Reconstruction of Power Supply System 20 kV Distribution to Compare Power Rate and Fall Voltage PT. PLN (Persero) Area Dumai

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Abstract: Electricity in Bagan Siapi city fire is channeled through a feeder distribution system of 20 kV. The main supply of Bagan Siapi-api city comes from PLTD unit Bagan Siapi fire which is Â± 1.5 kms from the load center and Duri Substation is Â± 102 kms from Bagan Siapi-api city through Hubung Ujung Tanjung. The long distances between the Duri Mainstation and Bagan Siapiapi city resulted in a 14.85 kV end-voltage and a 988.7 kW loss. Voltage losses resulted in ineffective service to the consumer and large network power losses being uneconomical for power delivery operations. The result of end voltage calculation is 10.42 kV and the power loss is 988.7 kW. After the New Substation operates, reconfiguration-1 produces the lowest end-voltage calculation of 16.21 kV and a power loss of 136.59 kW, while reconfiguration-2 produces a low end stress calculation of 17.37 kV and a power loss of 56.93 kW.

Keywords: feeder 20 kV, voltage drop, power loss, substation, reconfiguration.

1. Introduction

PT PLN (Persero) Dumai Area with Rayon Bagan Siapi-api unit as the implementer is a unit that provides electricity service directly to consumers in Rokan Hilir district. The source of electricity comes from PLTD Bagan Siapiapi with capacity of 12,340 MW and Duri substation (90 MVA) through feeder distribution system 20 kV to Ujung Tanjung relay station then to Bagan Siapi fire town with total length 102 kms, and electrical system embrace radial system pattern. The magnitude of the load supplied can increase the voltage drop and the power losses in the system feeder 20 kV.

This is due to the parameters that determine the voltage drop and power losses other than the impedance is the current flowing on the system coming from the load. Power loss is a function of the square of the current on the system, so the greater the current will increase power losses and voltage drops. Therefore, to reduce the voltage drop and power losses by shortening the distance of the load center and the source of its power supply. The way to shorten the channeling distance between the power supply and the load center is to reconfigure the load after the build-up of the substation. The purpose of this study is to analyze whether the development of Bagan Siapi-fire substations by shortening the distribution can be one of the solutions in improving the characteristics of 20 kV feeder between the Ujung Tanjung Transmission Bridge to Bagan Siapi-api City, which includes voltage drop, load current, and loss - loss of power.

2. Literature Review

Muhammad Nasir Malik stated that the large drop of stress and total power loss in the primary distribution network of feeder Adyaksa Substance Panakukang Makassar with descriptive research method [1]. Danang Ramadhianto stated that the magnitude of the shrinkage of energy that occurs in power distribution network and to analyze the shrinkage value of energy, through the method of measurement and calculation and then compare the results of both [2]. Fery Jusmedy, stated that the stresses and losses on the 115 kV PT. Chevron Pacific Indonesia using ETAP 4.0 software [3]. A.V.Sudhakara Reddy states the Dragon Fly Meta-heuristic Algorithm (DFA) is used to restructure and identify the optimal Switches to minimize real power losses In the distribution network. Strategies have been tested The bus system 16 bus, 33-bus and 69-bus IEEE to demonstrate Achievement and adequacy of technical proposals. The result indicates that a significant reduction of loss and increase in real power voltage profile [4].

Anita Gupka, et al declare to reduce losses which is less or less and then determine the reduction of losses in terms of units and annual savings in the form of rupees Because of the proposed method. To examine the feasibility of the proposed work, the annual savings and return periods of the proposed method are also determined [5].

Based on the results of the analysis of the calculations using the ETAP 7.5 program the lowest voltage on the Caterer Feeder channel is found in TR.1064 transformer of 16.27 kV whereas The lowest voltage on the Idiac Feeder on the SP.26 transformer is 19.87 kV with a total power loss of 731.04 kW. After reconfiguration, then reconfiguration 2 then the lowest voltage of Caterer Feeder is on transformer TR.1102 of 18,70 kV, at Feeder Langgam channel that is on SP.26 transformer equal to 19,05 kV and on channel of white sand feeder on transformer ST.262 Of 18.78 kV with a total power loss of 410.65 kW. Total power loss savings were obtained at 320.39 kW [6].

Julen Kertoni et al stated that Reconfiguration was carried out by load transfer by means of status change and changes to Load Break Switch layout simulation results based on ETAP 12.6 on the lowest four-voltage reconfiguration on Stork feeder Sakti is 18.664 kV with a power loss of 0.598 MW and 0.787 MVAR [7].

2.1. Power System
Electric power system consists of three main components, namely power generation, transmission and distribution. At the center of electricity is done by generating electricity by utilizing synchronous generators. The electrical power generated at the center will be transmitted through the transmission system. Before transmitted, the voltage is increased by a step-up transformer at the center of the power. The voltage is raised to a high voltage level (between 70 kV to 150 kV) or extra high voltage (above 150 kV). The transmission system can be a system Air or ground cables.

2.2. Distribution Network
The distribution network consists of two types, medium voltage distribution network and low voltage distribution network. For medium voltage distribution network there are three types of configuration. Among them are radial configuration, lup configuration and spindle configuration.

2.3. Radial Configuration Distribution Network
Radial configuration is an interconnection between substations of distribution, where several distributed series of distribution substations supplied by a busbar Substation. This configuration consists of several repeater out of the substation and the source of the voltage only one direction saja.Dalam penyulang there are substations that are equipped distribution By voltage-lowering transformer to low voltage. This configuration is the simplest and easiest configuration in operation.

2.4. Distribution Network Loop Configuration

The configuration of the loop is the interconnection between the distribution substations that form a loop. In this configuration there can be more than one busbar of the Substation, and each of the repeater forms a closed circuit with the Substation. The advantage of this magnetic configuration is the power supply Of the substation is more secure.

2.5. Spindle Configuration Distribution Network

The spindle configuration is a series connection between a distribution substation which both ends are connected by the busbar of the Substation and Connector, which is the hallmark of this network is the presence of an express feeder. This express repeater serves as a repeater reserve that will supply the load power when one of the feeders is interrupted. In this spindle network there are several repeater supplied by Substation and ends in a substation.

2.6. Voltage Drop

Voltage falling in general is the voltage used at the load. The voltage drop is caused by the current flowing through the wire resistance. The voltage drop V on the conductor is greater if the current I in the conductor is greater and if the conductor resistance R? The greater the value. As a result the value of the voltage on the recipient side will be different from the voltage value of the sender. The equation of voltage drop can be seen in equation 1.

$$\Delta V = I \times Z \qquad [1]$$

Informasi :

ΔV = Voltage drop (volt)

I   = current (Amper)

Z   = Impedance (ohm)

In theory this is meant by the voltage drop (ΔV) is the difference between voltage sent (V_s) to receive a voltage (V_R), the voltage drop can be defined in equation 2.

$$\Delta V = V_S \times V_R \qquad [2]$$

information :

ΔV = Voltage drop (volt)

V_S = Send voltage

V_R = Voltage received

2.7. Power Loss

Power losses are the amount of power lost in a network, which is equal to the power supplied from the source less the amount of power received. Selection of cable types to be used in the distribution network is an important factor to be considered in the planning of a power system. Types of cables with small resistance values be able to minimize power losses. The amount of power losses in the distribution network can be written as follows:

$$\Delta P = I^2 . R \text{ (watt)} \qquad [3]$$

Infomation :

ΔP= Power loss on the network (watt)

I = Flow current on the network (Ampere)

R = Pure prisoners

For power losses on three-phase networks expressed by the equation:

$$\Delta P = \sqrt{3} . I^2 . R \text{ (watt)} \qquad [4]$$

By ignoring capacitive currents in the system, the currents along the length of the wire can be considered equal and the magnitude is equal to the current at the receiving end.

$$I = \frac{P}{\sqrt{3}VI\cos\varphi}\text{(ampere)} \qquad [5]$$

The amount of power in the three-phase system is

$$P = \sqrt{3} \; V \; I \; Cos \; \varphi \text{ (watt)} \qquad [6]$$

Information :

P   = Load power at the receiving end of the system(Watt)

V   = Fasa Voltage (Volt)

Cosφ = Load power factor

Voltage is also very influential on power losses, the greater the voltage on a system, the smaller the current on the system. While the current is one of the factors that affect the magnitude of power losses on a system.

3. Methodology

Reconfigure the distribution network by resetting the network configuration by opening and closing the switches on the distribution network to reduce the loss of power in the distribution network and / or to improve the reliability of the distribution system so that the efficiency of the power supply is increased and the consumer can be served well. Network Reconfiguration is an attempt to change the shape of a distribution network configuration by operating remote controlled switches on the distribution network without causing risky consequences on the operation and shape of the entire distribution network system. Under normal operating conditions, network reconfiguration is performed for two reasons.

- Reduce loss of power in the system (loss reduction).

- Get a balanced load to prevent overloading on the network (load balancing).

4. Results and Discussion

4.1. Impedance Calculation

The distribution system of 20 kV Duri Substation to City Bagan Siapi-api uses AAAC (All Allumunium Alloy Conductor) wire with 240 mm2 cross-section for main system, and 150 mm2 with 70 mm2 for branching system. The three wire conductor is arranged 19 fibers. The system configuration is horizontal with distance between phases 75 cm. The average temperature of the distribution system environment used temperature 300 C. The dc resistance at temperature 20 0C and the temperature coefficient (α) At temperature 20 0C as follows :

Table 1. Resistance dc and Temperature Coefficients

Wire Delivery AAAC	Dc resistance (temperature 20 ^{0}C)	Temperature Coefficient at 20 ^{0}C (α_{20})
70 mm^2	0,438	
150 mm^2	0,210	0,00360 / ^{0}C
240 mm^2	0,137	

Source: Standard of State Electricity Company (SPLN 41-8:1981)

Then the impedance can be calculated as

a. For cross-section area 240 mm^2

Dc Resistance :

$$R_{dc}\,(30\,^0C) = R_{dc}(20^0\,C)\ x\ [1 +\ \alpha_{20}\,(30^0\,C - 20^0\,C)]$$
$$= 0{,}137\ x\ [1 + 0{,}00360\ (10)]$$
$$= 0{,}137\ x\ [1 + 0{,}0360]$$
$$= 0{,}141932\ Ohm\,/\,km$$

The amount of skin effect factor (*mr*) is:

$$mr \quad = 0{,}0118\ x\ \sqrt{f} = 0{,}0118\ x\ \sqrt{50}$$
$$= 0{,}08343$$

Resistance ac :

$$R_{ac} \quad = \frac{1}{2} R_{dc} \times \left[\sqrt{1 + \frac{(0{,}08343)^4}{48}} + 1 \right]$$
$$= 0{,}5\ x\ 0{,}141932\ x\ 2$$
$$= 0{,}141932\ Ohm\,/\,km$$

$$GMR \quad = 0{,}4345\ x\ \sqrt{A}$$
$$= 0{,}4345\ x\ \sqrt{2{,}4}$$

$$= 0{,}67312\ cm$$

$$GMD \quad = \sqrt[3]{D_{rs} \times D_{st} \times D_{tr}}$$
$$= \sqrt[3]{(75) \times (75) \times (150)}$$

$$= 94{,}5\ cm$$

$$X = (2.\pi.f)\ x\ (2\ x\ 10^{-4})\ x\ \ln\!\left(\frac{GMD}{GMR}\right)$$

$$= (2\ x\ 3{,}14\ x\ 50)\ x\ (2\ x\ 10^{-4})\ x\ \ln\!\left(\frac{94{,}5}{0{,}67312}\right)$$

$$= 0{,}3105\,Ohm\,/\,km$$

$$Z = 0{,}1419 + j\,0{,}3105 \qquad\qquad = \sqrt{(0{,}1419)^2 + (0{,}3105)^2}$$

$$= 0{,}34139\,Ohm\,/\,km$$

b. For cross-sectional area 150 mm^2

DC Resistance:

$$R_{dc}\,(30\,^0C) = R_{dc}\,(20\,^0\,C)\ x\ [1 +\ \alpha_{20}\,(30^0\,C - 20^0\,C)]$$
$$= 0{,}21\ x\ [1 + 0{,}00403\ (10)]$$
$$= 0{,}21\ x\ [1 + 0{,}0403]$$
$$= 0{,}21846\,Ohm\,/\,km$$

The amount of skin effect factor (*mr*) is :

$$mr = 0{,}0118\ x\ \sqrt{f} = 0{,}0118\ x\ \sqrt{50}$$
$$= 0{,}08343$$

Ac Resistance :

$$R_{ac} = \frac{1}{2}R_{dc} \times \left[\sqrt{1 + \frac{(0,08343)^4}{48}} + 1\right]$$

$$= 0,2187 \, Ohm / km$$

$$GMR = 0,4345 \times \sqrt{A}$$
$$= 0,4345 \times \sqrt{1.5}$$
$$= 0,53215 \text{ cm}$$
$$GMD = \sqrt[3]{D_{rs} \times D_{st} \times D_{tr}}$$
$$= \sqrt[3]{(75) \times (75) \times (150)}$$

$$= 94,5 \text{ cm}$$

$$X = (2.\pi.f) \times (2 \times 10^{-4}) \times \ln\left(\frac{GMD}{GMR}\right)$$

$$= (2 \times 3,14 \times 50) \times (2 \times 10^{-4}) \times \ln\left(\frac{94,5}{0,53215}\right)$$

$$= 0,32527 \, Ohm / km$$

$$Z = 0,21847 + j\,0,32527$$
$$= \sqrt{(0,21847)^2 + (0,32527)^2}$$

$$= 0,39183 \, Ohm / km$$

c. For cross sectional area 70 mm^2

 DC Resistance :

$R_{dc}(30\,^0C) = R_{dc}(20\,^0C) \times [1 + \alpha_{20}(30^0 C - 20^0 C)]$
$\quad\quad\quad\quad\quad = 0,438 \times [1 + 0,00403\,(10)]$
$\quad\quad\quad\quad\quad = 0,438 \times [1 + 0,0403]$
$\quad\quad\quad\quad\quad = 0,45565 \, Ohm / km$

The amount of skin effect factor (*mr*) is :

$mr = 0,0118 \times \sqrt{f} = 0,0118 \times \sqrt{50}$
$\quad\quad = 0,08343$

 Ac Resistance

$$R_{ac} = \frac{1}{2}R_{dc} \times \left[\sqrt{1 + \frac{(0,08343)^4}{48}} + 1\right]$$

$$= \frac{1}{2}(0,45565) \times \left[\sqrt{1 + \frac{(0,08343)^4}{48}} + 1\right]$$

$$= 0,45565 \, Ohm / km$$

$$GMR = 0,4345 \times \sqrt{A}$$
$$= 0,4345 \times \sqrt{0,7}$$
$$= 0,36352 \text{ cm}$$
$$GMD = \sqrt[3]{D_{rs} \times D_{st} \times D_{tr}}$$

$$= \sqrt[3]{(75) \times (75) \times (150)}$$

$$= 94,5 \text{ cm}$$

$$X \qquad = (2.\pi.f) \text{ x } (2 \text{ x } 10^{-4}) \text{ x } \ln\left(\frac{GMD}{GMR}\right)$$

$$= (2 \text{ x } 3,14 \text{ x } 50) \text{ x } (2 \text{ x } 10^{-4}) \text{ x } \ln\left(\frac{94,5}{0,36352}\right)$$

$$= 0,34920 Ohm / km$$

$$Z \qquad = 0,45565 + j\, 0,34920$$

$$= \sqrt{(0,45565)^2 + (0,34920)^2}$$

$$= 0,57437 Ohm / km$$

4.2. Determining the Value of Flow Current in Voltage 20 kV

To determine the value of current on the primary side of the transformer distribution, authors first examine the transformer load value on the secondary side. To determine the value of the current balanced authors calculated the average value of the sum of the load measurement phase Amper R = 106, S = 46 and T = 85 Amper Amper as follows:

For transformer T.001 secondary side flows

Balance stream:

$$I_{SC} = \frac{106 + 46 + 85}{3}$$

$$I_{SC} = 79 \text{ Amper}$$

After obtaining the current value at equilibrium condition, then to calculate the value of current on the primary side using the way the secondary side current value in balanced condition divided by the ratio of the voltage regulation in the tap changer or calculated as follows:

For transformers T.001 primary side currents;

$$I_{PR} = \frac{79}{(18000 / 380)} = 1.67 \text{ Amper}$$

4.3. Determine Voltage Drop and Power Loss Existing Conditions

In this condition the voltage drop is calculated, so it will get the value of transmitted and received voltage and inter-channel power losses calculated as follows.

Voltage Drop $\quad = \sqrt{3}$ x Arus x Total impedansi

$$= 1.732 \text{ x } 273.07 \text{ A x } 13.65 \text{ Ohm/km}$$

$$= 5.607 \text{ V}$$

So :

Send Voltage $\qquad$ = 20.400 V
Voltage Received $\quad$ = 20.400 V – 5.607 V

$$= 14.792 \text{ Volt}$$

Total Loss of existing power condition are:

$$= 1.198.417 - [\, (77.25 + 33.9)^2 \text{ x } 5.676 \text{ x } 3\,]$$

= 1.198.139 – 210.369

= 988.048 Watt

4.4. Condition of New Substation Operating (Reconfiguration 1)

In this condition, reconfiguration of medium voltage network has been done so that the configuration of the network where the power is not supplied again from the substation of thorns but has been supplied from the New Master Substation. So obtained the voltage drop and power loss as follows:
End Voltage at

OGF A at Bangko Pusako = 16.212 V

OGF B at Bagan Siapi-api = 19,130 V

Total total power losses OGF A and OGF B

=118.219 Watt + 18.372 Watt

= 136.591Watt

4.5. Condition of New Substation Operating (Reconfiguration 2)

In this condition, the reconfiguration of the medium voltage network has been done so that the network configuration is changed which the load of Banko Pusako is supplied again from the Duri Substation and the load to the Siam-Fire Channel is supplied from the New Master Substation. Calculation The total reconfiguration power losses of 2 are the sum of OGF A, OGF B, Power Supply from the Substation of Duri reduced the power losses of Feeder Polres and the Feeder of the White Land, so the calculation is as follows:

$= (41.110 + 18.373 +207.818) – [(77.25+33.9)^2 \text{x}5.676 \text{ x } 3]$

$= 267.301– 210.369$

$= 56.932 \text{ Watt}$

4.6. Comparison Of Losses And Voltage Each Configuration

From the calculation of losses and intermediate voltage of the medium-voltage network for the existing conditions, reconfiguration 1 and reconfiguration 2 are shown in table 2 as follows:

5. Conclusions

From the result of the discussion, it can be concluded that the voltage profile and power loss condition of power distribution from *Ujung Tanjung* to *Kota Bagan Siapi-api* with the result of end stress calculation is 11,542 kV and the power loss is 988.7 kW. After the new substation is in operation the reconfiguration-1 produces the lowest end voltage calculation of 16.21 kV and a power loss of 136.59 kW, while reconfiguration-2 produces the lowest end voltage calculation of 17.37 kV and a power loss of 56.93 kW

Table 2 Results Calculation of Voltage Drop And Power Loss Each Configuration

Configu-ration	Power loss	Send Voltage	Edge Voltage	Total Trafo ($V_p< 18$ kV)
	Watt	Volt	Volt	Unit
Eksisting	988.048	20.400	11.642	112
Reconfiguration 1	136.591	20.400	16.212	54
Reconfiguration 2	56.932	20.400	17.372	26

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