

The Method to Create Transmission Lines and Increase the Power System Stability by Using Interconnection System Model

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Abstract—because Java-Bali system is weak. The power system stability needs to be increasing the 500 kV transmission lines. The construction of the south transmission line, planned since 1996, has been hampered by land acquisition problems. Locals in Depok in West Java and in Klaten and Bantul, Central Java, have refused to make way for the power line.

A simulation by using Etap Power Station shows phenomena occurred during the blackout on August 18th 2005 the northern transmission line capacity extremely high (EHV) 500 KV transmission line Saguling-Cibinong (middle transmission line) is the only interconnected transmission line to invert electrical power from power station in East Java to West Java and Jakarta. The interconnection network along the Saguling-Cibinong transmission line cannot handle additional load since it almost reach its capacity limit. Moreover it is not flexible enough to supply power to Jakarta.

By adding the north transmission line Muaratawar-Cawang and Muaratawar-Cibinong, power supply from Muaratawar Steam Power Plant to Region 1 in third condition fifth phase will cause a large decreasing towards current line at the Saguling-Cibinong transmission line.

Keywords—blackout, security, EHV 500 KV, transmission line.

I. Introduction

Any disruption in the power interconnection system can affect the entire system. The worst impact that could be happened with the system is total, regional or partial blackout. As shown in Table I.

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TABLE I. LARGEST BLACKOUTS IN HISTORY [1][2][3]

Ranked	Blackouts	People Affected	Location	Duration
1 st	Java-Bali	100 M	Indonesia	2005-08-18
2 nd	Southern Brazil	75 M	Brazil, South, Southeastern	1999-03-11
3 rd	Brazil and Paraguay	60 M	Brazil and Paraguay	2009-11-10 2009-11-11
4 th	Italy	55 M	Italy	1999-03-11
5 th	Northeast 1	50 M	North America Northeastern	2003-08-14 2003-08-15
6 th	Northeast 2	30 M	North America Northeastern	1965-11-09

About 100 million people, half of Indonesia's population got impact of power outage that cut electricity to homes, businesses and trains. It also caused major traffic jams in the capital city. A failure in 500 kV transmission line between Cilegon and Saguling in West Java cut electricity supplies at 10.23 a.m. The fault caused disengages several power plants units from the network. Two units of the Paiton plant in East Java and six units of the Suralaya plant in West Java were shut down.[1]

The weakness of Java and Bali power system is caused by the lack of spare power stations and minimal transmission line (at the time of blackout on August 18th 2005 in the interconnection between Java and Bali only relying on the middle section Saguling-Cibinong temporarily northern and southern section is still incomplete). The network in tact (middle section) cannot handle additional load since that event almost reach its capacity limit.

Java-Bali blackout system might be cause by several issues such as:

1. A transmission line between cilegon and saguling leads to cascading failure.
2. Two units of the paiton plant in east java and six units of the suralaya plant in west java.
3. Loss of 2300 MW of generation that is roughly half of the supply.
4. Deficit of power due to low generation.

Lesson learnt:

1. Adequate generation to meet the needs
2. Adequate transmission line to withdraw power if N-1 Security fails.

The experts described this research on the investigation of grid blackouts. Operational mechanisms in the first condition should still be tried to maintain so that the transmission current line meets the N-1 criteria. If the first condition criterion is met, the current Saguling-Cibinong should be limited to 1000 A on each transmission line. Recommendations made in this study is regarding possibility of adding new lines of EHV 500 kV most optimal. Most effective how many transmission line should be build to maintain the system stability in the future.

II. Modeling Case

A. Case Study by Using the Java-Bali System

Data transmission system buses Java-Bali 500 kV are classified as follows:

- a. Swing Bus: Saguling.
Saguling EHV voltage is voltage in the actual Conditions of the most stable and connected in AGC (automatic governor control).
- b. Controller Bus: Cirata, Muara Tawar, Suralaya, Gresik, Tanjung Jati, Grati, and Paiton.
- c. Load Bus: Cilegon, Kembangan, Gandul, Cibinong, Cawang, Bekasi, Cibatu, South London, Mandiracan, Ungaran, West Surabaya, Depok, Tasikmalaya, Pedan, Kediri.

B. Algorithm to Maintain the System Stability in the Future Models

The simulation performed during this research is based on the occurrence of trouble pursuant to the electrical blackout of the Java-Bali system on August 18th 2005. It compiled of the following conditions:

- 1) Transfer power of the Saguling-Cibinong line EHV only represents the main line running from East Java to West Java.
- 2) A simulation related to the first condition, in which there is a EHV Line Saguling-Cibinong, also an additional EHV southern line on the Tasik-Depok-Gandul 2 circuit.



Figure. 1. Single line diagram

- 3) A simulation related to the first condition, in which there is a EHV Line Saguling-Cibinong, as well as an additional EHV Line Northern Muaratawar-Cibinong 1 circuit and Muaratawar-Cawang 1 circuit.
- 4) A simulation related to the first condition, where there is a Saguling-Cibinong transmission line, there is also an additional EHV North transmission line Muaratawar-Cibinong Circuit 1, a Muaratawar-Cawang circuit 1, and an additional EHV Southern Transmission line Tasik-Depok-Gandul.
- 5) A simulation related to the first condition, where there is a EHV Line Saguling-Cibinong trip, there's an additional EHV Northern Line Muaratawar-Cibinong Circuit 1, Muaratawar-Cawang Circuit 1, and also an additional EHV Southern Line Tasik-Depok-Gandul. Fig. 1 shows the area where the blackout occurred.

III. What Caused The Blackouts?

From each of the five conditions, there are six phases that have been adapted to the sequence which occurred during the Java-Bali System blackout on August 18th 2005 as follows:

1. The first phase at 08:59 WIB
Before Suralaya Steam Power Plant Unit 6 and 7 trips, the power balance on Java Bali System was fulfilled at normal frequency with:
 1. Region 1 Power station: 4744 MW
 2. Region 2 Power station: 956 MW
 3. Region 3 Power station: 791 MW
 4. Region 4 Power station: 4517 MW
 5. Total Java Bali system power station: 11008 MW.
2. Second phase at 08:59:27 WIB
Suralaya Unit 6 and 7 trips, Unit 5 run-back (decrease in power station capacity caused by disturbance) from 525 MW to 220 MW.
Loss of 1359 MW power station power in Region 1.
3. Third phase at 09:00:09 WIB
Priok Steam Power Plant #1.3 with DMN (netto power) 125 MW and Tambak Lorok Steam Power Plant ST 1.0 DMN 120 MW trip.
4. Fourth phase Load shedding
Decreased frequency System to with 48.6 Hz and happen automatic load shedding
Using UFR with total load released 335.25 MW with the following details:
 - first phase to 5 Region 1 with total load released 281.76 MW
 - 5 unit GI in Region 2 with total load released 32.71 MW
 - 8 unit GI in Region 3 with total load released 10.52 MW
 - 7 unit GI in Region 4 with total load released 10.26MWFrequency increased and reached a normal frequency around the hour of 09:10 WIB.
5. Fifth phase at 09:10 WIB
To make up for the shortage of supply power in Region 1, P3B ran power station Saguling hydro power 2x175 MW, Cirata 4x125 MW, along with Muaratawar Blok 3 and 4.
6. Sixth phase at 10:23:30 WIB
EHV central line Saguling-Cibinong circuit 2 tripped causing circuit 1 to trip at the hour of 10:23:32 WIB.

IV. Simulation by using Etap Power Station

Input data is in need:

1. Active and reactive power load and generation at each bus.
2. Applied voltage at each node bus.
3. Impedance magnitude per kilometer of 500 kV line
4. Large spacing between lines 500 kV bus (kilometer)

The simulation by using an Etap Power Station requires

predetermines parameter including number of iteration and precision. Higher number of iteration and precision requires longer computational time. Minimal number of iterations and the minimum level of precision that would require minimal effect on the results of calculations can converge on the run.

The result illustrating previous running in appropriate cases Model the incident electric power system blackout Java-Bali on August 18th 2005 is shown in Fig. 2

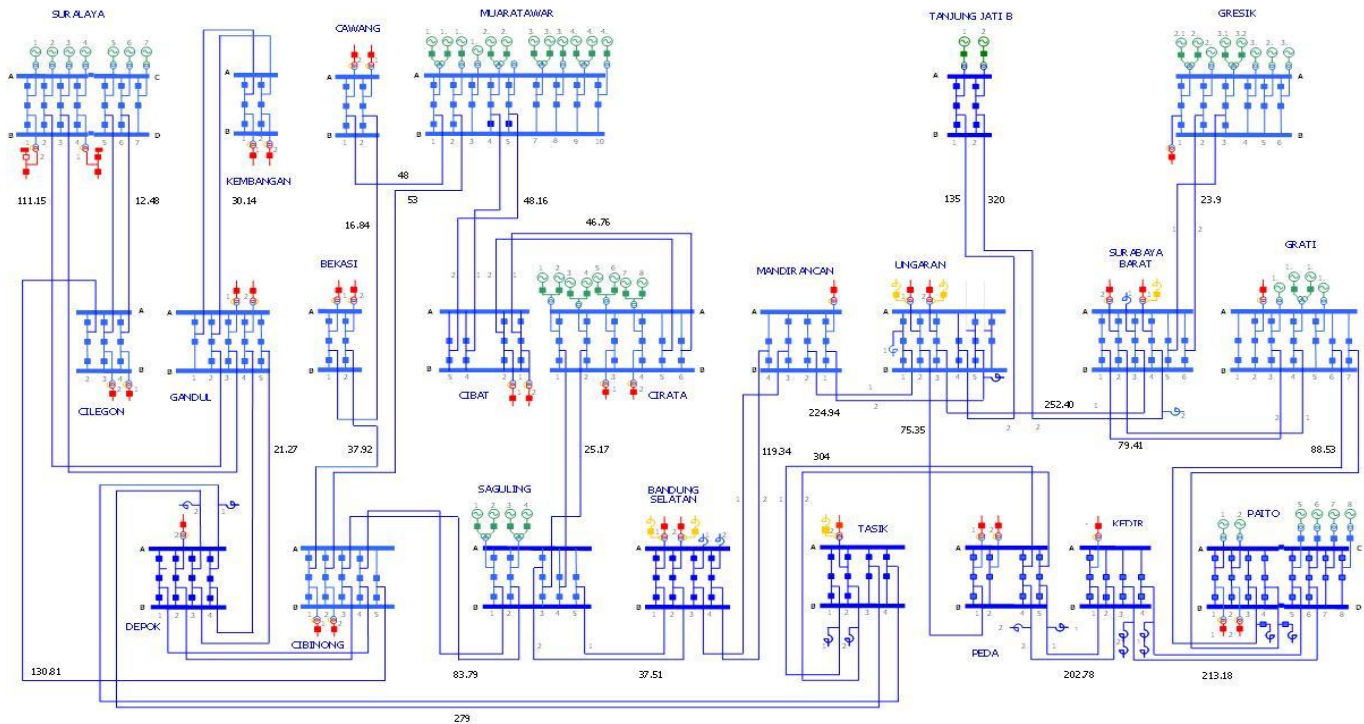


Figure. 2. Display network model by using software Etap Power Station

v. Simulation Results

Following are results of the electrical simulation conducted with software at the Etap Power Station. The maximum transmission lines limit in transmission line EHV Saguling-Cibinong 2 Circuit is 2,000 A (limited by the transformer current capacity installed). It means that current transmission line above 1000 A does not meet security N-1. This is caused by, in the case of transmission line current per circuit flowing above 1000 A then it will a trip will occur in Circuit 1 meaning the transmission line current will add on to the load of the first circuit until overload occurs at the second transmission line, causing both transmission lines to trip.

Based on the data shown in Table II. Additional of the EHV southern line at Depok-Gandul Circuit 2 in Second Condition tripped Circuit 2 Saguling-Cibinong at second phase and even third phase. However, adding EHV northern

lines Muaratawar-Cibinong and Muaratawar-Cawang in third Condition might have prevented the blackout on August 18th 2005.

All conditions show that 2nd Phase and 3rd Phase are the most vulnerable against the occurrence of a trip on the Saguling-Cibinong line from other phases.

Table II, also appears that in 1st condition, the trip incident on Circuit 2 of the Saguling-Cibinong line following 5th Phase (blackout August 18th 2005) could have been prevented by adding EHV northern lines Muaratawar-Cibinong and Muaratawar-Cawang, or adding the EHV southern line Depok-Gandul Circuit 2.

VI. Conclusion

According to the aforementioned discussion, it can be concluded that:

1. Transfer of power between regions remains safe enough at first phase of all conditions since it has not yet surpassed the technical limits.

2. The configuration of the condition that met the N-1 security criteria as simulated in this research are 3rd condition and fourth condition. Third condition would be the most effective condition.

TABLE II. SIMULATION MATRIX CONDITION

Event	Transmission line	First Condition current (A)	Second Condition current (A)	Third Condition current (A)	Fourth Condition current (A)	Fifth Condition current (A)
First Phase	Saguling-cibinong	768	302	453	148	562
	Depok - Gandul		557		547	
	Muaratawar-cibinong			138	- 70	
Second Phase	Muaratawar-cawang	1515		531	387	498
	Saguling-cibinong		1084	953	679	483
	Depok-Gandul		436		414	
Muaratawar-cibinong		396	248	955		
Third Phase	Muaratawar-cawang	1585		718	602	1133
	Saguling-cibinong		1584	996	996	- 6
	Depok-Gandul		- 6		- 7	
Muaratawar-cibinong		407	407	1582		
Fourth Phase	Muaratawar-cawang	1406		754	753	1635
	Saguling-cibinong		998	881	622	460
	Depok-Gandul		418		398	
Muaratawar-cibinong		355	218	862		
Fifth Phase	Muaratawar-cawang	1406		684	573	1060
	Saguling-cibinong		886	776	453	601
	Depok-Gandul		580		556	
Muaratawar-cibinong		475	308	759		
Sixth Phase	Muaratawar-cawang	2044		773	625	973
	Saguling-cibinong		678	579	- 200	654
	Depok-Gandul		702		655	
Muaratawar-cibinong		646	294	265		
	Muaratawar-cawang		828	556	546	

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References

- [1] www.wikipedia.org
- [2] www.nrelect.com , PSCSTM : Power Stability Control System
- [3] Prof Xinghuo Yu, Smart Grids : A Complex Network View, RMIT University, Australia 2011.
- [3] Mulyo Adji AG, Gambaran Umum Pengelolaan Electrical power system Java Bali, PT.PLN (Persero) Penyaluran and Pusat Pengatur Load Jawa Bali, 2005.
- [4] G. Andersson, P. Donalek, R. Farmer, N. Hatziaargyriou, I. Kamwa, P. Kundur, N. Martins, J. Paserba, P. Pourbeik, J. Sanchez-Gasca, R. Schulz, A. Stankovic, C. Taylor, and V. Vittal , *Causes of the 2003 Major Grid Blackouts in North America and Europe, and Recommended Means to Improve System Dynamic Performance*, IEEE Transactions ON Power Systems, Vol. 20, No. 4, November 2005.
- [5] S. Corsi, C. Sabelli, General Blackout in Italy Sunday September 28, 2003, h. 03:28:00, IEEE 2003.
- [6] John F.Hauer, Navin B.Bhatt, Kirit Shah, Sharma, Performance of "WAMS East 1 " in Providing Dynamic Information for the North East Blackout of August 14, 2003, IEEE 2003.
- [7] A. Berizzi, The Italian 2003 blackout, IEEE 2003.