# A STUDY ON THE EFFECTIVE POWER SYSTEM RESTORATION SCHEMES FOR LARGE-SCALE BLACKOUTS IN SYNCHRONOUS ZONES

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## (1) Overview

Blackout is a total power failure over a large area, usually caused by the failure of major generating equipment or transmission facilities. Engineering faults, ineffective communication, inability of system operators, operational problems in power system—generation reserve capacity, protection devices, frequency and voltage stabilizers—overloaded transmission lines and transformers, natural disasters, system operation in security limits, instability of supply-demand, and shortages in power investments can constitute these failures. Major blackouts of electric power systems in which many customers are left without power are rare events. However, the effects of blackouts, for instance, can be catastrophic for security of energy supply.

Security of electrical energy supply must be provided by countries for sustainable and successful competition in global perspective and ensuring their citizens' prosperity. Blackouts can cause not only economic disturbances but also social, security disturbances as well as death. Major factors, sequence of events, and lessons learned from blackouts have been reported in the literature since the first blackout which occurred in 1965, North America. However, these reports are expressly studied on one or more countries in the same area, or more than one blackout in a country (U.S.–Canada Power System Outage Task Force, 2004; Libdahl, 2004; Gomes, 2004a; Yang; 1996). Restoration activities of blackouts which affect multiple countries like 2003 Italy blackout (Berizzi, 2004) in UCTE (Union for the Co-ordination of Transmission of Electricity), 2003 Sweden&Denmark blackout (Larsson, 2004) in NORDEL (Organisation for the Nordic Transmission System Operators), and 2003 Croatia & Bosnia Herzegovina blackout (Dizdarevic, 2004) in UCTE are worked by taking into account the related countries particularly, not whole system that are connected synchronously.

Continuously, regional interconnected systems, especially in Europe and North America, are in the process of enlargement. Current projects show that, this process also will go on in the future (EU, 2008). Interconnected power grids not only have benefits on security of electricity supply, competition in power markets, and in increasing the quality of electrical energy but also in decreasing the number of major power failures. By the regional integration of the power grids, while power trading, cross-border exchanges, and competition in electricity markets are increasing, not only primary energy sources but also electrical energy dependence will be grown. Related to electricity dependence and rising interconnected power grids, effects and results of major blackouts that affect multiple countries can be enormous.

Blackouts occurred from past to present and studies on blackouts show that they can not be prevented. However, effects of blackouts can be decreased by lessons learned from the past blackouts. Effective restoration process is very important for decreasing the direct and/or indirect consequences of blackouts. For system restoration to be effective there must be a well thought out restoration plan, training exercises, and verification testing because the exact condition of the system at the time of failure will not be known ahead of time, the plan must be flexible. A great deal of additional information must be assembled and available to the system operator to support flexibility in blackstart operations. By interconnection of regional networks, restoration process of power grids become more important for customers and difficult for systems operator. The main purpose of this paper, different from others in the literature (e.g: Berizzi, 2004; Larsson, 2004; Dizdarevic, 2004; Gomes, 2004b; Roy, 2004; Al Bassam, 2000) restoration process of major blackouts that affect multiple countries in an interconnected grid is worked and suggestions are presented for decreasing the duration and increasing the efficiency of restoration schemes, by taking into account whole synchronous zones.

## (2) Methods

Operational problems in power system occurred with integration of regional networks are studied, data from technical reports of system operators are researched and effective restoration activities of wide area blackouts are explicated by comparative analysing of selected blackouts in global perspective from 1965 to present in this paper.

By the increasing size of interconnected power systems, cross-border exchanges, power trading, electrical energy demanded by customers, length of transmission lines, number of transmission system operators and complexity of power systems are grown. Previously stable and relatively predictable patterns of network use have in many cases been replaced with less predictable usage, more volatile flows, decreasing generation reserve capacity, and greater use of long-distance transportation, reflecting growing inter-regional trade. New patterns of transmission network use creates a far more complex and dynamic operating environment, with real-time monitoring and management by system operators becoming more and more crucial for maintaining transmission system security. In this more integrated and dynamic operating environment, an event affecting a relatively distant part of a transmission system may have greater potential to spread and severely disrupt the supply and operation of electricity markets. Impact of these situation occurred by interconnected power systems are analysed related to major facts that can trigger blackouts as mentioned in overview part of this text.

Data from technical reports of UCTE, which is the biggest and most complex interconnected system in global perspective, are researched and analysed to confirm the major reasons of failures in tie lines that connect countries in the region (UCTE, 2007). Congestion analysis on cross-border lines shows that interconnection lines in and around the North Eastern block have been used at their maximum capacities almost 100% of the time in 2006. The international tie lines, especially equal or greater than 220 kV, were not in operation because of different reasons like, maintenance, repairing, overloading, false operation, failure in protection devices or other elements, outside impacts etc. In addition, many major events experienced in different zones of UCTE during 2006 are analysed. Distribution of major events' reasons in UCTE, including overloading (also calculated brake), false operation, failure in protection devices or other elements, outside impacts (animals, trees, fire etc.), very exceptional conditions (weather, natural disaster etc.), other reasons and unknown reasons, are classified.

Restoration process of Rio de Janeiro Area in Brazil blackout and difficulties in the process are well expressed by Gomes. The main reasons of the delays and failures occurred during the restoration of 2003 Italy blackout are given by Berizzi. Roy mentioned frequently encountered restoration problems in the study of restoration practices in Western Region of India. The concepts and techniques inserted into the blackout restoration procedure for the complete restoration of the SEC-C network (Saudi Electric Company-Central Branch) are described by Bassam. In addition to declared, restoration activities of many blackouts are well analysed in global perspective in the related literature for understanding and improving effective methods for restoration schemes in interconnected networks.

The aim of this paper is to introducing new recommendations and procedures for decreasing the effect of major blackouts which affect multiple countries and decreasing the duration and increasing the efficiency of restoration schemes of the blackout by searching power system operation problems in interconnected grids, analysing data from technical reports and restoration process of blackouts which affect one or more country in the same area, or more than one blackout in a country. As case studies, 2003 Italy and 2003 Sweden&Denmark blackouts and 2006 UCTE disturbances are analysed.

## (3) Results

By the integration of regional power grids, while power trading, cross-border exchanges, and competition in electric markets are increasing, not only primary energy but also electricity dependence will be growing. Related to electricity dependence, effects and results of major blackouts that affect multiple countries can be enormous. In this paper, for decreasing the effects of blackouts, sample cases are explicated comparatively.

## (4) Conclusions

Blackouts occurred from past to present and can not be prevented. Main purpose of this paper is, giving recommendations for decreasing the effects of blackouts that affect multiple countries, detailing the methods for decreasing the duration and increasing the efficiency of process and making new recommendations for restoration activities in integrated power grids. Studies on restoration schemes of blackouts in interconnected power grids are going on by taking into account, risk analysis, technical, economic, and social size, environmental effects, funding etc. In consequent studies, making effective and practicable simulators on this subject are aimed.

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