

# Grid failure in Northern, Eastern and North-Eastern grid in 2012: Cause & its effect on economy of India An Review

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## ABSTRACT

*This paper describes as to how grid failure has occurred in the northern region, eastern region and north-eastern region of India and its effect on economy of country. The estimated data presented in the paper appears to be consistent with post-blackout surveys of affected manufacturers and businesses. The paper concludes with examples of impacts to major industries and attempts to put a face on the economic consequences of this unfortunate debacle.*

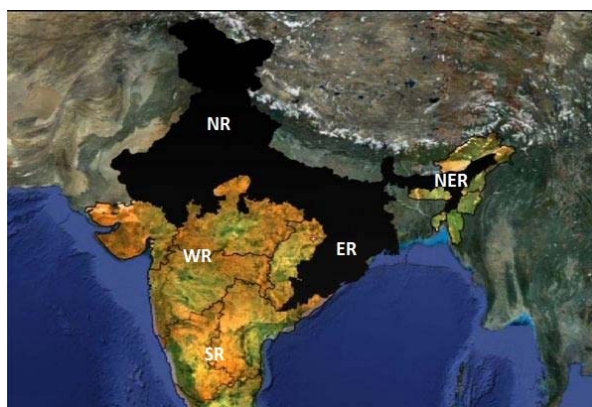
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## 1. INTRODUCTION

**B**lackout or power outage is a loss of the electric power to an area which can exist for short period of time or can exist for a long period of time if appropriate measures is not taken. The blackout can occur because of many causes of power failures in an electricity network. Examples of these causes include faults at power stations, damage to electric transmission lines, substations or other parts of the distribution system, a short circuit, or the overloading of electricity mains.

In July, 2012 there was a major grid disturbance in Northern Region at 02.33 hrs on 30-07-2012. Northern Regional Grid load was about 36,000 MW at the time of disturbance. Subsequently, there was another grid disturbance at 13.00 hrs on 31-07-2012 resulting in collapse of Northern, Eastern and North-Eastern regional grids as shown in fig. 1. The total load of about 48,000 MW was affected in this black out. The outage affected over 620 million people, about 9% of the world population or half of India's population, spread across 22 states in Northern, Eastern, and Northeast India.

An estimated 32 gigawatts of generating capacity was taken offline in the outage



**Fig.1.** Overview of affected regional grids

It was not the first time in history of India that grid failure has occurred, earlier to this a grid failure had occurred in 2001 which affected eight states of northern India. The states affected due to failure of the northern grid include Punjab, Jammu and Kashmir, Haryana, Delhi, Uttar Pradesh, Rajasthan, Union Territory of Chandigarh and Himachal Pradesh. The cause of grid failure in 2001 was a fault occurred in the 400kV Panki sub-station near Kanpur in Uttar Pradesh. The collapse

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of grid affected operation of various industries which indirectly affected economy of country.

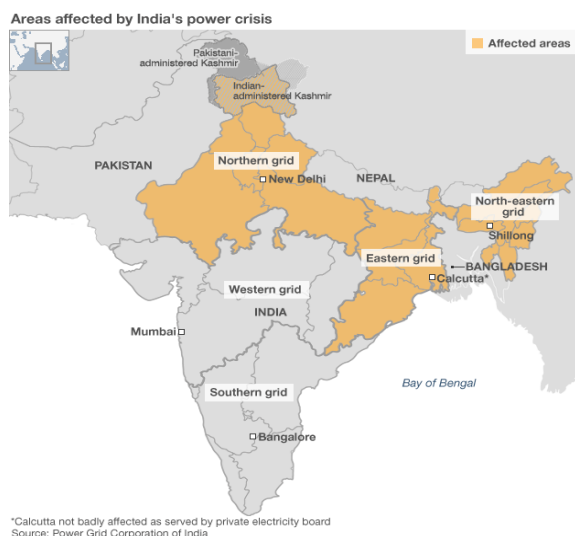
## 2. AN OVERVIEW OF GRID SYSTEM

A power grid is an interconnected network of transmission lines for supplying electricity from power suppliers to consumers. Any disruptions in the network causes power outages. India has five regional grids that carry electricity from power plants to respective states in the country.

### 2.1 Numbers of operating Grids in India

There are five operating grid in India as shown in fig.2:-

- Northern Grid(NR)
- Eastern Grid(ER)
- Northern-eastern Grid(NER)
- Western Grid(WR)
- Southern Grid(SR)



**Fig. 2.** Overview of five operating grid system with shaded portion indicating area affected during power crisis.

## 3. CAUSE OF GRID FAILURE

The cause of grid failure was that the grid was initially operating in insecure condition because of number of lines were not available due to either forced outages, planned outages or kept out to control high voltages. This resulted in a depleted transmission network, which coupled with high

demand in the Northern Region, resulted in over drawal of power by some states like Uttar Pradesh, Punjab and Haryana which lead to tripping of 400-kV Bina-Gwalior line, feeding the Agra-Bareilly transmission section. Initially the 400 kV Gwalior-Agra transmission line was carrying about 1055MW and 400 kV Gwalior-Bina was carrying about 1450 MW. The loading on 400 kV Gwalior-Agra was high. At 02:33:11:907 hrs, the 400 kV Bina-Gwalior line in WR (western) tripped on Zone 3 protection, which is due to load encroachment. Prior to tripping the voltage was 374 kV at Bina end and the line was carrying about 1450 MW approximately as per report of POWERGRID for this line. With the tripping of the above line, the supply to NR from 400 kV Agra-Gwalior was lost. With the tripping of the above line, the supply to NR from 400 kV Agra-Gwalior was lost. 400 kV Zerda-Bhinmal-Bhinmal (220 kV)-Sanchoe (220kV) and Dhaurimanna (220 kV) was the only AC tie link left between WR & NR. Subsequently 220 kV Bhinmal-Sanchoe line tripped on power swing, and as per SLDC Rajasthan 220 kV Bhinmal-Dhaurimanna tripped on Zone 1 distance protection. This resulted in loss of the WR-NR tie links. A small load at Bhinmal remained connected with WR system through the 400 kV Zerda-Bhinmal line. The tripping of the 400 kV Bina-Gwalior line initiated a very large angular deviation between NR system on one side and ER+WR+NER system on the other side. The power from WR to NR was now routed via WR-ER-NR interface, which is a very long path. Due to large power flows in the WR-ER-NR route, 400 kV Jamshedpur-Rourkela double circuit (in ER) tripped on Zone 3. Though the NR system, at this stage, was still connected to the ER system(which was connected to the WR), the machines in the NR system had started to slow down as compared to those in rest of the NEW grid. Therefore, angular separation between NR

and the rest of the grid continued to increase. This situation would eventually lead to angular instability (loss of synchronism). It is well established that under such situations, the distance relays near the electrical center of this separation are prone to pick up. Accordingly 400 kV ties between ER and NR (BiharSharif-Balia, Muzzafarpur-Gorakhpur, Patna-Balia, and Sasaram-Balia) tripped.

The NR system was thereby isolated from the rest of the grid. In the NR system, there was loss of about 5800 MW import and resulted in decline of frequency. NR System has Automatic Under Frequency Load Shedding Scheme (AUFLS), which can shed about 4000 MW of loads, and df/dt relays scheme, which can shed about 6000MW of loads, to improve the frequency and save the system under such emergency situations. However, not adequate load relief from the AUFLS and df/dt relays was observed and the NR system collapsed except for a few pockets at Badarpur and NAPS.

With the separation of NR from the rest of the grid, the ER+WR+NER grid had a surplus of about 5800 MW power exported to NR prior to the separation. This system had more generation and the frequency rose to 50.92 Hz and stabilized at 50.6 Hz. There was tripping of Korba (E) 2\*250 MW, APL Mundra 2\*660 MW, Dhuvaran 80 MW, Parli 210 MW and Nasik 210 MW units in WR and Mejia-B 400MW, DSTPS 250 MW and MPL 450MW in ER took place. APL Mundra units tripped on Special Protection Scheme. The reported loss of generation is of the order of 3340 MW. The sudden rise in frequency, close to 51Hz in the WR, also indicates inadequate primary response from generating stations. The primary response if enabled in NR could also have helped in curtailing the initial frequency dip in the Northern region.

In July 31/07/2012 the NEW grid failure occurred because before disturbance of grid, system was operating in insecure state as number of transmission line where out of operation due to either forced outages, planned outages or kept out to control high voltages which makes overall system weak as NR constituent were drawing excessive power from WR which led to over loading of transmission line .Before disturbance of grid NR-WR was connected to through AC tie link between 400KV Agra-Gwalior(one circuit), 220KV Badod-Kota & 220KV Badod-Modak lines. Earlier Badod-Kota 220KV tie lines was carrying 113 MW but its power flow reached to 298MW which led to tripping of line due to over loading. Similarly Badod-Kota was carrying 288MW from its initial 103MW which causes overloading and line tripped. The 400KV Bina-Gwalior line tripped because of load encroachment. The over draw of power by Auraiya(U.P) from Mahalgaon (M.P) resulted in the tripping of 220KV Bina-Gwalior transmission line as a result this NR system was isolated from WR system and the demand which was earlier fed from the WR got routed through WR-ER-NR system causing increase in the angular separation between the NR and WR systems, similar to the disturbance on 30th July 2012. The electrical center of the angular separation appears to be slightly inside the ER system from the WR-ER interface. This resulted in tripping of lines connecting unlike Ranchi and Rourkela to the rest of the ER. These buses formed part of the WR, which got separated from the rest of ER+NR+NER at about 13:00:20 hrs. The frequency plots from PMUs(phase measurement units) and the WAFMS(wide area frequency measurement syatem) from the NR and WR shows that the frequency in the WR rose to 51.4 Hz and that in the rest of the NEW grid stabilized close to 48.12 Hz. The WR system survived with the tripping of

Sipat 660MW, DSPM 2\*250MW ESSAR 125 MW and KLTPS 69 MW generating units. APL 660 MW generating unit tripped on Special Protection Scheme, associated with tripping of Adani-Manindragarh HVDC and frequency stabilized at around 51 Hz, with this effect the loss of import from about 3000 MW import from WR resulted in decline of frequency in the rest of the NEW grid, which has Automatic Under Frequency Load Shedding Scheme (AUFLS), that can shed about 5600 MW of loads, and df/dt relays scheme, which can shed about 6020MW of loads, to improve the frequency and save the system under such emergency situations. However, not adequate load relief from the AUFLS and df/dt relays was observed on 31st July 2012 as a result of which NEW grid collapsed. It may be noted that both on 30th and 31st July 2012, lot of tripping of lines were observed due to over voltage and also substantial under voltage at the tail end of the heavily loaded lines were observed, which caused operation of distance protection. These extreme voltage could have been avoided with the proper reactive power absorption/support from reactors/capacitors, dynamic compensator as well as synchronous generator.

#### **4. IMPACT OF GRID FAILURE ON ECONOMY OF INDIA**

India's energy crisis cascaded over half the country Tuesday(31/07/2012) when three of its regional grids collapsed, leaving hundreds of millions of people without government-supplied electricity in one of the world's biggest-ever blackouts.

##### **4.1 Effect on Railways**

Around 1.5 lakh passengers in 300 trains suffered delays as the power grid failure crippled operations across eight divisions of the northern railway on Monday, while 200 goods trains were

cancelled, said railway officials. The cancellation of goods trains, in order to accord priority to movement of the stalled passenger trains, resulted in a revenue loss of over Rs. 100 crore, officials said. Thousands of passengers were stranded for hours at Delhi's two main railway stations as all trains to the northern states of Punjab, Haryana, Himachal Pradesh and Jammu and Kashmir remained non-functional. According to the railways, electricity supply to the network has been restored in most places but many trains, including the prestigious Rajdhani, Shatabdi and express trains, were still running hours behind their schedules.

##### **4.2 Effect on Metro train**

Delhi Metro railway services also ceased to operate because of unexpected breakdown of power supply from Northern Power Grid, Metro services on all Lines remained suspended from 01:02 PM to 02:50 PM on 31/07/12. To ensure the safety & security of its passengers, Delhi Metro immediately evacuated all passengers from trains and stations.

##### **4.3 Effect on Leather industry**

Leather industry hub Kanpur suffered losses of about Rs450 crore on account of the power crisis triggered by the collapse of grids in the past two days, industry body IIA said today. According to Indian Industries Association (IIA), the massive power failure caused about 6,800 medium and small scale industries including tanneries in the city to shut the operations. These industries employ about two lakh workers."The two day power failure badly affected the industrial city of Kanpur," said Sunil Vaishya, Chairman, Kanpur unit of IIA, adding that the losses so far has been estimated at a whopping Rs 450 crore. The industries in the city are already getting lower than the required power supply, but this grid failure

forced the factory owners to shut operations and send workers on leave, he said. The workers have been asked to return to work after 'Rakhsabandhan' tomorrow. Besides the estimated loss of Rs 450 crore so far, the real losses are yet to be ascertained as the factory owners would not be able to execute the work orders on time, said Vaishya. Though the normal supply to the city has been restored, industrial units in the city are yet to get power supply to the full capacity, he added. The cottage industry in the city too suffered because of power failure. The country faced major power crisis for the second consecutive day on yesterday as three grids serving Northern, Eastern and North-Eastern regions failed yesterday afternoon. In the worst ever power crisis, over half of the country's population in 21 states went without electricity for several hours taking life out of gear and affecting about 600 million people.

#### **4.4 Effect on Steel industry**

Tata Steel(Jamshedpur) one of the major private steel industry was also affected with plants operating in a limited way following failure of the eastern power grid."The operations in Tata Steel are affected and plants are being operated with limitation, "according to Officials of Tata Steel.

Bokaro Steel Plant (BSL)-one of the five steel-producing units of the Steel Authority of India Limited (SAIL) - here on Thursday when production came down to zero following a 12-hour-long power failure since Wednesday night. The halt in production for so many hours in the 4.5-MT capacity BSL would affect its overall annual production target of 14 MT set by SAIL. BSL contributes around 26% of SAIL annual production and 20% in its profit. The financial loss caused to the company has not been assessed yet but it will be in several crores, said a BSL officer.

#### **4.5 Effect on Power industry**

Grid failure that left a major part of India in darkness, has impacted the volumes of power generation companies. The worst power black-out in the world hit their revenues by an estimated Rs 550 crore in two days. The companies affected by the grid collapse were state-owned power generator NTPC Ltd, Nuclear Power Corporation of India Ltd (NPCIL) and Neyveli Lignite Corporation (NLC) in the central sector. Among the states, power utilities of Rajasthan, Haryana and Uttar Pradesh had to shut capacity down. About 35,000 Megawatt (Mw) of capacity had to be shut as the northern grid, that caters to nine states including the national capital, collapsed under the weight of excessive load on Monday. Even before the exact cause of the incident could be understood, two additional grids – eastern and north-eastern, tripped along with the northern grid on Tuesday. The generation loss on the second day was 55,000 Mw. Taken together, the generation loss of 90,000 Mw on the two days was close half of India's installed power capacity of 200,000 Mw.

While some plants remained shut for a few hours or less than a day, others remained shut for more than a day before revival efforts kicked in. Power companies refused to divulge details of revenue loss from the incident but a back of the book calculation puts the figure at around Rs 550 crore, assuming an average Plant Load Factor (PLF) of 85 per cent, the total revenue loss to the companies is estimated to be Rs 550 crore. The calculation is based on a conservative estimate of sale price at Rs 3 per unit. NTPC was among the worst-hit, with six of its main plants brought down by grid failure. While the company did not share revenue loss details, based on the assumptions stated above, the impact on profit is expected to be around Rs 42.6 crore. "Around 7,000 Mw (a fifth of NTPC's capacity) went down for some

hours. The capacity started coming in within hours of the grid rectification,” a senior official from NTPC Ltd told Business Standard.

#### **4.6 Effect on Medium and Small industry**

India’s industrial sector suffered huge losses on Tuesday, as many factories had to stop production while others shifted to emergency generators as a massive power outage hit the country’s northern, eastern and northeastern regions. “Losses to business have been in thousands of crores of rupees, which pales into insignificance compared to the difficulty that the people of the country have had to face,” the Confederation of Indian Industry (CII) said.

#### **4.7 Effect on Agriculture**

As the country is already facing average annual rainfall which led to slowdown of agricultural activities in states like Punjab and Haryana because of grid failure these states were unable to water their fields.

### **5. CONCLUSION**

Based on the summary of recent events presented here, one can see a general trend in all of these recent blackouts, namely:

- a lack of reliable real-time data;
- thus, a lack of time to take decisive and appropriate remedial action;
- increased failure in aging equipment;
- a lack of properly automated and coordinated controls to take immediate and remedial action against system events in an effort to prevent cascading.

The blackout has not only affected the power sector but also it has devastating effect on several other industries which directly influences economy of country, so these blackout must be avoided by proper planning of the system and appropriate steps must be taken.

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