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DISASTER MANAGEMENT OF GRID FAILURE

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ABSTRACT

It is on record that the past blackout suffered by many developed and developing countries of the world have rendered immense financial loss and became a major source of embarrassment. The recently July'12 Indian blackout has proved one of the world's biggest power disasters caused by the failure of Northern grid. This not only caused a national financial loss to of several hundreds of crores but also has become a major embarrassment for India raising doubts on India's ability to cope with the world's expectations to become a future world economic power The issue is grave and requires concerted and focused attentions from the academia, industry, government, professionals and all stakeholder to address to all aspects of this calamity so that any such future threats may be pre-empted. Present article is an attempt to analyze events and reasons which lead to this disaster and suggest measures which would be helpful in avoiding the reoccurrence of any such future event.

Keywords: Blackout, Grid, Black Start , Grid Indiscipline.

I. INTRODUCTION

India has recently witnessed one of its worst blackouts in the recent times. Twenty Indian states and two union territories faced a complete power blackout on 30 July 2012 triggered by the failure of Northern grid. This incidence not only left more than 300 million people powerless in New Delhi and much of northern India but also became a reason for a national financial loss and a cause of an international embarrassment. This, however, also highlighted the chronic infrastructure woes holding back Asia's third-largest economy. The lights in Delhi and seven other states went out in the early hours, could not be restored by the morning rush-hour, and bringing the life to standstill as entire communication network including that of rail road became virtually dead.

The outage forced the shutdown of hydroelectric plants in the Himalayan state of Himachal Pradesh and thermal power stations in the wheat belt of Punjab and Haryana. Fortunately, Air traffic was unaffected due to the adequate backup was unaffected. This black day ultimately proved to be a national nightmare.

India is boastfully among emerging BRIC economies. On way to its journey to become a matured world economy from the emerging one it has to establish a vigorous infrastructure driven by transport network and overcome all sorts of Power woes. Power shortages and a creaky road and rail network have weighed heavily on the country's efforts to industrialize. The underperformance of the country in the recent past on infrastructure development and power eventually may become major reasons for a slump in the economy. India recently scaled back a target to pump $1 trillion into infrastructure over the next five years (1).

Blackouts lasting up to eight hours a day are frequent in much of the country and have sparked angry protests on the industrial fringes this summer, the hottest in years. Apart from the domestic implications, confidence of international community and financial stakeholders on India's capability to handle high industrial growth has become critical.

Importantly, of all the infrastructural needs power is a critical pre-requisite. There is an urgent need to take all possible measures to pre-empt any such future power woes.

II. A RECALL OF MAJOR GRID FAILURES IN THE WORLD

A review of account of major blackouts of the world (2) is an indicator of how the world tackled the important power issues which is the backbone of entire economic activity. It is evident from the chronology of events given below that post 20th century though the power demand increased in geometric terms no developed economy has a repeat power chaos Except India.

- Blackout on 09.11.1965, North-East of USA
- PJM blackout on 05.06.1967, USA
- New-York city blackout of 13.07.1977.
- Blackout on 04.08.1982 in Belgium
- Blackout on 14.12.1982 in Canada
- Blackout on 22.12.1982 (West coast power system USA)
- Blackout on 27.12.1983 in Sweden
- Blackout on 21.02.1995, USA
- Oswego (New-York district) blackout of 26.04.1995.
- Blackout on 02. and 03.07.1996 in the USA West coast power system
- Blackout on 10.08.1996 in the USA West coast power system
- Blackout on 25.06.1998, USA, north-west.
- Blackout on 11. 03.1999 in Brazil
- 19.blackout on 02.01.2001 Nortern grid India
- Blackout in Croatia - Bosnia on 12.01.2003.
- Blackout of 14.03.2005 in Australia
- Blackout of 25. 05. 2005, Moscow
- Blackout of the European power system of 04.11.2006.
- Byelorussian event of 25.06.2008.
- Northern Grid failure on 30/07/2012 in India

Even later half of the first decade of 21st century is free from any power woes in most of the developed countries. If this has something to indicate it's high time that India should give a serious thrust on the future challenges and its management of all our power disasters. The analysis of past events of power sector disasters is the first and immediate need of the hour.

III. ANALYSIS

A proper and efficient technical analysis is very important as such issues are very sensitive and become the subject of prolonged public debates which in turn affect the policymaking process. The Northern Grid failure that occurred on July 30 2012 occasioned a flood of comments in the print and electronic media; unfortunately, some of these comments were ill-informed and misleading. This could lead to people losing faith in one of the finest institutions in the country. A well-informed approach is necessary to fully understand the events that unfolded on July 30 and 31.

The present article is an attempt to perform a critical technical analysis on every single event right from the pre-breakdown to the restoration. Before a detailed analysis is made it is apt present a precursor to the supply-demand dynamics which is the main valve to cope-up with the daily power demand variations.

3.1 Supply-Demand Dynamic

The power demand systematically varies with the time of day — it is highest during evening peak hours (generally 6-10 p.m.) and lowest during the night hours (12 midnight-6 a.m.). This is because the commercial and institutional installations work on full load in day time whereas during night the main load comes from the domestic usage. In graphical terms the power demand variation may be called an S-curve.

During peak hours the demand is high and the power generators tend to slow down causing frequency to falls below 50 Hz. The frequency of 50 Hz corresponds to 3,000 rpm for a conventional two-pole generating set. During night (or off-peak hours), on the other hand, power system operators have to grapple with excess generation. Most power generators, therefore, reduce their generation off-peak hours to the extent possible to match the reduced demand. The nuclear and thermal power generators cannot reduce the generation below a technical lower limits called 'technical minimum' without a complete shutdown of unit. The restart of a thermal and nuclear power unit is a costly and a time consuming exercise. Hence, they are always reluctant to reduce generation below the technical minimum. Thus, when power generation exceeds demand, the generating sets speed up beyond 3,000 rpm and system frequency exceeds 50 Hz. Further, there is a frequency limit beyond which it is not advisable to run a generator, and the same will trip if that limit is crossed. That's what happened in the present case.

3.2 The Trigger of The Event And Its Culmination Into A Catastrophe

On July 30, going by the statements made by Power Minister, first failure of the Northern Grid took place at 2.35 a.m. at the grid frequency of 50.46 Hz which is beyond the upper operating limit. During this time the load had dropped much below the generation and the frequency had already exceeded the upper operational limit of 50.2 Hz (3). Unfortunately no control mechanism was operational to tackle the grid over frequency .Thus, either or both the generators and States infringed upon the grid operating discipline.

Demand-supply mismatch is a common event. Going by the reports of hearings being conducted by the regulator on the subject of grid indiscipline. Another uneventful night would have passed, had it not been for a trigger — which in this case was the reported tripping of a loaded line (400 kV Bina/Agra/Gwalior). Further loss of load in a scenario where there already exists oversupply, over frequency, (and presumably over-voltage) proved to be the proverbial last straw. Frequency went beyond trip settings, resulting in a series of generator and line shutdowns, known as a cascade tripping, because each tripping worsens the operating parameters for the surviving plant and has a snowballing effect. In the present context the crisp and a simple summary of the reasons triggering the event may be as follows:

i) For a demand/supply mismatch resulting in a grid over frequency of 50.4 Hz it is certain that there was violation of grid discipline by some or all sections of the consumers/constituents (states), and/or failure of the NLDC/RLDCs to correct it in time.

ii) The July 30 event was a matter of 'oversupply' and not 'overdrawal', though the eventual outcome was the same — a grid collapse.

iii) The July 31event, evidently and naturally, became a case of excess drawal. It is, although, difficult to piece together with any degree of exactitude the events leading to this failure, but one thing is clear — there was excess drawal vis-a-vis schedule by certain constituents that too at a time when the grid was in a fragile condition, and a trigger event like a line/equipment tripping took place, thus exacerbating an existing demand-supply mismatch. Both these events of 30-31 July indicate a blatant lack of grid discipline, dilapidated health of under/over frequency relays and impediments to speedy restoration of the system.

iv) The inaction of the NLDC/RLDCs is the next contributory factor, and all these combined to produce catastrophic failure when a crucial line trips due possibly to poor maintenance, or some other random cause.

The precedence of this catastrophes should be, therefore, be regarded an opportunity to identify remedial measures for pre-emption of any future repeat of such event. It is desirable that LDCs should come out of their akin to a dormant role. Firstly, persistent underdrawal or overdraw in disregard of LDC instructions amounts to grid indiscipline and needs to be firmly dealt with. Likewise, oversupply by generators, or failure to meet schedules also amounts to failure of grid discipline. Secondly the grid maintenance and its health audit should be strictly performed as per the laid down procedures. Therefore, State and generator discipline, and grid maintenance and operation all need more attention. All this is well within the competence of our power sector professionals and regulators, provided, of course, that they are not subjected to political interference.

IV.REMEDIAL MEASURES

The intent of the Electricity Act, 2003, is quite clearly to distance the Government from day-to-day operations of the power sector. A beginning can be made by further empowering the LDCs and making them independent of respective State governments. Responsible professional from relevant bodies like those from Power grid can be fully relied upon to take care of the grid and ensure reliable power supply, as they have done for the past 11 years (i.e. the previous grid collapse event). Thus, a three pronged remedial procedure could be proposed as per the following details so that any future recurrence of such catastrophes may be dealt with.

4.1 Avoidance of Blackout Due To Grid Failure

1. Implementing Under-frequency load shedding automatics (AUFLS).
2. Maintaining grid discipline.
3. Use of micro grids which may take power from local nonconventional energy sources after ascertaining power quality. States may be allowed to buy renewable energy certificates Encouraging rural power producers to reduce grid load.

4. Distribution generation, disturbances in a transmission grid could reduce the excessive withdrawal from the grid.
5. Proper coordination between RLDC and SRLDC's

4.2 Post Emergency Frequency Recovery

The post emergency frequency recovery is system recharge strategy which shows the technical prudence in the system at time of dismay. In the past many such events were tackled with utmost efficiency. As depicted in section II above the October, 1965 event was self-liquidated automatically within 100 seconds. In 1967, a series of four emergency events in the Latvian PS occurred in one day; each of them required 100 seconds for self-liquidation. This in itself indicates that the frequency avalanche disturbance transformed into an unnoticeable transient process, which could be exploited not only in its direct form but also as the inverted process .

One of the prime-most action points in such situations are that under-frequency load shedding (AUFSL1) is to be complemented with the following three elements:

i) Slow-acting under-frequency load shedding automatics (AUFLS2) for restoring the frequency, consisting of several stages with various time delay settings (e.g. 8-10, 15, 20, 25 s, and so on) and with a high setting for start (similar to the first stage setting of the fast-acting AUFLS), which serves for adjusting the retiming setting to the rated frequency after the start. The slow-acting AUFLS2 begins its operation of restoring the frequency up to the normal level after the fast AUFLS1 has been completed its operation (Fig. [2]).
ii) Automatic re-integration of split parts of a power system at a minor difference between their frequencies, using the available on all lines synchronism-check relays of automatic re-closing (ARC) devices;
iii) Automatic re-closing of consumers'lines by the normal frequency, exerting the control over frequency variations.

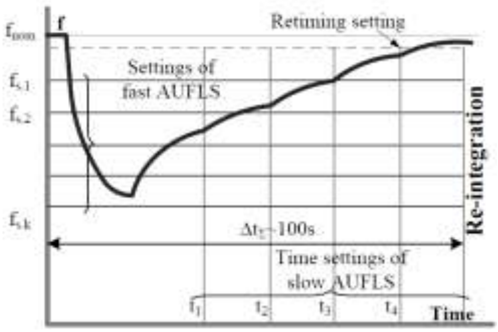

Figure-1: Reintegration of grid using AUFLS

4.3 Control Over A Power System In View of Its Security

From the viewpoint of security, the operational conditions of a power system can be classified as follows

(i) normal
(ii) pre-emergency
(iii) emergency

For normal operating conditions the mandatory security standards already exist along with power limitations in order to maintain voltage and frequency in the allowable margins [7]. Usually, this concerns observance of the (n-1) criterion, which means that at emergency tripping of one important element of a power system it is kept normally operating thus preventing the development of a cascading emergency. A power system operator has to perform non-stop monitoring the security criteria and ensuring the availability of power reserves needed for frequency and voltage control. A definite reserve must also be provided to secure the allowable power exchange in transmission lines.

A pre-emergency condition is imminent when on normal running, an element of a power system is tripped which disturbs its operation. In this case, the emergency condition, though, has not yet begun but the security criteria are not observed any more, and the development of an emergency process can start any time if there is enhancement of operational condition severity [3]. This is a critical phase and needs careful attention by the operators and all other professionals working on the power system. This situation should immediately be normalized by mobilizing the capacities and reserves.

Once the emergency condition has taken place, the process develops in a fast cascading manner and the situation eventually goes out of controls from the hands of the personnel managing it. In such condition a blackout can only be prevented by the fast-acting automatic protection means which should be unified and most simple.

To manage the emergency condition as mentioned above the measures shown in Fig. 2 [2] should be applied.

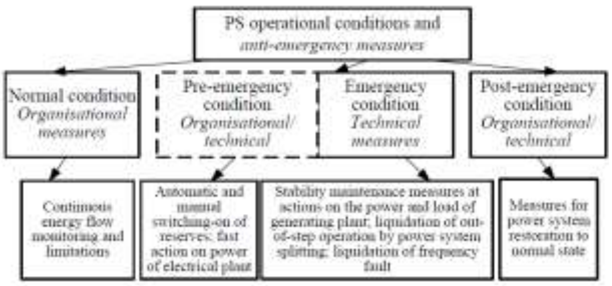

Figure 2: Classification of the anti-emergency measures by operating condition of a power system

Organizational measures as represented in the Fig 2 are associated with the attentive and alert timely action by the staff professional which must be taken in strict compliance to the written or electronic instructions. These measures should correspond to the human abilities to act and make decisions fast. To provide higher security, there is an urgent need for execution of instructions be made automatic. At normal operation these are applied in a usual order; however, in the pre-emergency condition special programs should be in place which would provide instructions for urgent actions in a changed situation.

Technical measures are unavoidable during emergency, in which case the events develop too fast for a manual action, and the blackout can only be prevented with fast acting technical means. In these cases the staff should be involved in the post-emergency stage.

V. CONCLUSION

Primary cause of PS blackouts is the transmission grid overload that triggers the development of cascading processes. A protection complex against blackouts is needed that momentarily removes the overload and automatically restores the normal system operation.

The Grid discipline along with the fast acting under frequency relay protection with backup protection with full automation is essential in the present case of blackout on 30 July 2012.

A proper coordination between the SDLC and RLDC and imposing the penalty on the persons responsible for overdrawing the power may also prevent the Disaster to reoccur.

The scheme of connecting the local micro grids to the grid which takes power from non conventional energy sources power producers after due verification of power quality meets the excess demand and reduces the possibility of the blackout

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