Power Blackout in Taif

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POWER BLACKOUT IN SAUDI ARABIA

Abstract

On 11th June, 2014, complete power blackout occurred in Saudi Arabia due to the tripping of relay. In this, the city of Taif witnessed the worst case of blackout at 14:29 hours causing havoc in the region where people were subjected to immense difficulty for unknown time period. Power blackout is not a unique accident of its kind. Many blackout incidents have been reported not only in Saudi Arabia but throughout the Middle East region and across other continents as well.

This report presents background, root cause analysis, event description and future recommendations for the above mentioned and other similar mishaps.

Keywords: Taif, Blackout
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Executive Summary

Saudi Arabia is one of the hottest countries of the world which means that the demand of energy in this region is greater than the average demand of other countries. Also, this country hosts millions of foreigners during pilgrimage season and round the year therefore, presence of a smooth power network is of utmost priority.

This report is about the power blackout incident that occurred in the city of Taif of Saudi Arabia on 11th June, 2014. Initially, the literature review of similar incidents of the past have been investigated of the Arab world. The next section outlines the function of Saudi Electricity Company (SEC). This is then followed by a description of the actual event covering details of the incident and an analysis of the cause behind the event. Furthermore, general causes leading to power outage is discussed. This is then followed by the impact of such events and recommendations to avoid such mishaps in future.
Introduction

Being a developed nation, Saudi Arabia faces the problem of power outage as well. Although this phenomena is usually part of the third world countries but states with large number of manufacturing plants suffer from this similar cause. In such scenarios, it has been a common practice to save energy and meet energy shortfalls occurring in distribution to the allocated network. Consumers make sure to store power back-up for long and unpredictable hours of power outage. Even after taking the above mentioned measures, power outage can occur in developed countries due to unforeseen circumstances. One such case was reported in Saudi Arabia on 11th June, 2014 when due to the tripping of relay, the city of Taif witnessed the worst case of blackout at 14:29 hours causing havoc in the region where people were subjected to immense difficulty for unknown time period.

Historical Background

Power outage is not an uncommon incident in Saudi Arabia. Since, Saudi Arabia hosts the world’ largest gathering during Haj season and also is one of the hottest countries of the world therefore, incidents of blackout have been observed in the previous years as well. According to the Committee of Interconnected Arab Networks (CIAN) report of March 2006 “Major Interruptions Blackout Study”, number of power fault records reported in Arab countries till 2005 is given below (Committee of Interconnected Arab Networks, 2006):
Out of the above mentioned records, 42 percent of these were reported to be 100 percent blackout in which the system was incapable of enduring any load. Majority of these incidents occurred as a result of malfunctioning or mishandling of the system or the equipment. The outage duration lasted from 28 minutes to 10-12 hours (Committee of Interconnected Arab Networks, 2006).

A brief overview of one of the similar incident that happened in Taif is given below:

**Taif Blackout**

On April 4, 2014, the city of Taif witnessed a power breakdown. At 19:00 hours, the 110 kV network of Taif was caught with a partial blackout. However, after 3 minutes the 110 kV bus station completely tripped due to over-current caused by over load. After almost half an hour that is at around 19:31 hours, AD 10 feeding to AD 05 AMT tripped due to high thermal load. WRCC then opened AD09 TPS2 at 20:57 hours for power flow management which lead to the tripping of AD07 at HVT due to overloading. When WRCC tried to restore the system then at 21:59 hours AD13 tripped by overloading.
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(ABDULRAHEEM, 2014).

After analysis it was found out that Taif’s 110 kV network was run by a 380/110 kV 500MVA power transformer. The power flow was balanced by starting the AD09 at TPS2 substation. Following this, AD07 at HVT linked to AD07 of NGD tripped due to overload. In this situation, both lost their connection and hence, all feeders present at HVT substation and connected to BB 2B & BB1 were deprived of power. It was later found out that bus section AD13 was off. Due to overcurrent in relay. This was the reason why all feeders connected to BB2B and BB1 were then fed from TPS2 and NGD. When WRCC took the decision to switch off AD 09 at TPS 2, all the feeders lost their excitation power (ABDULRAHEEM, 2014).

Overview of Saudi Electricity Company (SEC)

Saudi Electricity Company (SEC) was established in 2000 which is 81 percent owned by government out of 74 percent is contributed by the government itself and 7 percent is owned by Saudi Aramco. It is responsible for generation, transmission and distribution of power across the country and ensuring 100 percent quality customer satisfaction. The main function of SEC is to provide economical and reliable energy network throughout the region (AL DEKHAYL, 2012).

The Subsidiaries of SEC are as follows:

- Four Generation Companies (GENCO’s)
- One Transmission Company (National Grid)
- One Distribution Company (DISTCO)

The purpose of all these sub sections is to collaborate and work in junction to generate the required amount of energy for consumption and provide rapid solution in case of any emergency situation.
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Description

Event

On June 11, 2014 at around 14:29 pm, the city of Taif witnessed blackout with a power loss of 783 MW for 38 minutes ("TRIPPING IN 380 KV TAIF SUBSTAION IN TAIF AREA", 2014). The mishap brought the area’s life to a halt since power outage is an unusual activity in the region so the residents are generally unprepared for such interruptions. Students preparing for examinations were deprived of this basic necessity while the general public was left helpless with no power back-up. Day-to-day activities of the people was disturbed like parties, events and etc. forcing them to postpone their plans till life became normal. Being one of the world’s hottest region, the unplanned outage took the people by surprise in season of heat wave leaving them helpless and unable to cope with the unexpected situation that arose following the power fault ("TRIPPING IN 380 KV TAIF SUBSTAION IN TAIF AREA", 2014).

Analysis

After investigation it was found that operating Siemens 380KV Bus Bar differential relay type 7SS522 system one and system two both tripped all 380KV lines connected to BB1 and BB2B (AC008, AC04, AC07 and AC09 feeders) at HVT substation of Taif. The network is designed in such a way that 380KV feeder AC08 is located on BB 2B. WRCC closed Q1 of AC08 in order to shift the feeder to BB1. When both the isolators of AC08 are closed then tripping and opening of AC05 bus coupler and AC06 bus section is blocked. Since all three; AC05, AC06 and AC08 are closed therefore, the load is shared on AC09 and AC03 ("TRIPPING IN 380 KV TAIF SUBSTAION IN TAIF AREA", 2014).

In the above mentioned blackout, WRCC issued the open command to Q2 of AC08. Within a couple of seconds after the execution of this command, AC05 and AC06 both tripped
due to earth fault that caused overcurrent in relays. At the time of investigation, it was intimated that time delay for earth fault did not contribute to tripping process since the two seconds delay mentioned above of AC05 and AC06 had already been minimized to zero seconds due to the energization requirement of AC10. Around 14:30:05 pm bus section AC06 and bus coupler AC05 were tripped and the circuit breaker along with isolators of AC08 were working as coupler. It was then doubted that during the opening of Q2 of AC08 which usually requires a few seconds either it was unable to tolerate the current produced during this process or physical contact of Q1 of AC08 was loose. With regard to either of the situations mentioned before, differential current of 16 kA for 50 ms was generated in L1 which caused 380 kV BB differential relays (BB1 and BB2B) to trip the 380KV feeders connected to bus bars during their operation ("TRIPPING IN 380 KV TAIF SUBSTAION IN TAIF AREA", 2014). Figure 2 describes the sequence of event that took place as explained above that ultimately resulted in blackout in the region ("TRIPPING IN 380 KV TAIF SUBSTAION IN TAIF AREA", 2014).
Figure 2 Sequence of events leading to Taif Blackout ("TRIPPING IN 380 KV TAIF SUBSTAION IN TAIF AREA", 2014)

Taif Transmission Network

Following figure 3 shows the 380 / 110 kV transmission network of Taif ("TRIPPING IN 380 KV TAIF SUBSTAION IN TAIF AREA", 2014).

Figure 4 shows the single line diagram of HVT Substation ("TRIPPING IN 380 KV TAIF SUBSTAION IN TAIF AREA", 2014).
Figure 3 380 / 110 kV transmission network of Taif ("TRIPPING IN 380 KV TAIF SUBSTAION IN TAIF AREA", 2014)
Causes & Solution of Blackout

According to Committee of Interconnected Arab Networks, 2006, two major causes have been identified for power interruptions:

1. Human Error
2. Equipment Error

Equipment error is further divided into two sub category: malfunctioning and wrong settings. It has been researched that almost 100 percent of power blackout incidents are the result of equipment faults while a small portion of this share are caused by human mismanagement (Committee of Interconnected Arab Networks, 2006). In the above case of Taif incident, the main causes are described below:

Lack of System Maintenance:

In the historical event of Taif, it was found out that the bus section AD 13 relay tripped due to current exceeding the threshold value. Therefore, the protection engineering department
should regularly monitor the relay settings of all bus stations and bus couplers present in the grid station and should take rectification measures in case of any faults (ABDULRAHEEM, 2014).

Electric circuits, wires and switch boards should be prevented from exposure to moisture since, it may lead to short circuit. In case of a weak transmission network, poor relay settings, frequent and unexpected tripping of generators, power faults are usual and should be avoided ("Causes of Power Failures & Power Outages | Diesel Service", 2016).

**Lack of System Testing**

It was found out that two possible reasons lead to the tripping of feeder AC 08. Firstly, either Q1 of this feeder deteriorated and was unable to make proper contact. Or Q2 was not capable of carrying the current generated during this process. This problem requires that proper testing of Q1 and Q2 should be done before the working process so that tripping of the feeder could be avoided ("TRIPPING IN 380 KV TAIF SUBSTAION IN TAIF AREA", 2014).

The process of opening and closing that is adapted while the working of bus couplers and bus stations in these transmission networks like AC05 and AC006 respectively can lead to wear and tear thus, causing an increase in time delay. This means that this switching process will require more operational time. Hence, it is important that this procedure is regularly monitored and any undesirable delays should be reported ("TRIPPING IN 380 KV TAIF SUBSTAION IN TAIF AREA", 2014).

**Power Surges**

Power surges are abnormal high voltages that can affect the working of electrical equipment. It can cause fast and frequent overheating of the system resulting in unfortunate events. Also if operational maintenance is not carried out regularly then electrical lines may
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malfunction. Hence, power protection circuits should be implemented and verified regularly ("Causes of Power Failures & Power Outages | Diesel Service", 2016).

Impact of Blackout

The impact of power blackout is vast and effects each and everything happening in its vicinity. Every kind of business and trade is effected and due to power breakdown, the industries are unable to meet their required production level and hence, pose a negative impact on the economy of the country (Setrana, 2016). The outage will also effect traffic flow since traffic signal and street lights operated through commercial power will be effected and will stop working, creating a havoc on roads. Since Saudi Arabia heavily depends on water treatment plants for drinking and water for other purposes therefore, this will affect the working of these plants as well. Cooling systems are a necessity in Middle East countries because of their extremely high temperatures. Therefore, cooling systems will stop working causing a halt in the routine of the people. Lastly, all types of communication will be disturbed since they energy required to power them will not be available ("Long Term Power Outage", 2016).

Future Recommendation

Every year the average hours for which power outage occurs is increasing. Although Middle East has a vast share of gas reserves but due to lack of planning, corruption, mismanagement and poor coordination amongst the Arab world in term of trade, these reserves are not being properly utilized. However, the use of gas instead of petroleum as a source of fuel will result in a cleaner environment free of any pollution. Other renewable resources can also be utilized. For example, Saudi Arabia has excess of solar energy that can be easily used as an alternative of energy source (Khoudouri, 2016).
Existing working transmission networks should have better reactive power as it contributes to blackout. Regions that frequently suffer from power blackout should be provided with SVC for voltage regulation. New shunt reactors should be installed and power back-up with an automatic on/off procedure should be made available all the time. Operational planning trainings should be held in order to revise and follow up the regulations followed in the system. The network working and methods should be analyzed accurately using professional tools and software. Any upgradation required should be carried out precisely. Also, the input source and output load should be verified vigilantly according to the threshold set among all nodes that is generation, transmission and distribution. System settings should be set according to the requirements of routine work or any special activity taking place (Committee of Interconnected Arab Networks, 2006).

**Conclusion**

The blackout that occurred in Taif was a source of huge disturbance for the country economically, socially and personally. Preventive measures should be taken in order to minimize such accidents in the future which are a source of problem for all fields. Error-free and reliable energy network should be made available so that in case of any unavoidable situations, routine tasks are not affected and the network functions smoothly.
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References


TRIPPING IN 380 KV TAIF SUBSTAION IN TAIF AREA. (2014)

