peak Load (kW)
6	Lease PLTD	Capable Power = 3.7 Mw
7	PLTD Rema	Capable Power = 2.6 Mw
8	PLTMH Sepakat	Capable Power = 1.6 Mw
9	PLTM Lawe Sikap	Capable Power = 7 Mw
10	PLTM Pantan Cuaca	Capable Power = 4.5 Mw

2. Determines the daily load profile in order to track peak loads. First, the hourly load value is divided by the daily maximum load value to convert the load data to per unit.

Table 4. Example of daily load profile of Kutacane ULP Feeder

Time	Semadam			Lawe Pakam			Likat		
	I (A)	CN2 (kW)	pu	I (A)	CN4 (kW)	pu	I (A)	CN5 (kW)	pu
1	34,00	1.059,98	0,68	34,00	1.589,98	0,62	51,00	904,10	0,62
2	35,00	1.091,16	0,70	35,00	1.621,15	0,63	52,00	935,28	0,64
3	36,00	1.122,34	0,72	36,00	1.652,33	0,65	53,00	966,46	0,66
4	37,00	1.153,51	0,74	37,00	1.839,38	0,72	59,00	1.059,98	0,72

5	38,00	1.184,69	0,76	38,00	1.870,56	0,73	60,00	1.215,86	0,83
6	39,00	1.215,86	0,78	39,00	1.901,74	0,74	61,00	1.247,04	0,85
7	40,00	1.247,04	0,80	40,00	1.932,91	0,76	62,00	654,70	0,45
8	35,00	1.091,16	0,70	35,00	1.558,80	0,61	50,00	779,40	0,53
9	31,00	966,46	0,62	31,00	1.589,98	0,62	51,00	779,40	0,53
10	33,00	1.028,81	0,66	33,00	1.652,33	0,65	53,00	841,75	0,57
11	34,00	1.059,98	0,68	34,00	1.652,33	0,65	53,00	841,75	0,57
12	35,00	1.091,16	0,70	35,00	1.621,15	0,63	52,00	872,93	0,60
13	36,00	1.122,34	0,72	36,00	1.901,74	0,74	61,00	966,46	0,66
14	37,00	1.153,51	0,74	37,00	1.995,26	0,78	64,00	997,63	0,68
15	38,00	1.184,69	0,76	38,00	2.088,79	0,82	67,00	1.059,98	0,72
16	40,00	1.247,04	0,80	40,00	2.244,67	0,88	72,00	1.184,69	0,81
17	41,00	1.278,22	0,82	41,00	2.338,20	0,91	75,00	1.215,86	0,83
18	42,00	1.309,39	0,84	42,00	2.307,02	0,90	74,00	1.247,04	0,85
19	50,00	1.558,80	1,00	50,00	2.556,43	1,00	82,00	1.465,27	1,00
20	50,00	1.558,80	1,00	50,00	2.525,26	0,99	81,00	1.309,39	0,89
21	49,00	1.527,62	0,98	49,00	2.462,90	0,96	79,00	1.247,04	0,85
22	47,00	1.465,27	0,94	47,00	2.369,38	0,93	76,00	1.091,16	0,74
23	45,00	1.402,92	0,90	45,00	2.244,67	0,88	72,00	997,63	0,68
24	43,00	1.340,57	0,86	43,00	2.182,32	0,85	70,00	935,28	0,64
Max		**1.558,8**			**2.556,4**			**1.465,3**	

3) Performing a power flow simulation on the Sincal PSS application. After all the parameters are entered in the PSS Sincal application, the data will be processed by the application and we will see a power flow diagram display as shown below:

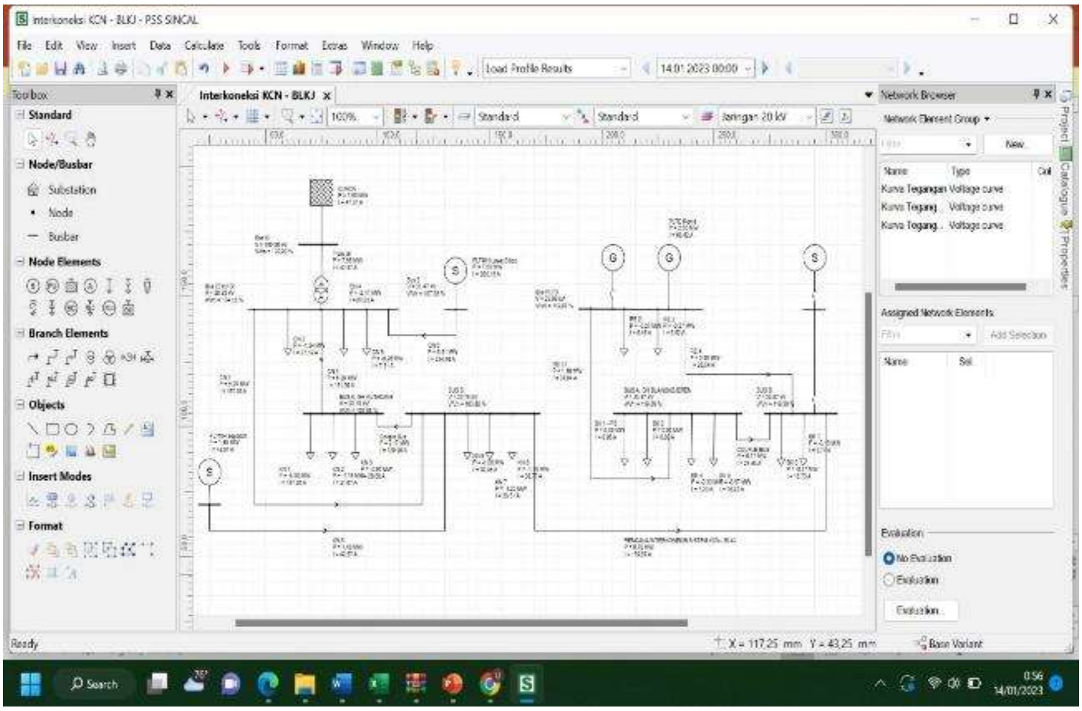

Figure 8. Kutacane-Blangkejeren ULP Single Line Diagram in PSS Sincal Application

b. GI and DG Interconnection Scenario Using PSS Sincal Application

The system load value fluctuates constantly and is always changing [14]. The voltage at the receiving end drops when the load increases and vice versa. The following three scenarios will be tested in order to identify the best power source for the Blangkejeren ULP system:

- The Blangkejeren ULP system is fully supplied from GI Kutacane, PLTMH Sepakat and PLTM Lawe Sikap
- The Blangkejeren ULP system is supplied from GI Kutacane, PLTMH Sepakat, PLTM Lawe Sikap, Rema PLTD and Rental PLTD
- The Blangkejeren ULP system is supplied from GI Kutacane, PLTMH Sepakat, PLTM Lawe Sikap and Rema PLTD

The following information is derived from the three scenarios that have been simulated using the PSS Sincal application:

Table 5. Data Table Showing the First Scenario's Power Flow Simulation Results

Node	Network level	P(MW)	Q(Mvar)	V(kV)	V/Vn (%)
Bus GI	Network 150 kV	16,21	-3,89	150	100,0
Bus 20 kV GI	Network 20 kV	-4,42	0,00	20,34	101,7
Bus Lawe Sikap	Network 20 kV	5,90	2,86	20,89	104,5
PLTD buses	Network 20 kV	-0,74	0,00	12,52	62,6
Bus A GH Blangkejeren	Network 20 kV	-1,54	-0,00	12,56	62,8
Bus A GH Kutacane	Network 20 kV	-8,16	-0,00	20,14	100,7
Bus PLTMH Sepakat	Network 20 kV	1,20	0,58	20,43	102,1
Bus B GH Blangkejeren	Network 20 kV	-1,30	0,00	12,56	62,8
Bus B GH Kutacane	Network 20 kV	-4,44	0,00	20,14	100,7

Table 6. Table of Power Flow Simulation Outcomes Data, Second Scenario

Node	Network level	P(MW)	Q(Mvar)	V(kV)	V/Vn (%)
Bus GI	Network 150 kV	11,19	-10,86	150,00	100,0
Bus 20 kV GI	Network 20 kV	-4,53	0,00	20,92	104,6
Bus Lawe Sikap	Network 20 kV	5,90	2,86	21,47	107,3
PLTD buses	Network 20 kV	5,41	3,05	27,42	137,1
Bus A GH Blangkejeren	Network 20 kV	-1,78	0,00	27,19	135,9
Bus A GH Kutacane	Network 20 kV	-8,52	-0,00	20,87	104,3
Bus PLTMH Sepakat	Network 20 kV	1,20	0,58	21,14	105,7
Bus B GH Blangkejeren	Network 20 kV	-1,47	0,00	27,19	135,9
Bus B GH Kutacane	Network 20 kV	-4,96	0,00	20,87	104,3

Table 7. Table of Power Flow Simulation Results Data, the Third Scenario.

Node	Network level	P(MW)	Q(Mvar)	V(kV)	V/Vn(%
Bus GI	Network 150 kV	13,82	-7,97	150,00	100,0
Bus 20 kV GI	Network 20 kV	-4,53	0,00	20,68	103,4
Bus Lawe Sikap	Network 20 kV	5,90	2,86	21,23	106,1
PLTD buses	Network 20 kV	1,71	1,26	21,17	105,8
Bus A GH Blangkejeren	Network 20 kV	-1,78	-0,00	21,07	105,3
Bus A GH Kutacane	Network 20 kV	-8,52	-0,00	20,56	102,8

Bus PLTMH Sepakat	Network 20 kV	1,20	0,58	20,84	104,2
Bus B GH Blangkejeren	Network 20 kV	-1,47	0,00	21,07	105,3
Bus B GH Kutacane	Network 20 kV	-4,96	0,00	20,56	102,8

The third scenario is determined to be the most ideal interconnection scenario based on the analysis of the simulation results data. According to ESDM the technical specifications for network operation are satisfied (frequency range: 49.5 to 50.5 Hz; voltage: 20 kV, maximum +5%, minimum -10%)[15].

Conclusion

Technically, it is possible to operate the ULP Kutacane interconnection network with ULP Blangkejeren. The best case scenario involves GI Kutacane, PLTMH Sepakat, PLTM Lawe Sikap, and PLTD Rema providing the 20 kV ULP Blangkejeren system (third scenario). In the third situation, the most ideal connectivity network voltage is 21.07 kV.

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