Contingency Analysis of Electric Power Systems Sub-System 150 KV West Java Area II

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Abstract. Main generation area II technically served several plants that Jatiluhur, Saguling and Cirata. The backbone of the generation (slack bus) held by two units supplied by IBT 500/150 kV with a power capacity of each IBT is 500 MVA. One sample is a sub-system supplier Cirata has 13 transmission line connecting the substation 8 (GI) and has a total of 17 150/20 kV transformer with a capacity of 930 MVA, while the existing generation units at 150 kV Cirata subsystem is PLTPb Patuha with a power of 55 MW. Given the large power capacity with the strategic and vital functions of the sub-systems of 150 kV Cirata requires maximum control and optimization so that the distribution of electricity in West Java can be properly maintained. System Reliability of the power system must be maintained in order to supply power from the generator to the consumer to keep going well. In this study, the disorder will be analyzed is the contingency (N-1), a discharge of one of the channels on the system. Then analyzes the current and voltage changes to prepare for system improvements. Repairs are done when the contingency is to release the load (load shedding). Reliability was measured after load shedding in this study is to measure the quality of the voltage on the load side. At the time of the contingency (N-1), a decline below the voltage value SPLN on some rails GI, including rail Cigereleng (124.8 kV to 136.8 kV), rail Lagadar (125.4 kV to 137.1 kV), rail Padalarang (126.1 kV to 137.5 kV), North Bandung rail (125.5kV be 137.3 kV) and rail Cibabat (125.6 kV to 137.2 kV).

1. Introduction

Disturbance is the release of one of the channels on the system, or more commonly called a contingency (N-1). As for the electric power system that will serve as the object of research is on Cirata subsystem 150 kV. Cirata subsystem is part of the 150 kV interconnection system 150 kV West Java. Cirata subsystem 150 kV get GITET Cirata supply of 500 kV through two IBT unit capacity of 500 MVA by the ratio of 500/150 kV. Subsistem Cirata has 13 150 kV transmission line interconnecting with 8 substations (GI) 150/20 kV, has 17 units trasformator with a total capacity of 960 MVA, with a ratio of 150/20 kV burden and has only one generating unit of PLTPb Patuha of 55MW. To the years 2013-2014, there have been 17 times the disturbances in the form of contingency (N-1) at 150 kV conductor on the system of West Java. In other words, the disruptions arising from the release of one of the channels on the system is often the case, and the study was conducted on 150 kV Cirata susbsistem order to be useful when it will make improvements to the system. The transmission
system must be periodically analyzed by function Contingency Analysis (CA) to predict a potential problem if the elected elements of the power system issued (out of service). CA function using the results of the count state estimation as a base case and examine certain contingency cases to determine whether there is a potential overload or voltage problems that arise. Each case must contain elements such contingency branch outages, reactor or capacitor switching, for power outages, outages for element load and switch equipment changes. Every contingency case can contain up to five elements outage specified by the user interactively through the display slices. Each case should be given a number of cases that are marked with one of the multiple levels of user priority. Prioritas level which will be discussed during each execution of the CA should be flagged by users [1]. The release of the load (load shedding) is one of the phenomena taking place in the power system of electricity which allows for some of the load out of the system, resulting in stability of the power system. This is usually due to more load on the system, so as to restore the system to normal conditions required release some particular load.

According to Rahman [3] abnormality that caused the overload is generally triggered by several things, namely the generation that is detached from the system and a disturbance in the transmission system so that there are some who can not supply the load from the system interconnect. In the electric power system there are different kinds of loads such as induction motors and lighting. The load has a value of priority needs and economic value for its users.

2. Research Methods

Steps being taken with regard to the data analysis of this study as follows.

a. Make modeling one-line diagram in ETAP
b. Perform data input power grid, buses, generators, transformers and load on ETAP
c. Simulate the flow of power in a state of peak load use ETAP program 7 to determine the reliability of the system voltage
d. Make improvements to the system, the load shedding 1 until the voltage back to the permitted limit
e. Make a list of contingency (N-1)
f. Perform power flow analysis of the state of contingency (N-1) using ETAP
g. Identify the current and voltage changes after the contingency (N-1)
h. Make improvements to the system
i. Check the effectiveness of improvements based on the reliability of the system is measured based on the voltage, the channel loading, and loading transformers.

In the block diagram of the steps undertaken can be described in the following flow chart.
The following image channels that will be released for contingency analysis (N-1). The process of analysis, the channel released until all the contingency list is finished simulation.
3. Results and Discussion

3.1. Peak Load Condition

Voltage data each time the rail substation peak load conditions:

| NO | REL GJ  | VOLTAGE (KV) |
|----|---------|--------------|
| 1  | BDUTR   | 109.4        |
| 2  | CBBAT   | 109.5        |
| 3  | CGRLG   | 106.7        |
| 4  | CKMPY   | 137.4        |
| 5  | CRATA   | 140.9        |
| 6  | LGDAR   | 108.6        |
| 7  | PBRAN   | 137.0        |
| 8  | PDLRG   | 110.8        |

Rel Cikumpay, Cirata and Pabuaran the voltage peak load is well within SPLN. While the remaining 90% is below the nominal voltage of the system.

Imposition channel during peak load occurs excessive loading on some channels, such as in the following table.

| NO. | LINE (FROM TO) | I NOMINAL (A) | LOADING (%) |
|-----|----------------|---------------|-------------|
| 1   | Cirata 1 – Cikumpay | 1620         | 43.4        |
| 2   | Cikumpay 2 – Pabuaran 2 | 1620     | 3.8         |
| 3   | Cikumpay 1 – Pabuaran 1 | 1620    | 8.3         |
| 4   | Cirata 2 – Padalarang | 1400       | 82.7        |
| 5   | Cirata 1 – Padalarang | 1400      | 82.7        |
| 6   | Lagadar 2 – Padalarang | 580      | 47.7        |
| 7   | Lagadar 1 – Padalarang | 580     | 103.9       |
| 8   | Cigereleng – Lagadar 2 | 580      | 27.1        |
| 9   | Cigereleng – Lagadar 1 | 580      | 59.1        |
| 10  | Padalarang – Cibabat 1 | 1200     | 41.7        |
| 11  | Padalarang – Cibabat 2 | 1200    | 19.1        |
| 12  | Padalarang – Bdg Utara | 580      | 26.7        |
| 13  | Padalarang – Bdg Utara | 580     | 58.1        |

Even channels of Lagadar 1 toward Padalarang experiencing overload, ie 103.9% of the nominal I penghantarnya. Any transformer loading takluput of excessive loading during peak loads, as shown by Table 3.

| NO. | TRAFO | CAPACITY (MVA) | LOADING (%) |
|-----|-------|----------------|-------------|
| 1   | BDUTR III | 60            | 90.6        |
| 2   | BDUTR IV  | 60            | 66.1        |
| 3   | CBBAT I   | 60            | 82.6        |
| 4   | CBBAT II  | 60            | 73.4        |
| 5   | CBBAT III | 60            | 76.9        |
| 6   | CGRLG IX  | 60            | 74.9        |
| 7   | CGRLG VII | 60            | 80.7        |
| 8   | CKMPY I   | 60            | 82.9        |
| 9   | CKMPY II  | 60            | 81.3        |
| 10  | LGDAR I   | 30            | 65.1        |
| 11  | LGDAR III | 60            | 52.1        |
| 12  | PDLRG I   | 30            | 66.9        |
| 13  | PDLRG II  | 30            | 78.8        |
Almost all experienced transformer overload which is 13 units that experienced at peak load conditions of the system total 17 transformers and the rest burdened less than 50%. Before the contingency analysis, the system must first be restored to normal conditions, where the value of the voltage is already at the limit value SPLN and channel loading and loading the transformer is back to normal. Normal conditions in this study are in shedding1 load condition (LS1). The results of the analysis will be discussed below LS1.

3.2. Contingency Analysis

Contingency analysis was conducted on six (6) channels, namely (1) Cirata2-Padalarang, (2) Lagadar2-Padalarang, (3) Cigereleng-Lagadar1, (4) Padalarang-North Bandung, (5) Padalarang-Cibabat1, and (6) Cikumpay1-Pabuaran1. But as samples for this case is done only on the channel Cirata2-Padalarang, because the others are identical. The contingency analysis techniques can be explained as follows.

**contingency 1**

![Contingency Channel 1 (Cirata - Padalarang)](image)

Simulation in the picture above, the channel is marked released and the data obtained:

| Kondisi  | Rel | Rel Voltage (kV) | Line             | Inom (A) | \( I_L \) (%) |
|----------|-----|-----------------|------------------|---------|-------------|
| Normal   |     |                 |                  |         |             |
| Cirata   | 146.8 | Cirata 2 – Padalarang | 1400 | 36.3 |
| Padalarang | 136.4 | Cirata 1 – Padalarang | 1400 | 36.3 |
| Bdg Utara | 135.8 |                  |                 |         |             |
| Cibabat  | 135.8 |                  |                 |         |             |
| Cigereleng | 135.0 |                  |                 |         |             |
| Lagadar  | 135.6 |                  |                 |         |             |
| Failure  |     |                 |                  |         |             |
| Cirata   | 146.7 | Cirata 2 – Padalarang | 1400 | - |
| Padalarang | 126.1 | Cirata 1 – Padalarang | 1400 | 67.4 |
| Bdg Utara | 125.5 |                  |                 |         |             |
| Cibabat  | 125.6 |                  |                 |         |             |
| Cigereleng | 124.8 |                  |                 |         |             |
| Lagadar  | 125.4 |                  |                 |         |             |

From Table 4 it is seen that with the release of Cirata2-Padalarang channel, channel-Padalarang Cirata1 increased loading, but not exceeding the first amount. If the current value (%) in the above table is transformed into amperes, then its value is 508.2 A. In the contingency 1, the voltage drop occurs on the rail Padalarang, North Bdg, Cibabat, Cigereleng and Lagadar. The fifth voltage on the rails under the limit value SPLN. Similarly, for analysis kontingensi2, kontinensi3, kontingensi4, kontungensi5, and kontingensi6 done in the same way.
3.3. Analysis of Load Shedding

The solution to the six cases of contingency and the peak load cases above, be done by improving the system is to load shedding or often referred to as load shedding.

| No | Solution | Released Load | Trafo | Capacity (MVA) | Information |
|----|----------|---------------|-------|---------------|-------------|
| 1  | LS1      | Semua         |       | 205.0         | Solusi untuk beban puncak |
| 2  | LS2      | BDUTR III, CBBAT I, CGRLG VII, LGDAR I, PDLRG II | 88.0  | Solusi untuk kontingensi 1 |
| 3  | LS3      | CGRLG VII     |       | 6.9           | Solusi untuk kontingensi 2 |
| 4  | LS4      | CGRLG VII, CKMPY I | 15.3  | Solusi untuk kontingensi 3 |
| 5  | LS5      | CGRLG VII     |       | 1.4           | Solusi untuk kontingensi 4 |
| 6  | LS6      | CBBAT I, LGDAR III, CGRLG VII | 5.1   | Solusi untuk kontingensi 4 |
| 7  | LS7      | CGRLG VII     |       | 0.8           | Solusi untuk kontingensi 5 |

Simulation of load shedding 1 (LS1) is a solution for peak loads. Here is the data release of the load:

| NO. | LOAD ID      | LOAD (MVA) | Before LS1 | After LS1 |
|-----|--------------|------------|------------|-----------|
| 1   | LD BDUTR III | 49.0       | 28.7       |           |
| 2   | LD BDUTR IV  | 37.5       | 23.1       |           |
| 3   | LD CBBAT I   | 45.4       | 27.8       |           |
| 4   | LD CBBAT II  | 42.6       | 27.5       |           |
| 5   | LD CBBAT III | 42.8       | 28.9       |           |
| 6   | LD CGRLG IX  | 41.8       | 23.7       |           |
| 7   | LD CGRLG VII | 44.2       | 23.8       |           |
| 8   | LD CKMPY I   | 49.2       | 36.5       |           |
| 9   | LD CKMPY II  | 48.1       | 36.3       |           |
| 10  | LD CKMPY III | 25.8       | 23.1       |           |
| 11  | LD LGDAR I   | 17.3       | 12.6       |           |
| 12  | LD LGDAR II  | 24.0       | 12.4       |           |
| 13  | LD LGDAR III | 30.2       | 17.1       |           |
| 14  | LD PBRAN I   | 26.8       | 23.3       |           |
| 15  | LD PBRAN II  | 18.3       | 16.0       |           |
| 16  | LD PDLRG I   | 19.1       | 8.2        |           |
| 17  | LD PDLRG II  | 22.0       | 10.1       |           |

The simulation results load shedding 1 above table of data obtained as follows:

| Kondition | Rel Voltage (kV) | Overload Line | Inom (A) | II (%) |
|-----------|------------------|---------------|----------|--------|
| Before LS1|                  | Lagadar1 – Padalarang | 580      | 103.9  |
| Bdg Utara | 109.4            |               |          |        |
| Cibabat    | 109.5            |               |          |        |
| Cigereleng | 106.7            |               |          |        |
| Cikumpay   | 137.4            |               |          |        |
| Cirata     | 140.9            |               |          |        |
| Lagadar    | 108.6            |               |          |        |
| Pabuaraan  | 137.0            |               |          |        |
| Padalarang | 110.8            |               |          |        |
Based on table 6 and table 7 can be concluded that with the release of the total load of 205 MVA, or by 35.1% of all transformers burden of making a channel Lagadar 1 - Padalarang back operating normally and the voltage on the rails that were previously under the limit SPLN, now the value of the voltage is at SPLN tolerance limits, in Table 4.12 indicated that the minimum voltage after LS1 amounted to 135.0 kV on the rail Cigereleng.

Shedding2 load simulation (LS2) is the solution to kontingensi1 case, the interference on a channel Padalarang Cirata2 which causes the channel regardless of the system. Here is the data for the load shedding LS2 solution:

Table 8. Load Data Released on LS2

| NO. | LOAD ID          | LOAD (MVA) |
|-----|------------------|------------|
| 1   | LD BDU TR III    | 24.5       |
| 2   | LD CBBAT I       | 23.8       |
| 3   | LD GRLG VII      | 20.3       |
| 4   | LD LGDAR I       | 19.8       |
| 5   | LD PDRLG II      | 8.6        |

The simulation results load shedding 2 tables on the data obtained as follows:

Table 9. Results of Simulation Solutions LS2

| Kondisi | Rel Voltage (kV) | Line         | Inom (A) | I_L (%) |
|---------|------------------|--------------|----------|---------|
| Before LS2 |                  |              |          |         |
| Padalarang | 126.1            | Cirata 1 – Padalarang | 1400 | 67.4 |
| Bdg Utara  | 125.5            | Cirata 2 – Padalarang | 1400 | -     |
| Cibabat   | 125.6            |              |          |        |
| Cigereleng| 124.8            |              |          |        |
| Lagadar   | 125.4            |              |          |        |

After LS2

| Kondisi | Rel Voltage (kV) | Line         | Inom (A) | I_L (%) |
|---------|------------------|--------------|----------|---------|
| Padalarang | 137.5            | Cirata 1 – Padalarang | 1400 | 42.8 |
| Bdg Utara  | 137.3            | Cirata 2 – Padalarang | 1400 | -     |
| Cibabat   | 137.2            |              |          |        |
| Cigereleng| 136.8            |              |          |        |
| Lagadar   | 137.1            |              |          |        |

From Table 9 it can be concluded that by means of load shedding by 88 MVA or 26.4% of the total power when a contingency one, making loading channel decreased and the voltage on the rail Padalarang, North Bandung, Cibabat, Cigereleng and Lagadar changing values become normal, ie located on the boundary SPLN. Likewise in the same manner simulating LS3, LS4, LS5, LS6 and LS7 for kontingensi2, kontingensi3, kontingensi4, kontingensi5, and kontingensi6

3.4. Conclusion

1. Concentration of skim milk 7% and fermentation time 27 hours is formulation that is liked by panelis based on hedonic test.
2. Chemical content of mung bean kefir that is liked by panelists has pH 3.8, acid total is 0.27%, alcohol level is 0.38% and its viscosity is 3.35 dPaS.

Conclusion
1. The value of the voltage on the rail substations in every case study contingency (N-1) decreased below the lower limit SPLN, i.e. -10%. Hence, in the contingency (N-1) voltage at 150 kV Cirata subsystem unreliable.
2. Of the 17 units of transformers, there are two transformer units are low power factor, namely the transformer Lagadar 1 and 2. Thus subsystems Pabuaran Cirata 150 kV if judged by the quality of power is said to be a little less reliably.
3. Of the five cases, SAIFI value most and are out of the standard value occurs in one case only, namely when load shedding 2 (LS2). While most large SAIDI index and are outside the standard value occurs in two cases, namely when load shedding 2 (LS2) and load shedding 5 (LS5). So subsystem Cirata 150 kV when rated on the two indices above said not reliably when Contingency Contingency 1 and 4.
4. To improve the system of contingency due to interference can be done by the release of the load (load shedding).

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