Review Paper on Power System Blackout: A Serious Issue

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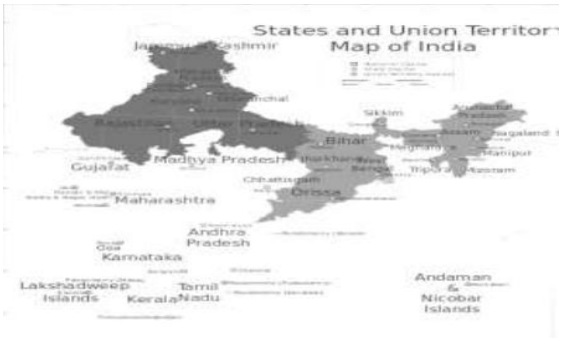
***Abstract*- Every human being is completely depends upon electricity because without electricity we have not done our work easily in modern era so that the power system failure is a serious issue. When a power system is subjected to a large disturbance control action need to be taken to steer system away from severe consequence. Due to this disturbance blackout in the system is developed.**

INTRODUCTION

Meaning of blackout-A blackout refers to the total loss of power to an area and is the most severe form of power outage that can occur in a power system. It can be thought of as a situation when loads of thousands of megawatts is disconnected from the generators supplying power in specific wide area. Blackout situation doesn't arises all of sudden but as series of events. There are many causes of power failures in a power system network like faults at power stations, damage to electric transmission lines, substations or other parts of distribution system, a short circuit, or the overloading of electricity mains. As a result the entire high voltage transmission grid to force out of service, thereby isolating the load it would normally serve.

JULY 2012 INDIAN BLACKOUT



Here Dark shaded region shows affected states on 30 July power outages and Mild shaded region shows affected states on 31 July 2012. On early morning of July $30th$ the electricity supply demand balance tightened in the northern state of Uttar Pradesh. Trouble spread in chain reaction, causing blackout for entire northern grid affecting 300 million people and ending at around 7 pm on same day. Another blackout came at 1p.m on July 31 and covering northern, eastern, north-eastern grids affecting 600 million people. Transportation services were disrupted, traffic signal fails to work, and coal miners were trapped in mines as elevators were shut down. Direct cause of large blackouts includes electricity supply capacity failing to meet growing demand in India. Due to less rainfall hydroelectric power output was reduced and there is increase demand for electricity to pump ground water for agricultural irrigation due to droughts and as peak summer duration electricity demand increases to power air conditioners, coolers, fans etc. Grid troubles contributed to spreading in a chain reaction national wide. It is considered as the largest power outage in history as number of people affected.

Major Causes

There are several factors that contributed in beginning of grid collapse. The 400 kV Bina-Gwalior-Agra-2 was under planned shutdown since 28th July 2012 for up-gradation work to 765 kV. Thereafter outages started from the afternoon of 29th July 2012.

TABLE I: Sequence of Outages on 29 July.

S. No.	Time	Transmission element	Reason
1.	29th	220 kV	Tripped due to operation

	July 2012 ,15:15	Kota, Badod	of distance protection three phase Zone-1 indications at Badod end
2.	29th July 2012, 15:40	220 kV Bhinmal(PG)Sirohi	Phase to earth fault.
3.	29th July 2012, 21:45	400 kV Bhinmal, Kankroli	Tripped due to Insulator de-capping
4.	29th July 2012, 22:18	400 kV Zerda, Kankroli	Emergency outage for a period of two hours to takeout one Tool &Plant which got stuck with one polymer Insulator.

The NR is connected to WR through a number of interconnections but it was pragmatic that many of the interconnections were out of service due scheduled and forced outages at the time of disturbance. The 400(kV) Bina-Gwalior-Agra was the only main AC circuit remain which connect NR to WR. Thus the flow of power from WR to NR region via Bina-Gwalior-Agra link increased which led to overloading of the tie-line. The regional load dispatch centre initiate load shedding to reduce the load on this line but the measure taken were inadequate WR was also informed to reduce the generation to curb the power flow through this line but the reaction was not quick enough and With the growing load, the current flow through the transmission line increased and due to lack of reactive power compensation, the voltage profile of the line dropped. This condition was sensed by the distance relay as fault and it tripped the line.

Following are the sequence which lead to northern grid blackout is shown in table.

TABLE II: Sequence of Outages on 30 July

Date & Time	Transmission Element
30th July, 2012, 02:33:11	400kV Bina – Gwalior-1 Line Tripped.
30th July, 2012, 02:33:13	220 kV Gwalior-Malanpur 1. Zone-1 Tripped (on Power Swing) with the above events, practically all the AC links from the WR to the NR were lost.
30th July, 2012, 02:33:14	400 kV Jamshedpur – Rourkela line, line-1, 2, and 3 tripped on zone 3 protection.
30th July, 2012, 02:33:14	400 kV Gorakhpur-Muzaffarpur-2 tripped (on Power Swing).
30th July, 2012, 02:33:15	400kVBalia – Biharsharif-2 line tripped (on power swing).

BLACKOUT ON 31st JULY 2012

Again on 31st July 2012 there was more severe unpleasant incident took place and the grid disturbance cut off the WR from rest of grid system and the system was operating in an insecure condition at the frequency 49.84 Hz prior to disturbance. The NR was connected to the WR via majorly 3 AC tie-lines but soon all of them tripped one by one. This time, the electrical centre of the power swing was inside the ER and nearer to the WR-ER interface. So the situation was slightly different from that on 30th July. As a result of the power swing, the tie-lines between WR and the ER tripped. Eventually due to tripping of some generating unit because of under frequency relay, large angular oscillations were generated in the rest of the system and a large number of lines tripped within the new grid and finally NEW grid system collapsed. Below table shows the sequence which lead to blackout initiation on 31st July as follows:

TABLE III: Initiation of Outages on 31 July

Date & Time	Transmission Element
31 July,2012, 13:00:13	400kVBina – Gwalior-1,2 line tripped 220kV Shivpuri-Sabalgarh-1 tripped.
31 July,2012, 13:00:15	132kV Pichhore-Shivpuri tripped 400 kV Ranchi- Maithon-1 tripped (due to Power Swing).
31 July,2012, 13:00:18	220 kV bus coupler tripped at Tarkera tripped 400 kV Jamshedpur-Rourkela-1 tripped.

Once again due to severity of the frequency fluctuation, practically all the AC links from the WR to the rest of the grid were lost. After several minutes Indian grid collapsed as shown in table below:

Date & Time	Transmission Element
31 July,2012, 13:01:28	400 kV Kankroli-Jodhpur tripped due to dip in voltage, Wagoora-Kishenpur (1&2) (tripped due to Power Swing)
31 July,2012, 13:01:30	Ballabhgarh-Gr Noida tripped, Z1, 3phase, Kanpur-Panki-1 tripped (Under voltage)
31 July,2012, 13:03:18	400kV Patna-Balia-2 tripped (3-ph fault), Kankroli - Debari 220kV tripped (Under voltage protection)

CAUSES

Overloading and lack of reactive power compensation resulted in tripping of transmission lines. All the generating units are equipped with Power System Stabilizers. Which protect the system

from instability. But they were not calibrated properly and hence could not function well.

- It was observed that the load relief that should have been achieved due to operationof under frequency relays and df/dt was not achieved.
- There is a need of tools that can estimate the state of the system dynamically and ata faster rate. This will enable the operators to know the actual power flows on different lines.

By analysing above situation and events it is observed that blackout is progressed with some regularity and it can be divided into several phases as precondition, initiating events, cascade events, final sate and restoration. Different precondition happened before blackout like system stressful condition, inadequate reactive power reserve, important equipment out of service, natural reason such as wind, thunderstorm etc. initiating events are various in different blackout. Short circuit, overload, protection hidden failure and loss of generator are initiating events which directly cause blackout.

KNOWLADGE FROM MAJOR BLACKOUT

Due to cascaded events, the electrical distance between generator and loads is increased by tripping major transmission lines. This causes deviations in generator load angles and creates inadequate coupling between the generating systems due to lag of synchronising power. When the angle difference between two regions is large then the line in between two regions will be depressed with low voltage. Line tripping due to heavy load and depressed voltage is caused mostly by the distance protection relay as fault detection in zone 3. Therefore, in the power system operation, keeping a flat voltage profile is always recommended to keep the security at a higher level.

The blackouts mostly happened due to voltage collapse rather than under frequency conditions. When a line trips, the rest of the lines must carry the power, thus consume more reactive power and reduce the voltage at the load centre without affecting the frequency. Shortage of reactive power causes more voltage drop at stressed line loading conditions. Therefore the voltage become as a key stress indicator of the power system rather than the frequency. Also the voltage drop at the load centre indicates that the systems will experience the low frequency after it breaks up into islands.

IMPACT OF BLACKOUT

Electricity fuels our existence. It powers water purification, waste, food, transportation and communication systems. Modern social life is impossible to imagine without it. Blackout includes measurable economic losses and less easily quantified social costs. Supply will become ever more precarious because of peak oil, political instability, infrastructural neglect, global warming and the shift to renewable energy re-sources. Demand will become stronger because of population growth, rising levels of affluence and the consumer „addictions" which accompany this.

In examining these blackouts numerous causes were reported, including: technical failure, extreme weather events, political spite, deceiving the enemy during war, sabotage by narcoterrorists or political opponents, in-adequate generation capacity, financial problems, corruption, increased airconditioning use, infrastructural neglect, punishment for non-payment of power bills and a lack of re-sources to generate electricity.

Modern societies have become dependent on airconditioning, computers, lights, fridges and freezers that are, in turn, dependent on an uninterrupted supply of electricity. Such is our dependency that our comfort, security, communication systems, transport, health, food supply, businesses and social equity systems strain when electricity supplies are interrupted.

Increasing numbers of people are living longer and enjoying rising living standards. This increases demand for electrical appliances. Across the same time period demand for electricity is estimated to grow. This will require additional giga-watts to be generated. No one knows how this will be generated. Guaranteed electrical power is also under threat because of resource constraint: fossil fuel depletion and the transient nature of renewable energy sources. Peak oil and climate change are also causing an increase in the demand for electricity.

In consequence blackouts will become more frequent. This means that serious questions will have to be asked at both the individual and collective level concerning what is wanted and what is needed,

balancing what is good for individuals with what is good for others and ultimately what is good for the environment.

CONCLUSION

The present power situation in India is a big spar that needs to be carefully handled. The demand is on a much higher side compared to the supply, thus the Indian industry and its general society are experiencing frequent power shortages. Blackouts are usually a result of series of event rather than one single. However, it becomes extremely essential to find out that one single incident that initiated the process. As day by day power demand increases, so to meet the power demand emphasize should be given on renewable energy sources like energy from waste, energy from tidal wave etc.

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