Research on the August 14th Blackout in North America and Canada

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Abstract: The aims of this research are finding the major causes of the blackout on August 14th 2003 in North America and Canada and the lessons can be learned in China. This essay researched lots of documents and reports from many authorities and scholars and found that this accident was a cascading effect caused by a certain fault point and the essential causes are the problem of power dispatch and system information management. This accident can be a good lesson to Chinese power network to set a high standard reliable system. This report also gives the recommendations to current China system.

Keywords: August 14th blackout; Power system; Fault; China power grid

1. Introduction

Around 16:15 on August 14, 2003 (New York time), the Northeastern and Midwestern United States and the Canadian province of Ontario had a widespread power outage which became the world's second most widespread blackout in history. [1]

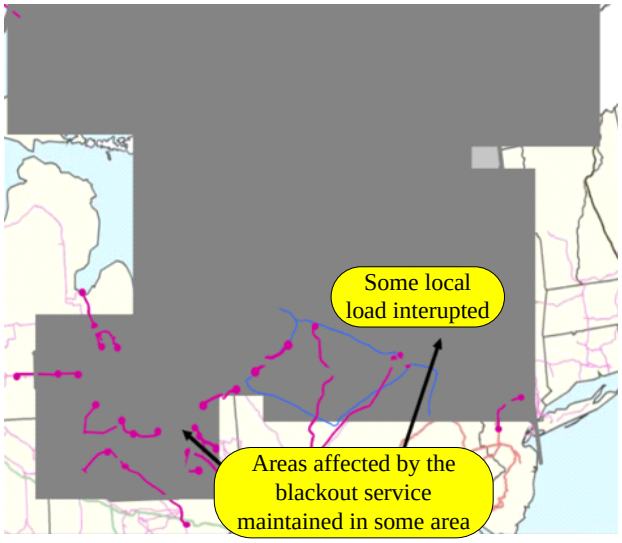

Figure 1. The affected area of northeast blackout of 2003

From the report of U.S.-Canada Power System Outage Task Force, the direct cause of this accident was a software bug in the alarm system at the control room of FirstEnergy Company located in Akron, Ohio. However, the operators were still unaware of the need to redistribute load even after overloaded transmission lines had already drooped into the trees. After about 4 hours, totally 256 generators had disconnected with the network and the transmission lines of this whole area had tripping operation. This fault lasted for 2 days and it was estimated that 55 million people were affected. [2]

Generally, this accident caused a number of casualties and an enormous economy losses, also could be threaten to the national security. The power outages in the US and Canada have caused worldwide concern. At present, power experts from all over the world have conducted extensive and in-depth discussions on many aspects of the national energy chain – power transmission, grid reliability, power system and investment to find the best way to construct a reliable network and reduce the probability of failure.

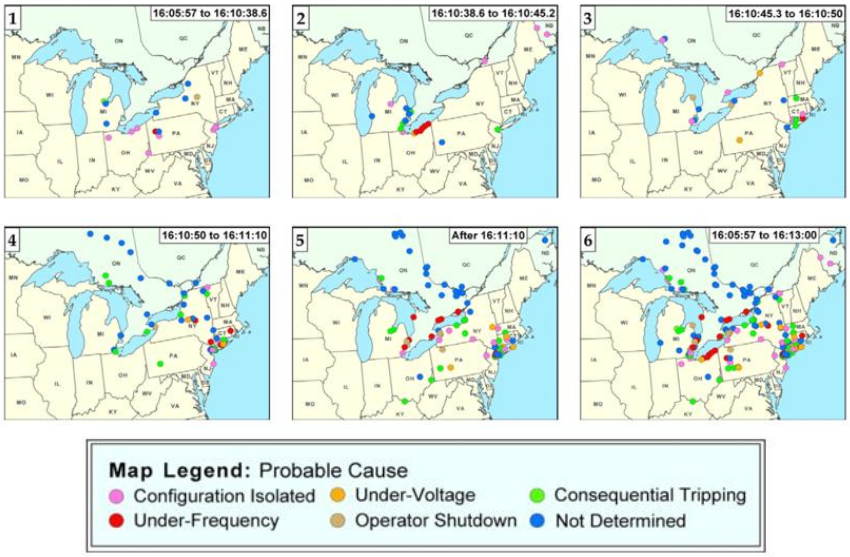

Figure 2. Process of generators disconnection

The electrical grid is caught in a political and technological energy war over what can most efficiently, safely, reliably and cost effectively provide commercial power for an increasing national load. The common causes of a widespread outage could be in these situations which shown in the following.

The damage of destruction of grid and power angle stability caused by rare faults;

The frequency collapse caused by the unbalanced output and load of the unit;

Voltage collapse caused by insufficient system reactive power;

hacking, power grid damage caused by abnormal automation equipment.

The first two reasons are much more common. Both rare fault and overloaded load can cause the rising of the flow current, and the electrical resistance of lines will produce more heat as the current carries increases. Due to the heat action, the soft metal conductor will expand and lengthen, and sag. If the line sags too low, a short circuit fault over to nearby objects may occur, and the automatic protective will detect the excessively high current and quickly disconnect the line with fault, and the load carried by the previous line will be transferred to other lines. However, if the other lines do not have enough capacity to hold the extra current, their overload protection will react as well, causing a cascading failure then lead to a widespread outage in a huge area in a short time.

2. Causes of the Blackout

2.1. Direct cause

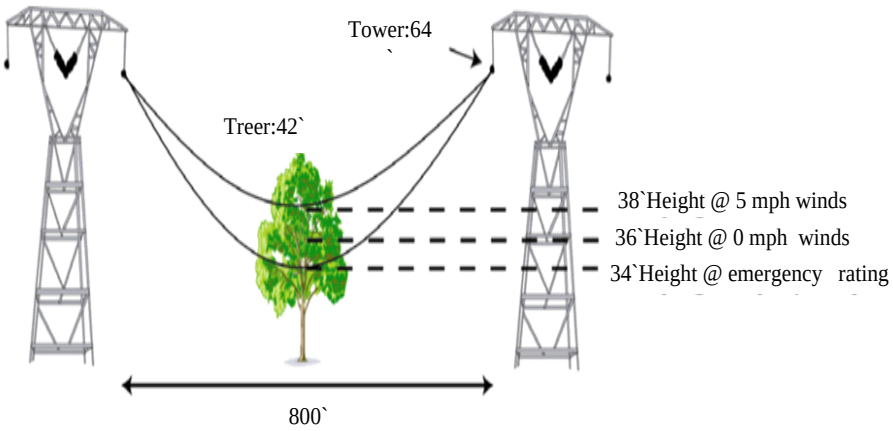

Figure 3. Direct cause

The direct cause of this blackout was a short circuit fault which happened between the transmission line with a tall tree. In a sense, this was the dereliction of duty of FirstEnergy (FE) which was the power company as a charger of local electrical business. Because they did not trim trees in its rights of way, so each early 345 kV line faulted on a tree that was too tall. What is more, this company also failed to study and understand the inadequacies of the FE system and didn't operate the system with appropriate voltage criteria. Hence, when the alarm called, the operator of this company didn't recognize its system deteriorating and didn't act to restore its system to a secure condition which caused a cascade fault. Generally, it is human factor.

2.2. Primary cause

This incident exposed many problems in the power grid system which were the primary of this blackout, they are: defects in the power grid structure.

The North American grid includes three independent grids which are Eastern Interconnected Grid, Western Interconnected Grid, and relatively small Texas power grid. The main fuses that are believed to cause a blackout are the large ring network of Erie Lake in Detroit, Toronto and Cleveland which belongs to Eastern Interconnected Grid. The currents flowing along the ring often turn without any warning, causing the load on the lower city to increase.

Undeveloped protection control technology.

Since the relay protection and safety and stability control system coordinated by the plant network had not been established, many generator sets were quickly withdrawn when the system voltage drops, which aggravated the occurrence of voltage collapse.

No unified scheduling mechanism.

There was a lack of timely and effective information exchange between power grids in various regions. Therefore, in the process of accident development, unified command of accident handling could not be achieved, resulting in the spread of accidents.

Profit-driven electricity market system.

There were some negative effects on the marketization of electricity. After deregulation of electricity, investment in power grid equipment was correspondingly reduced. It was because that American society seeks to maximize the pursuit of economic benefits. Grid companies with utility properties could only be managed under existing conditions, and there were many hidden dangers in terms of security.

3. Literature References

The problem of the construction of the power system was prominent in this accident. Qi Y (2004) pointed that the US-Canada grid was formed by the joint of multiple power grids, had no unified plans of the grid, which perplexed the power system and made it more and difficult to be found the fault point and controlled by operators. [3] The other primary cause was the unbalanced power grid dispatch. Lan. H. B. and Yang. J (2004) mentioned that the sufficient reactive reserve in the northeastern region allowed the grid to cope with voltage and frequency fluctuations after an accident, avoiding large-area unit trips caused by voltage drops. However, the Midwestern power grid could not Reacted in this way. [4] What is more, the undeveloped electricity market system is a big threaten. Qi. Y (2004) had also reported that because of the market mechanism, the price of the power plant bidding on the grid, the profit margin of the grid company was reduced, and the return on investment was extremely low, which caused the investors not to pay attention to the grid construction, thus affecting the development of the grid.

After this accident, lots of scholars in China analyzed this outage deeply and put up many proposals considering many factors to develop Chinese grid. Wei. Z. K (2004) pointed that State Grid should take the lessons of power dispatch and unified management. [5] Wang. H (2004) also wrote in his report about how to develop the grid connection of separate big area [6]. Shen. D. F and Zhu. Z. L (2004) combined with the status of Jiangsu Province, China, giving a proposal of giving more professional training to the operators and improve the threshold of job admittance standard. [7]

4. Summary

To sum up, the causes of this accident were diversified and this accident exposed many problems of the power system of North America. The direct cause could be considered the human factor of First Energy company and the primary causes were including the weak network structure, aging devices, undeveloped relay protection abilities, and the mechanism which was not unified and motivated by profit. It is true that this blackout is a good lesson to any country and China can learn a lot from that.

5. Recommendation

The large-scale power outage accident had occurred in the US power grid several times which a lesson could be taken by other country. Combined with Chinese current state of network, the following suggestions are given from the lessons of the Northeast Blackout of 2003:

Set a unified planning of system and power dispatch

China should learn to persist on the principle of decentralized access to the receiving end system; strengthen the main support of the intermediate support and receiving end systems of the transmission channel; achieve reasonable hierarchical partitioning; and unify the arrangement of operation modes.

Strengthen relay protection and develop the stability with automatic devices.

Nowadays, the requirements of China for secondary relay protection and safety automatic devices are higher. It is necessary to develop advanced and reliable relay protection devices and stable control technologies.

Strengthen power system simulation and perform accident maneuver work.

Perform simulation test and accident maneuver of the power system. Through the accident prediction analysis, we can find out the weak links in the system and make a good plan for possible accidents, which is very important to prevent the occurrence of large-scale blackouts.

Improve the smart grid application.

At present, China's power system reform has been further deepened, and the West-East Power Transmission, North-South Mutual Supply, and National Grid Interconnection Project are gradually being developed. In order to adapt to this situation, the key technology is improving smart grid construction which can use bigdata to analyze the network precisely.

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