Contingency Analysis of South Bandung Electric Power System

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Abstract. Electric power transmission system must operate reliably and continuously, but in fact there are many disturbance that affect the reliability and stability of the power system. This study aims to determine the weak elements of power system when release of components occur. This study uses simulation with Newton Raphson power flow method for contingency analysis. The study is located in South Bandung electric power system with voltage of 150 kV. In this study, the object of contingency analysis is IBT-II 500/150 KV at peak periods load in 2013 to evaluate the system reliability when release of the Inter bus Transformer (IBT). Selection of the component is based that IBT is the most important component in the power supply that should be maintain continuously. The results of the study and analysis show that in the event of contingency almost all bus voltage has decreased below the limit allowable voltage and IBT-I get overloaded, then the maneuver is performed according to the procedures of specified load. The results of this study can be use as a reference for the electric power operating system which has conditions similar to the simulated cases.

1. Introduction
In the past many widespread blackouts have occurred in interconnected power systems. Therefore, it is necessary to ensure that power systems should be operate most economically such that power is delivered reliably [1]. Contingency analysis is an analysis to determine the power flow changes as a result from outage of one of the components of the power system. The outage can occur due to failure of component or because it will do regular maintenance and should be taken off from the power system [2]. Therefore, contingency analysis can be a solution to analyze an electric power system to prevent blackouts. Contingency analysis can also be a reference for security planning the optimal operation of the power system [3].

Contingencies have any impact on power flows and voltage on the buses that are in a sub-system, then the results of the contingency analysis can be operation planning of the power system to operate normally with certain limits. Contingency analysis is one of the security system function and must be conducted to know the next condition after contingency occur [2].
From the contingency analysis, we will get some parameters required in the planning system, which is identify critical contingency, identify potential outage that can lead breakout, determine which weak parts of the transmission system, and if necessary, load shedding can minimize the amount of system outage to maintain reliable operation of power system. From previous study, Contingency analysis is very useful for planning the power system network [4] as well as designing a system to detect weaknesses in their entirety [5]. Because the important of contingency analysis, and there are no research that analyze South Bandung power system, so the researchers decide to conduct it.

The research conducted to know weak component of South Bandung power system when contingency condition occur, so it can help for avoiding blackout. In the simulation will determine voltage at every bus, operation condition and how to do load maneuver if IBT (Inter Bus Transformer) II as the biggest contingency index fall on outage [6]. So we can know where the bus from South Bandung System that has potential to overload or voltage problems arising from contingencies then it can be directly obtained maneuvering solution of the load and system reliability can be maintained.

2. Method
There are methods used in Contingency analysis [7-11]. This research conducted by load flow contingency analysis using Newton Raphson method [12]. The object of simulation is South Bandung power system, because it is one of the most vital sub-systems in West Java, in terms of political, this system plays an important role as a center of government and should be kept out of things that can disrupt the continuity of electricity supply. In terms of load, this system is the fastest growing region, therefore it should be analyzed periodically to provide optimum electrical circulation. Consideration of component IBT 500/150 KV selection is there are many risk can happen if the IBT out from system so the simulation system is needed to determine which load need to maneuvered. The data used is the peak load of 2013 which occurred on 17 October 2013 at 19:00 pm. Following flowchart of the research:
The research start with data collection from Indonesia Electrical Company and then identification data conducted to defined which data needed for the simulation. After the data completed, simulation is performed and the researchers make some analysis to find the maneuver scheme for avoiding blackout. Analysis conducted with Newton Raphson load flow method. Following single line diagram of the simulation.

**Figure 1.** Flowchart of the research.
Figure 2 shows the single line diagram of South Bandung power system which has IBT-II as object of the simulation. From the simulation conducted will show how condition of the system when IBT is out from the system.

3. Result and Discussion

3.1. Normal Condition
When system at normal condition, it is assumed all components connected to the system. The data in the form of voltage values in the KV and load value in MW and MVAR. Furthermore, that will be emphasized is the analysis on each bus to see if there is a bus that crosses the line voltage in the range of +5% and -10% from 150 KV [13]. Following graphic of normal condition voltage at every bus:
When simulating normal condition of the system, there is GI Cianjur that occurs at 89.99% voltage or 0.01% less than the minimum allowable voltage standards based PLN. This is due to many industries are located around this GI. This will certainly affect the stability of the voltage on the bus around it.

3.2. Contingency Condition

When contingency occur, the simulation done by removing the appropriate component that has been determined, that is IBT-II at line GITET South Bandung to GI South Bandung. In this simulation will be analyzed how changes occur and what the resulting impact that could disrupt power flow value flowing. Following general data on the contingency condition compared with the data during the simulation at normal condition.

| Condition   | Contingency | Normal   |
|-------------|-------------|----------|
| Load-MW     | 908.823     | 1007.941 |
| Load-Mvar   | 502.027     | 517.84   |
| Loss-MW     | 15.839      | 15.654   |
| Loss-Mvar   | 205.594     | 188.167  |

It is seen that when a contingency occurs, there is amount of losses, and overall flow of power losses when contingency condition is greater than losses at normal condition. This is harm to both the PLN as the electricity provider as well as for consumers. At the time of outage of IBT-II, the system becomes unstable due to insufficient supply of energy. Great power that should be borne by two IBT, be borne by the only IBT so it made IBT exceeding the capacity of its ability.

From the simulation obtained that the system has run into abnormality operating voltage. If this lasts for a long time, then the system at the risk of blackout. Following graphic of the voltage:
At the time outage of IBT-II simulation GITET South Bandung, there are some GI which run into under voltage these are GI South Bandung amounted to 89.36%, GI Cigereleng amounted to 87.39%, GI Cibeureum amounted to 87.19%, GI Cianjur amounting to 85.23%, GI Panasia amounted to 88.88%, GI Kamojang amounted to 89.49%, GI Cikasungka amounted to 87.95%, GI Rancakasumba amounted to 87.82%, GI North Bandung amounted to 86.06%, GI Dagopakar equal to 86, 3%, GI Rancaekek amounted to 87.44%, GI Ujungberung amounted to 86.48%, and GI Kiaracondong amounted to 87.02%, or in other words almost all GI run into decreased voltage.

When contingency condition occur, part of the operating system should immediately take a decision to carry out the maneuver loads in coordination with the dispatcher on the field. Maneuvers should be a final decision and should not be arbitrary in determining which load to be off because it would create new problems. So the simulation is important to be done before the outage really occurred.

3.3. Recovery Condition
In this simulation, created maneuver the load solutions due to the outage of IBT-II at South Bandung electric power systems. The processes of the maneuvers load is when IBT off, OCR (Over Current Relay) work to provide current limitation borne by IBT are still connected to the system. And then Tele protection enabled to disconnect the line or load being targeted OLS (Over Load Shedding) which can’t be reached directly by field officers, especially for load with radial network. After that communication with plants in other areas is done to supply the region of load or line being targeted OLS, while awaiting IBT can be used again it is conduct to make consumers didn’t feel the shedding. If entering of loose components (IBT) lasted a long time and supply from other areas still can’t meet the system, then rolling blackouts is done until the loose IBT can re-enter.
Table 2. OLS load target

| Stages | GI   | Load              |
|--------|------|-------------------|
| Stage 1| GI BDSLN | TRF – 3          |
|        |       | PNSIA 1 – 2      |
|        | GI CGRLG | IBT 2 150/70 KV  |
|        | GI UBRNG | TRF – 3          |
|        |       | TRF – 5          |
|        | <     | DGPKR 1-2        |
| Stage 2| GI CGRLG | TRF – 6          |
|        | GI BDSLN | TRF – 1          |
|        | GI CNJUR | TRF – 3          |

From the above OLS targets, carried out two stages, if by one stage release the system is back to normal then the second stage is not necessary, and vice versa. After release of the load, the voltage returns to normal values and other buses that still connected are not being under voltage so at least there are buses that can be saved, and decrease the risk of blackout. Following Voltage at every bus after load shedding:

![Voltage at every bus after load shedding](image)

**Figure 5.** Voltage at every bus after load shedding

In this simulation, the direct load shedding is done in two stages because after stage one is done there are still under voltage bus remaining. After the release, it appears that all of the buses are still connected back to the normal condition.

3.4. Compare of the result
From the simulation, there are voltage changes after load maneuver is done from contingency condition. Following the voltage comparison of improvement condition:
Table 3. Voltage comparison of improvement condition.

| Bus ID   | Normal condition | Contingency condition | After Maneuver |
|----------|------------------|-----------------------|---------------|
| BDSLN I  | 141.54           | 134.04                | 142.38        |
| BDSLN II | 141.54           | 134.04                | 142.38        |
| BDUTR I  | 135.99           | 129.09                | 0             |
| CBREM    | 138.11           | 130.78                | 140.05        |
| CGRLG I  | 138.42           | 131.08                | 140.38        |
| CKSKA I  | 138.74           | 131.92                | 141.6         |
| CKSKA II | 138.75           | 131.95                | 141.63        |
| CNJUR    | 134.99           | 127.84                | 138.16        |
| DGPKR I  | 136.38           | 129.45                | 0             |
| KMJNG I  | 141.03           | 134.23                | 143.61        |
| KMJNG II | 141.03           | 134.23                | 143.61        |
| KRCDG I  | 137.61           | 130.53                | 140.2         |
| PNSIA    | 140.78           | 133.32                | 0             |
| RCKBA I  | 138.53           | 131.73                | 141.39        |
| RCKBA II | 138.53           | 131.73                | 141.39        |
| RCKEK II | 138              | 131.16                | 141.06        |
| UBRG I   | 136.67           | 129.72                | 140.13        |
| UBRG II  | 136.67           | 129.72                | 140.13        |
| WYWDU    | 142.82           | 135.76                | 144.49        |
The comparison table above shows that when a contingency occurs, there are voltage drop exceeds the maximum allowed. Therefore load maneuver is done to reduce the amount of reactive power flowing in the system, so the voltage after maneuver back to normal condition and the most important is avoid the risk of blackout.

Sequence of reentering components can be done conditionally, but on the pitch maneuver loads have certain considerations, including these areas are vital and must not be extinguished in a long time, for example, public services, central government, etc. and the area is close to the source of power supplies such as generators or IBT so that it becomes the path for the electricity supply to the bus afterwards.

4. Conclusion
From the simulation results obtained that at normal condition there is power flow bus voltage value below allowable limits that need to be improved. When contingency condition, almost the entire bus voltage decreased and it would at risk of total blackout, therefore, be anticipated by doing maneuvers load. Analysis of the contingency can be used as solution for planning the power system operation by identifying the weak components to minimize the impact of failures that cause the release of components.

5. Suggestion
For the next research, contingency analysis can conduct with another method especially for vital region which needed high continuity electrical system.

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