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Feasibility Study on The Operation of Toboali Substation to Reduce The Use of Fossil Fuels as Power Plants and Energy Loss by Computer Simulation.

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Abstract. This study discussed the analysis of load flow before and after the Toboali Substation (GI Toboali) - that is still in development process stage when the paper is written-. This study was operated in a computer simulation using ETAP Software. The Toboali substation needs to be built because Toboali diesel power plant will be shut down because the Toboali diesel power plant is a diesel power plant leased from PT. Megapower. From the simulation results it was found that before the Toboali substation operated the energy loss was 3,895.7 MWh/year and after the Toboali Substation operated an energy loss was 3,377.5 MWh/year and will reduce 20 tons/day usage of biodiesel. It is expected that when the Toboali substation operates it will reduce the energy loss and electricity dependence of the region on fossil energi and also it will increase power system reliability.

1. Introduction

Seeking from the future aspect, green energy is an alternative source for power generation that provides unlimited energy. The only need is to aware people for energy conservation along with environment. This is a step to generate different forms of energy in most of the field with clean source (less of fossil fuel use). Day by day the demand of clean energy is increasing; green energy will fulfill the need with more advanced technological systems. But it will take time when every single house operates their electrical appliances by using their own power producing system such as solar panels, small wind turbines etc. [1]

At present, Toboali substation is being carried out to reduce the operating, improve the power system reliability and rental cost of the Toboali diesel power plant and to improve the quality of the voltage and power losses and to support government programs so that they do not rely on fossil fuels fully. After Toboali sub-station operates, it is planned to divide the load. Previously, the Tukak Sadai was a stand alone feeder, so after the GI Toboali operated is divided into Tukak and Sadai feeders. Sukadamai feeder is divided into Sukadamai and Pemda feeders. The Tiram Puput express feeder is divided into Tiram express feeder and Puput express feeder. As well as the addition of two other express feeders [2].
In this study, load flow will be compared between before and after the operation of the Toboali substation. Some research used as a reference is about the analysis of load flow [3-9], planning the construction of substations and network reconfiguration [10-11], and about green energy [1]. Other studies use ETAP to compare various load flow methods [12-13]. Also, there are several books that discuss load flow [14-15].

2. Research Methodology

In this study, the results of the flow of power will be compared that includes the tip feeder voltage and power loss between before and after the substation operated. Load data used was the measurement data of the last distribution transformer loading. Voltage synchronization between systems was at a value of 20.6 kV. Simulation using ETAP software with Power Flow Analysis using Newton Raphson method. All data used field data so that the simulation results before Toboali substation operates will be very close to real conditions.

3. Results and Discussion

3.1. Simulation Analysis of System Condition Before Toboali Sub Station Operates

In load flow analysis, it will only be analyzed at a nominal voltage of 20 kV with a household load of 400/230 Volt. In the Toboali and Koba systems, both are synchronized 20.6 kV loaded to minimize end voltage that is too small with ETAP simulation results as follows

| Feeder         | Kota | Rindik | Bikang | Sukadamai | Tukak | Sadai | Tanjung | Labu | Express Feeder (EF) | Tiram Puput | Palas | Paku |
|----------------|------|--------|--------|------------|-------|-------|---------|------|---------------------|-------------|-------|------|
| Voltage (kV)   | 20.373 | 20.519 | 20.19  | 20.556     | 20.415 | 20.181 | 20.632  | 16.569 | 18.297              |

The loss value obtained by calculating losses on line, on distribution transformers, and other installed components. The value of these losses was obtained from the report summary, which also includes losses on feeders. The value of Toboali’s system losses on software can be seen in Table 2.

Table 2. Summary report of Toboali system condition before Toboali Substation operates from ETAP

| Source (Swing Buses) | 7.739 | 9.794 | 12.483 |
|----------------------|-------|-------|--------|
| Source (Non-Swing Buses) | 6.490 | -0.708 | 6.528 |
| Total Demand | 14.229 | 9.086 | 16.883 |
| Total Motor Load | 3.938 | 2.410 | 4.616 |
| Total Static Load | 9.420 | 5.714 | 11.018 |
| Total Continant I Load | 0.000 | 0.000 | 0.000 |
| Total Generic Load | 0.000 | 0.000 | 0.000 |
| Apparent Losses | 0.872 | 0.962 |
| System Missmatch | 0.000 | 0.000 |
| Number of Iterations | 3 |
From the summary of the simulation on the software, it can be seen that the value of the Toboali system loss conditions before the Toboali substation operates was 0.872 MW. The value of these losses was relatively high. But PLN itself does not have a standard for maximum losses allowed in a network. It can be calculated that energy losses for one year were 3,895,747 MWh/year. This value is still quite high, so it is necessary to build a Toboali substation, and the end voltage of Paku and Palas feeders are still below the standard, which is around 17 kV.

### 3.2. Simulation Analysis of System Condition After Toboali Sub Station Operates

In load flow analysis, it will only be analyzed at a nominal voltage of 20 kV with a household load at 400/230 Volt. When the Toboali substation has been operated, the Toboali diesel power plant will be shut down because the Toboali diesel power plant uses a 6 MW generator engine which is leased from PT. Megapower.

#### Table 3. End voltage of Toboali System before Toboali Sub station operates

| Feeder       | Kota | Rindik | Bikang | Sukadamai | Tukak | Sadai | Tanjung Labu | Pemda | EF Tiram | EF Puput | Palas | Paku |
|--------------|------|--------|--------|-----------|-------|-------|--------------|-------|---------|---------|-------|------|
| Voltage (kV) | 20.056 | 20.204 | 20.053 | 20.499    | 20.548 | 20.497 | 20.189       | 20.577 | 20.598  | 20.598  | 17.393 | 17.705 |

The loss value obtained by calculating losses on the line, on the distribution transformer and other installed components. The value of these losses was obtained from the report summary, which also includes losses on feeders. The value of Toboali\'s system losses on software can be seen in the following Table 4.

#### Table 4. Summary report of Toboali system condition after Toboali substation operates from ETAP

| Source (Swing Buses) : | 7.598 | 9.448 | 12.124 |
|------------------------|-------|-------|--------|
| Source (Non-Swing Buses) : | 6.490 | -0.753 | 6.533  |
| Total Demand : | 14.088 | 8.696 | 16.556 |
| Total Motor Load : | 3.954 | 2.420 | 4.636  |
| Total Static Load : | 9.378 | 5.691 | 10.970 |
| Total Costant I Load : | 0.000 | 0.000 | 0.000  |
| Total Generic Load : | 0.000 | 0.000 | 0.000  |
| Apparent Losses : | 0.756 | 0.585 |
| System Missmatch : | 0.000 | 0.000 |
| Number of Iterations : | 3 |

From the summary of the simulation in Table 4, it can be seen that the value of the Toboali system power losses conditions before the Toboali substation operating was 0.756 MW. This loss value was relatively high. But PLN does not have a standard for maximum losses allowed in a network. And the Toboali system had a load of 14.088 MW. It can be calculated that the energy loss for one year was 3,377,5056 MWh / year and had a loss of 3.96%. If compared to the conditions before the Toboali Substation operates, a table can be made as follows:
Table 5. Comparison of end voltage of Toboali system between before and after Toboali substation operates

| Feeder   | Voltage (kV) Before | Voltage (kV) After |
|----------|---------------------|--------------------|
| Kota     | 20.373              | 20.056             |
| Rindik   | 20.519              | 20.204             |
| Blikang  | 20.190              | 20.053             |
| Sukadamai| 20.556              | 20.499             |
| Tukak    | 20.415              | 20.548             |
| Sadai    | 20.181              | 20.497             |
| Tanjung Labu | 20.556          | 20.189             |
| Pemuda  | 20.632              | 20.577             |
| EF Tiram| 20.632              | 20.598             |
| EF Puput| 16.569              | 20.598             |
| Palas   | 18.297              | 17.393             |
| Paku    |                     | 17.705             |

From Table 5, it can be seen that Toboali substation construction causes the end voltage of feeder to be closer to the nominal voltage of 20 kV because Toboali diesel power plant will be turned off after the Toboali Substation operation. But this does not improve the quality of the voltage of Paku and Palas feeders supplied from Koba Substation. To improve the quality of end voltage of Koba substation, further studies are needed, but not discussed here.

After the Toboali substation operated, the energy loss also decreased, that was from 3895.7 MWh/year to 3377.5 MWh/year, or equivalent to reducing losses from 4.53% to 3.96%. In addition, it will certainly eliminate the price of biodiesel for the operation of the Toboali diesel power plant which requires approximately 20 tons of biodiesel every day or about save IDR 139,400,000 for a single day. It also will eliminate the cost of renting Toboali diesel power plant with the amount that is not calculated here.

It can be concluded that the Toboali Substation operation will cause the end voltage of feeder in Toboali to be close to the nominal voltage of 20 kV except for Palas and Paku feeders which remain below the standard.

4. Conclusion

Based on the results of the Toboali system load flow analysis between before and after the operation of Toboali substation, the following conclusions can be drawn:

1. Based on the results of the load flow analysis between the conditions before the Toboali substation operation and after the Toboali substation operation it was found that the end voltage of each feeder will be close to the nominal voltage on the busbar which is 20 kV, except for Palas and Paku feeders because the supply is obtained from Koba substation. However, change in the value of the load flow is not so significant.

2. Energy losses can be reduced when Toboali Substation is operational, from 872 kW/year to 757 kW/year. And the percentage of losses will be reduced when the Toboali substation is operating, from 4.53% to 3.96%.

3. The operation of Tobolali substation can reduce costs because of the lease of Toboali diesel power plant and the operation of the diesel-fueled Toboali diesel power plant so that it is more environmentally friendly. It also reduces fuel for Toboali power plant that requires approximately 20 tons of biodiesel every day and it can save money about IDR 139,400,000 just for the Toboali diesel power plant fuel.

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