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# Stability and Sustainability Analysis of Power in a Deregulated System

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## ABSTRACT

In a deregulated power system it is expected that the federal government should hand off and involves private operators of electricity to satisfy the system load requirements with a reasonable assurance of continuity and quality stability. Operators are under considerable pressure to run the power system in the most economical manner. Thus producing electrical energy to meet the demand at the lowest possible cost and enabling as many transactions as possible. These economic considerations invariably put more stress on the transmission system because more power ends up being transmitted over longer distances. Balancing the grid for profit and proper faults management are thus crucial to achieve continuity and system stability.

**Keywords:** *N-1 secure system, N-2 secure system, symmetrical faults, unsymmetrical faults, open conductor faults*

## 1. INTRODUCTION

Under deregulated power system, these various units, generation, transmission and distribution are decentralized for effective fault management and control. The resultant effect is that the entire power system is better equipped for real time fault localization and isolation in the event of fault occurrence to enhance power stability. (it should be noted that faults that occurs in any power system whether deregulated or regulated are the same.) Faults are classified into three categories, namely, symmetrical, unsymmetrical and open conductor faults. Symmetrical fault are, three- phase fault, three- phase fault to ground. Unsymmetrical fault are, phase – to phase, two phases to ground and single – phase to ground. While open conductor faults are, one –phase broken wire and two phase broken wire. Avoiding faults and wide scale consumer disconnections are possible provided the system is operated with sufficient security margin. There must be enough reserve generation capacity to make up for the loss of a generating unit and enough transmission capacity to handle the power flow displaced by the outage of a line. It is always possible to dream-up sequence of unfortunate events that would bring distability in any power system, and securing the system against all possible contingencies is clearly impossible. The fundamental principle only calls for securing the system against all credible contingencies. It is typically assumed that the probability of two or more independent faults or failures taking place simultaneously is too low to be considered credible. Most security rules therefore call for the system to be able to withstand the loss of any single component. When the power system satisfies this criterion, it is said to be 'N –I secure'' because it could loss any of its components and continues operating. Similarly, in 'N – 2 secure system', no consumer would be disconnected even if two components are suddenly disconnected, so, stability and continuity of power is guaranteed. Analytical methodology is employed to analyse the system stability and the security cost of a simple two – bus, three – line system against single contingency.

### 1.1 Literature Review

Protection, in general means the function in a power system designed to prevent or minimise damage to equipment, life and property. System instability is prevented; reliability and uninterrupted services are enhanced. The type of protection depends upon the cost criteria or the economics where different types of protection are involved. The earliest form of protection was the fuse and still in use up till date due to its simplicity and cheapness. However it has its limitations, when faulty it requires replacement before power supply could be restored; also lack the speed of operation and selectivity. Another type of protection medium in use these days is the protective relays, with high sensitivity, reliability, selectivity and high speed of operations.

### 1.2 Methodology

The analytical method is employed in this research work to analyse the system stability and the cost of securing a two – bus, three – line system against single contingency. The fundamental principle is that power system should always be operated in such a way that no credible contingency could trigger cascading outages or instability. This approach is chosen because all power systems are routinely affected by unpredictable faults and failures such as lightning strikes on transmission lines, mechanical failures in power plants, or fire in substations. In avoiding faults and wide scale consumer disconnections, the system is operated with a sufficient security margin.

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## 2. SOME ABNORMAL CONDITIONS THAT CAN CAUSE INSTABILITY

1. Overload
2. Over- voltage in the system due to internal (switching) or external (interference).
3. Overheating, due to loss of cooling medium
4. Fire hazards.
5. Unbalanced loading.
6. Loss of synchronism etc.

Some abnormal conditions in a system are not essentially faults but they do cause damages to equipment which invariably leads to power outage, causing instability in the system.

### 2.1 Primary and Secondary Relays

The primary relays scheme are the first line of defence in the system, designed to removed minimum of faulty equipment from service, thereby maintaining stability. The secondary relays scheme is independent of the primary relays scheme and it operates if the primary relay scheme fails. The back-up protection comes in overlapping zones.

### 2.2 Protection Zones

The power system is divided into protective zone that can be protected adequately with the minimum amount of the system disconnected.

The protective zones are

1) Generator
2) Step –up transformers
3) Buses
4) Transmission circuits
5) Step – down transformers

Distribution circuit

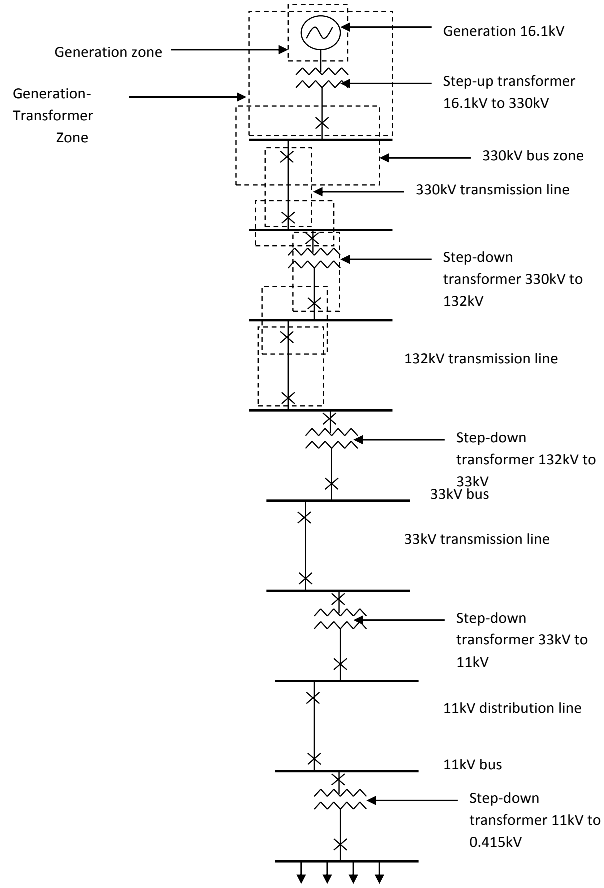


**Fig 1.0 Typical Protection Zones In A Power System**

## 2.3 Securing a Simple Two-Bus, Three-Line System against Single Contingency

## Implementation

Implementing the security concept, figure 2 below is used for analysis.

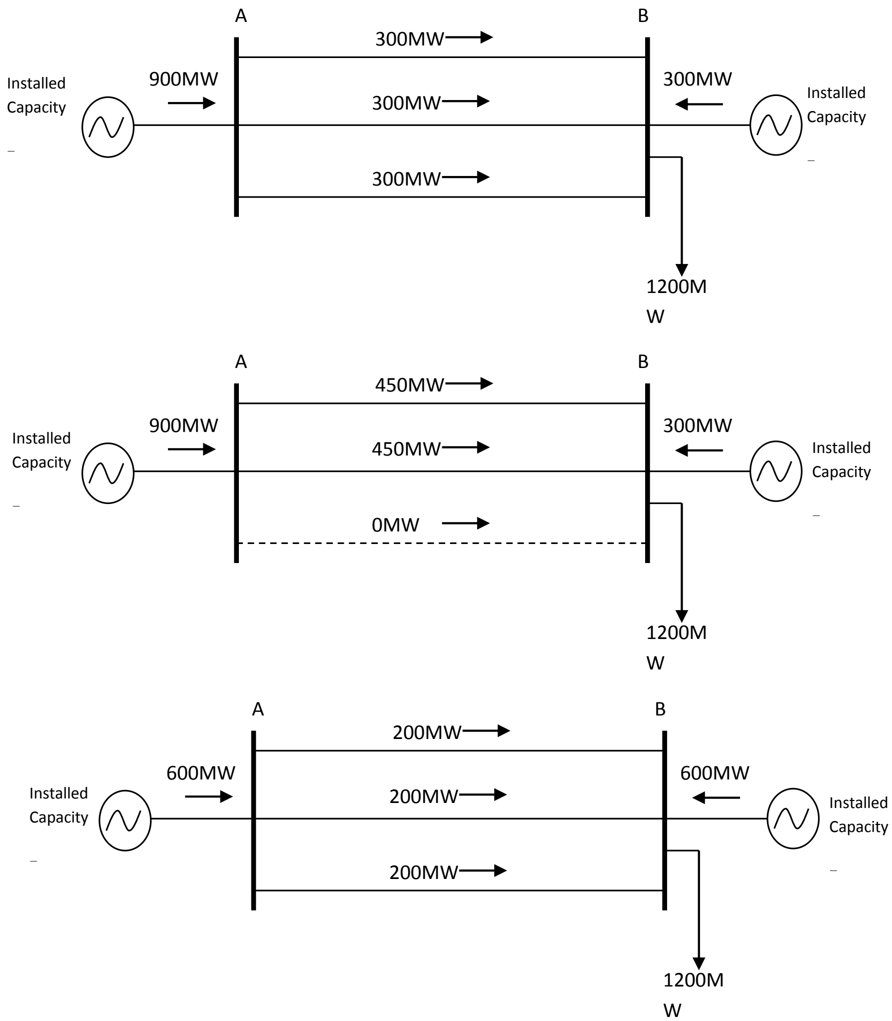


**Fig 2 A simple two-bus, three line system against single contingency**

## 3. RESULTS ANALYSIS

In figure 2 above, N-1secured system is presented and analyse using a simple two- bus, three – line system against a single contingency. Area A and B are connected through a transmission corridor comprising three identical lines, each has a capacity of 300MW. A load of 1200MW is to be served from area B. in the analysis the following assumptions were made;

1. The generators on either area have sufficient capacity to supply the entire load.
2. The marginal cost of energy in area A and B are ₦20/MWh and ₦50/MWh respectively.
3. The cheapest way to supply the load without overloading the lines is to generate 900MW in area A and 300MW locally.

This dispatch and the resulting line flows are presented in figure 2 above.

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## The Cost of Security

The hourly cost of operation for the insecure condition of figure 2A is given as;

$C_1 \times 900 \times 20 \times 300 \times 50 =$ ₦ 33,000/h

Similarly, the hourly cost of operation for the N–1 secure condition of figure 2C is given as;

$C_2 = 600 \times 20 \times 60 \times 50 =$ ₦ 42,000/h.

The ₦ 9,000 per hour difference between the two values represents the cost of security.

## 4. DISCUSSION OF RESULTS

If fault occurs on one of the lines, in a fraction of seconds the protection system for the line detects it and immediately removes it from service. The power that flowed through this line is redistributed between the remaining two lines. This is shown in figure 2B. This redistribution causes heavy overloads. The two remaining lines are likely to be disconnected through the actions of their protection systems. With the loss of a transmission line, the network configuration changes resulting to increase in the system impedance. In view of the above to prevent such cascading outages from leading to a blackout, the following points are suggested.

1. The loading of transmission lines should be limited to a value well below their full capacity as shown in figure 2C 'N-1 secure'' dispatch

2. Dynamic security analysis programs that alert operators to any contingency that would affect the voltage or angular stability of the system should be put in place. Using these programs, operators can check that their systems are in a state that satisfies the security rules.

3. The protection system should be modernized to reduce the probability of malfunction. This enhances the system reliability.

## 5. RECOMMENDATION TO ENERGY CONSUMERS AND SYSTEM OPERATORS

Making a system secures, to be reliable, efficient and stable for power transmission comes at a cost.

1. Consumers have to pay high energy tariff for cost of security as evidence in the analysis.

2. Operators should upgrade transmission networks; transmission capacity can be increased by installing power system stabilizers or inter-tripping schemes that disconnects some customers in a controlled manner to limit disturbances.

## 6. CONCLUSION

Some of the key results achieved in this research work shows that for system stability and reliability, power system operators should adhere strictly to the security rules, transmission capacity should be upgraded and modern protective devices should be installed for efficiency and continuity of power supply. Power stability is the hub of economy growth of any nation. More jobs will be created both in private and the public sectors.

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