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Congestion Management in Restructured Power Systems with Economic and Technical Considerations

R. Manikandan [a, *], P. Kavya [b], R. Shalini [b]

[a] Assistant Professor, Department of Electrical and Electronics Engineering, Vivekananda College of Engineering for Women, Tamil Nadu, India.

[b] UG Student, Department of Electrical and Electronics Engineering, Vivekananda College of Engineering for Women, Tamil Nadu, India.

*Corresponding Author:eeemanikandan25@gmail.com DOI: https://doi.org/10.34256/bsr1916

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Abstract: In this paper, restructuring of monopolistic power systems is inevitable in this day and age to cope up with the radical growth of power demand. In developed countries restructuring is already in place while developing countries are getting accustomed to it. Above and beyond the benefits to customers in terms of economy and quality, there are several challenges prevailing particularly in transmission while exercising deregulation. The foremost challenging task of Independent System Operator (ISO) is managing the transmission line congestion in a deregulated power system. In most of the congestion management techniques, only the economic aspects are considered. The minimum voltage derivation for electronic industries and acceptable voltage derivation for high power applications are considered with suitable weighting factors in the objective function.

Keywords: Independent System Operator (ISO), Power Systems,

1. Introduction

Power system security is one of the crucial tasks for power system engineers. Contingency analysis is used to predict the loss or failure of the transmission line, generator or the transformer. It is used to find out the line overloads or voltage violations and to start measures to remove these violations. It is of two types of violations occur, one is low voltage violations and other line MVA limits violations. FACTS devices are placed in transmission lines. FACTS are power electronic based and other static controllers to improve the quality of controllability and increase power transfer capability [1]. It can be defined as the specific set of events occurring within a short duration of time. With the global trend towards deregulation in the power system industry, the complexity of contingency analysis results in daily operation and system studies have been increasing. Not only deregulation resulted in much large system model sizes, but also contingency analysis computed in the restructured power markets to monitor the states of the systems [2]. A disturbance that can occur in the network and can result in possible loss of parts of the network like buses, lines, transformer or power units. Load flow analysis is an adequate means for studying the effect of a possible contingency on a given operating point of a network [3]. Two types of violations-low voltage and line MVA limits violations. LOW VOLTAGE VIOLATIONS-This type of violations occurs at the buses. This suggests that the voltage at the bus is less than the specified value. The operating range of voltage at any bus is generally 0.95-1-05p.u. Thus if the voltage falls below0.95 p.u, then the bus is said to have low voltage. If the voltage rises above the 1.05 p.u, then the bus is said to have a high voltage problem. It is known that in the power system network generally reactive power is the reason for the voltage problems. Hence in the case of low voltage problems reactive power is supplied to the bus to increase the voltage profile at the bus. In the case of high voltage reactive power is absorbed at the buses to maintain the system normal voltage. LINE MVA LIMIT VIOLATIONS-This type of contingency occurs in the system when the MVA rating of the line exceeds given rating. This is mainly due to increase in the amplitude of the current flowing in that line. The lines are designed in such a way that they should be able to withstand 125% of their MVA limit. Based on utility practices, if the current crosses the 80-90% of the limit, it is declared as an alarm situation [4]. Contingency analysis is one of the "security analysis" applications in a power utility control centre that differentiates an Energy Management System (EMS) from a less complex SCADA system. Its purpose is to analyse the power system in order to identify the overloads and problems that can occur due to a "contingency". It is abnormal condition in electrical networks. It occurs at whole system or part of a system under stress. It is due to the sudden opening of the transmission line, generator tripping, and sudden change in generation, sudden change in load value. It provides tools for managing, creating, analysing and reporting lists of contingencies and associated violations [5]. Most power systems are designed with enough redundancy so that they can withstand all major failure events. Contingency analysis is one of the major components in today's modern Energy Management systems. For the purpose of fast estimating system stability right after outages, the study of contingency analysis involves performing efficient calculations of system performance from a set of simplified systems conditions [6]. Contingency analysis is used as a study tool for the offline analysis of contingency events, and as online tool to show operators what would be the effects of future outages.

1. security is determined by the ability of the system to withstand equipment failure.

2. Weak elements are those that present overloads in the contingency conditions (congestion).

3. Standard approach is to perform a single (N-1) contingency analysis simulation.

4. A ranking method will be demonstrated to prioritize transmission planning.

5. Congestions are therefore a primary tool used for the preparations of the annual maintenance plan and the corresponding outage schedule for the power system [7]. Most important task encountered by the planning and operation engineers for bulk power system. The line outage distribution factor (LODF) is one of the important linear sensitivity factors which play a key role in finding the effect of the critical contingencies and hence suggesting possible preventive and corrective actions to solve the violations in the system.1.LODFs are used to approximate the change in the flow on one line caused by the outage of second line.2.typically they are only used to determine the change in the MW flow compared to the pre contingency flow.3.LODFs are approximately independent of the flows but depend on the assumed network topology[8]. Power Transfer Distribution Factors (PTDFs) show the linear zed impact of a transfer of power. The increasing load demand in power systems without accompanying investments in generation and transmission has affected the analysis of

stability phenomena, requiring more reliable and faster tools. Power Transfer Distribution Factor (PTDF) is the comparative change in the power flow on a particular line due to a change in vaccination and conforming withdrawal at a pair of buses. PTDFs are depending on the topology of the electric power system, the behaviour of controllable transmission system elements as their parameters are advanced, and on the operating point. That is, PTDFs change when outage of line happens, if a controllable element reaches its control limits, also has the pattern of injections and withdrawals change the loadings on the line in the system. For the case of undistinguishable radial parallel lines, however, the PTDFs are completely autonomous of line loading. Moreover, it is known empirically that, given a fixed topology and disregarding controllable device limits, the PTDFs are relatively insensitive to the levels of injections and withdrawals [9] and [1]. Contingency analysis has been an integral part of power system planning and operations. Dynamic contingency analysis is often performed with offline simulation studies, due to its intense computational effort. Due to a large number of possible system variations, covering all combinations in planning studies is very challenging [10]. In power system operation, transmission congestion can drastically limit more economical generation units from being dispatched. In this work, optimal transmission switching as a congestion management tool is utilized to change network topology which, in turn, would lead to higher electricity market efficiency [11]. Congestion management is applied for two broad paradigms. They are cost free means and not cost free means. The past includes actions be like out-aging of congested lines or operations of transformer taps, phase shifts or facts devices. These means are termed as cost-free only because the marginal costs (and not the capital costs) involved in their usage are nominal. The not-cost-free means include1. rescheduling generation –this leads to generation operation at an equilibrium point away from the one determined by equal incremental costs. Mathematical models of pricing tools may be incorporated in the dispatch framework and the corresponding cost signals obtained. These cost signals may be used for congestion pricing as indicators to the market participants to rearrange their power injections/extractions such that the congestion is avoided. 2. Prioritization and curtailment of loads/transactions –a parameter termed as willingness-to-pay-to-avoid-curtailment is introduced. This can be an effective instrument in setting the transaction curtailment strategies which may then be incorporated in the optimal power flow framework. The dispatch problem has been formulated with two different objective functions: cost minimization and minimization of transaction derivations. Congestion charges can be computed in both the cases [12]. In a restructured environment, each buyer can buy the power from the cheapest generation existing, within geographical location of buyer and seller as well. Congestion occurs when the system operator finds that all the transitions are not allowed due to overloading on the transmission networks. The scale of transmission congestion management in the deregulated environment involves defining a set of rules to ensure control over generators and loads in order to maintain acceptable level of system security and reliability. These rules should ensure market efficiency maximization with short term as well as long term horizons. In a restructured structure, the market must be modelled so that the market participants or (buyers and sellers of energy) hold freely transactions and play as per as market forces but in a manner that does not threaten the security of the power system [13]. Congestion management has across the world become an important activity of the power system.

2. Power World Simulator

When power World Corporation first introduced simulator in the mid 1990s, we introduced a new interface to power system analysis that was built on top of the Windows 95 platform. This interface made your power system analysis tool look and feel the same as other software used on daily basis. The heart of this interface was the familiar menu structure still used by most software today. In simulator 5.0 we first introduced toolbars to the interface, which complemented the traditional menu structure.

Since that time, simulator has grown substantially as more and more features have been added to make your analysis faster, easier, and more convenient. However, the basic user interface with the menu structure and toolbars remained unchanged. Over the last few versions of our products, we have found it increasingly difficult to fit all these new features into the menu and toolbar structure in a manner that made the program approachable and continued our history of being easy to use for all users.

The primary flaw with the menu structure is that all menu items and toolbar buttons visually appear to have the same priority, making it difficult to signal to the user the most commonly used features were added, the menus got longer making.

3. Result and Discussion

This contingency may cause transmission line overloading and bus voltage limit violation. So the violation of the generation, transmission line and transformer losses are tabulated. And the selection of contingency is based in maximum violation in the system to be selected.

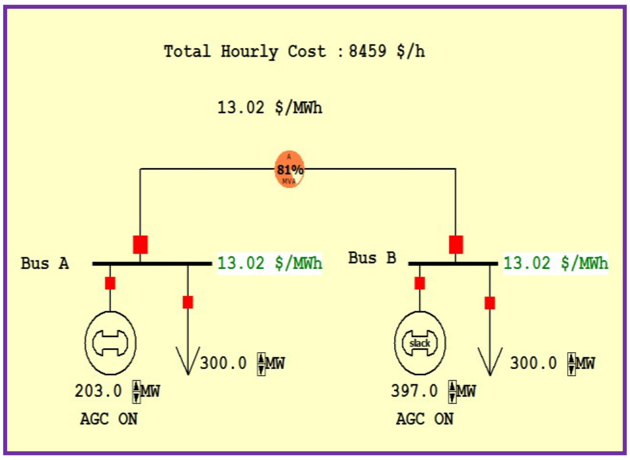

Figure 2.1. bus system power flow Diagram

	Label	Skip	Processed	Solved	Post-CTG AUX	Islanded Load	Islanded Gen	QV Autoplot?	Violations	Max Branch %	Min Volt	Max Volt	Max Interface %
1	L_0000011-000002AC1	NO	YES	YES	none	300.00	203.00	NO	0				

Figure 2.2. Bus system contingency analysis

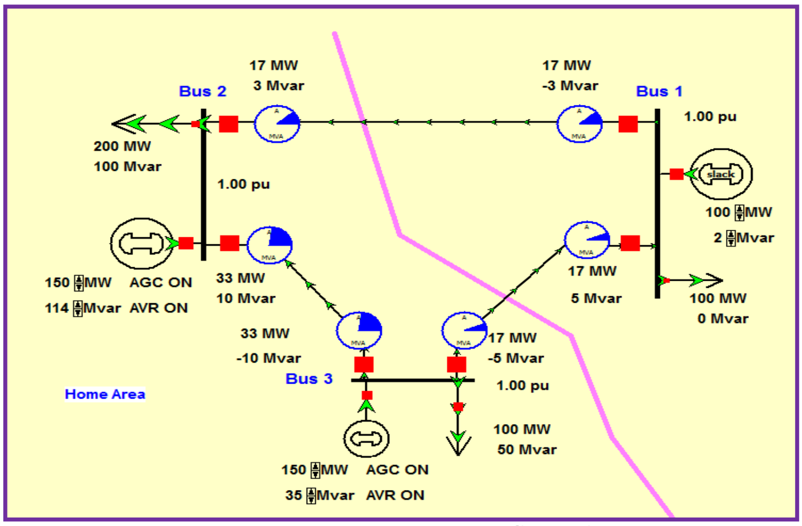

Figure 2.3 Bus system power flow diagrams

	Label	Skip	Processed	Solved	Post-CTG AUX	Islanded Load	Islanded Gen	QV Autoplot?	Violations	Max Branch %	Min Volt	Max Volt	Max Interface %
1	L_0000011-000002AC1	NO	YES	YES	none	300.00	203.00	NO	0				

Figure 2.4. Bus system contingency analysis

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