सत्यमेव जयते

Government of India
Ministry of Power
Central Electricity Authority

REPORT OF THE INQUIRY COMMITTEE
ON
GRID INCIDENT IN NORTHERN REGION
ON
7th AND 9th MARCH, 2008

NORTHERN REGIONAL POWER COMMITTEE
KATWARIA SARAI,
New Delhi
December, 2008

Report of the Inquiry Committee on Grid incident in Northern Region on 7th and 9th March, 2008

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EXHIBITS

Report of the Inquiry Committee on Grid incident in Northern Region on 7th and 9th March, 2008

1. Introduction

1.1 Power supply in Delhi and neighbouring constituent States of Northern Regional Electricity Grid was severely affected on 7th and 9th March, 2008 due to tripping of a large number of important transmission lines in midst of dense foggy weather conditions resulting in widespread disruption of normal life and railways traffic. On both these days, tripping of transmission lines started at around midnight and position worsened with the passage of time reaching the critical situation during 0700 - 0800 hours. The emergent conditions were handled by the northern regional and state grid operators with utmost care and meticulous management of the generation and power flow to prevent cascading failure. With the rise in temperature during the day, the situation started improving with the restoration of lines at around 0930 hours and power supply was restored near normal conditions by noon. The severity of the grid incident could be gauged by trippings and the loss of load and generation on these days as given below.

Date	Loss of Load	Nos. of affected lines (220 kV above)	Loss of Thermal Generation
7th March, 2008	2000-6000 MW	204	3670 MW
9th March, 2008	2000 – 5000 MW	141	2355 MW

The severely affected States were Delhi, Haryana, Punjab, Uttar Pradesh and Rajasthan. Around 1000-1500 MW of the surplus power in the northern region due to loss of load was exported to neighboring regions.

1.2 The Central Electricity Authority vide their order no. CEA/ 5-41 (04)/Secy- 2008/40 dated 13-3-2008 (**Annex-I**) constituted a Committee comprising the following to inquire into the grid incident and ascertain the cause of grid disturbance and suggest remedial measures to avoid recurrence of such incident:

1.	Shri S.M. Dhiman	Member (Grid Operation and Distribution), CEA	Chairman
2.	Shri S.P.S. Gaharwar	Member Secretary, Northern Regional Power Committee	Member Convener
3.	Shri S.K. Soonee	Executive Director, Northern Regional Load Dispatch Center	Member
4.	Shri R.N. Nayak,	E.D, (Engg.), PGCIL	Member
5.	Shri S.R. Sethi,	Director (O), DTL	Member
6.	Shri R.S. Lamba	Director (PR), BBMB	Member
7.	Shri Neeraj Gulati,	CE (SO), HVPNL	Member
8.	Shri Ashok Kumar,	CE (TR), UPPTCL	Member
9.	Shri Tapan Chatterjee	CE (GM), CEA	Member
10.	One representative from Railway Board		Member

1.3 The Terms of Reference of the Committee are as under:

(a) To analyse the cause leading to grid incident on 7th and 9th March 2008.
(b) To review the restoration of system.
(c) To review the performance of the protection system.
(d) To suggest remedial measures to avoid recurrence of such disturbance in future.
(e) Any other relevant issues connected with safe and secure operation of the Grid.

The Inquiry Committee was advised to furnish the cause of disturbance within two months. Subsequently, two months extension for completion of inquiry and submission of the report was given by the competent Authority.

1.4 Shri R.K. Jain, DEE, Power Supply, Ministry of Railways participated.

1.5 The Member Secretary, Northern Regional Power Committee (NRPC), in his communication to the State Load Dispatch Centers of the Northern States requested for information on the sequence of events as recorded in the event loggers on 7th and 9th March, 2008.

1.6 After the receipt of some of the data and its analysis, the first Meeting of the Committee was held on 22nd April, 08 at NRPC New Delhi. A detailed presentation of the events during the above incidents was made by the Northern Regional Load Dispatch Centre (NRLDC) and thereafter the action taken by the constituents was also discussed. The similarity of these incidents with the one occurred during the previous year on 27th Jan, 2007 was also discussed. The Committee discussed the report and the recommendations. Shri PP Francis, DGM (OS), NTPC was co-opted as member of this committee.

1.7 The second meeting was held on 8th July, 08, where in draft report was discussed and members were requested to send their comments for finalization of the report. Third meeting was held on 17th Oct, 2008.

1.8 Fourth and final meeting was held on 15.12.08, wherein recommendations were discussed and the report was signed by the members.

1.9 The Committee analyzed information and data supplied by the Constituents and NRLDC on its SCADA system.

2. Overview of Northern Regional Grid

2.1 For integrated power generation planning and evolving the requisite transmission system, five contiguous regions in the country were considered; each comprising a certain number of neighboring States to set out geographical coverage for evolving the regional power grids leading ultimately to formation of the national power grid. The Regions are the Northern (N), Western (W), Southern (S), Eastern (E) and North-Eastern (NE).

2.2 Northern Region is the largest in geographical area amongst the five regions in the country covering approximately 30.7% of the area and having largest number of constituents (9 states/UT, 4 Central Generating Companies, one Central Transmission Utility, Bhakra Beas Management Board and Nuclear Power Corporation of India Ltd). It has largest sized hydro unit (250 MW at Tehri/ Nathpa Jhakri) in the country. Northern Grid has an effective capacity of 36,885 MW as on 31.03.08. The Thermal-Hydro (i/c RES) mix is of the order of 61:39.

2.3 Northern Region has country's first High Voltage Direct Current (HVDC) long distance transmission system in the country (2x750 MW, +/- 500 kV Rihand-Dadri HVDC bipole) and first HVDC back-to-back interconnection with Western

Region (2x250 MW back-to-back HVDC station at Vindhyachal). It has 1 x 500 MW HVDC back- to –back interconnection with Eastern Region at Pusauli. NR has country's first and only 400 kV Static VAR Compensators (SVC's) (2x +/- 140 MVAR SVC at Kanpur).

2.4 The large Coal pithead thermal power stations are located in the extreme Southeastern part of the Regional Grid constituting generation capacity of around 7000 MW against which normal generation level is 5500-6000 MW.

2.5 Major generating stations including Super Thermal Power Stations of NTPC at Rihand and Singrauli are located in the eastern part of the grid. Due to such concentration of generation in the eastern part of the grid and major load centers in the central and western part of the grid there is bulk active power transmission from eastern to western part over long distances.

2.6 To handle this bulk transmission of power, a point to point high voltage DC line viz. HVDC Rihand-Dadri bipole with capacity of 1500 MW exists and operates in parallel with thirteen 400 kV AC transmission lines connecting Eastern part (Eastern UP subsystem) with Rest of Grid besides under lying 220 kV network.

2.7 With the commissioning of 400 kV Muzaffarpur (ER) –Gorakhpur (NR) D/C line in August, 2006, Northern grid got synchronized with the Western Region (WR), Eastern Region (ER) & North Eastern Region (NER). Since then NR, WR, ER and NER grids (i.e. Central Grid) are operating in synchronous mode. 765 kV Bina-Gwalior-Agra line (charged at 400 kV) was commissioned on 31st March 2007 and provides direct AC interconnection of Northern Region with Western region.

2.7 The operation of the entire Northern Regional grid is co-coordinated in real time by the Northern Regional Load Dispatch Centre (NRLDC) and eight State Load Dispatch Centres (SLDCs).

The Map indicating 400 kV and above lines in NR is enclosed at **Exhibit- I.**

3. Description of the Disturbance

3.1 Antecedent Conditions

3.1.1 On the intervening night of 6th -7th March 2008, the frequency was low and was hovering below 49.0 Hz. The availability was around 20585 MW against normal requirement of 23500-24000 MW due to forced outage of Unchahar #2 (210 MW), Singrauli#2(200 MW), Panipat#1&2 (210 MW each), Obra#13 (200 MW).

3.1.2 Details of generation pattern & inter-regional flows prior to the incident, voltage profile for 7th March 08 and outages of generators and loads and load loss from 7th March 08 to 9th March 08 is enclosed at Annexure **-II.**

3.2 Weather Conditions

3.2.1 The prevalence of foggy conditions in the northern region during winter months is a common phenomenon. The foggy conditions prevail during the period from mid December to mid February beyond which the frequency of occurrence of foggy conditions diminishes due to temperature rise. The extended winter during the year 2007-08 resulted in foggy conditions during March. Report of IMD received in this regard is given at Annex**-III.**

3.2.2 The sensors are being installed by PGCIL at a number of the substations in the Northern region for online monitoring of the weather parameters like temperature and relative humidity. The temporal pattern of temperature and prevailing relative humidity at Minto road, SLDC Delhi in first 11 days of March, 2008 as per information available with the NRLDC shown graphically in **Exhibit-II**. The foggy conditions occur during winter when relative humidity exceeds 85-90% and

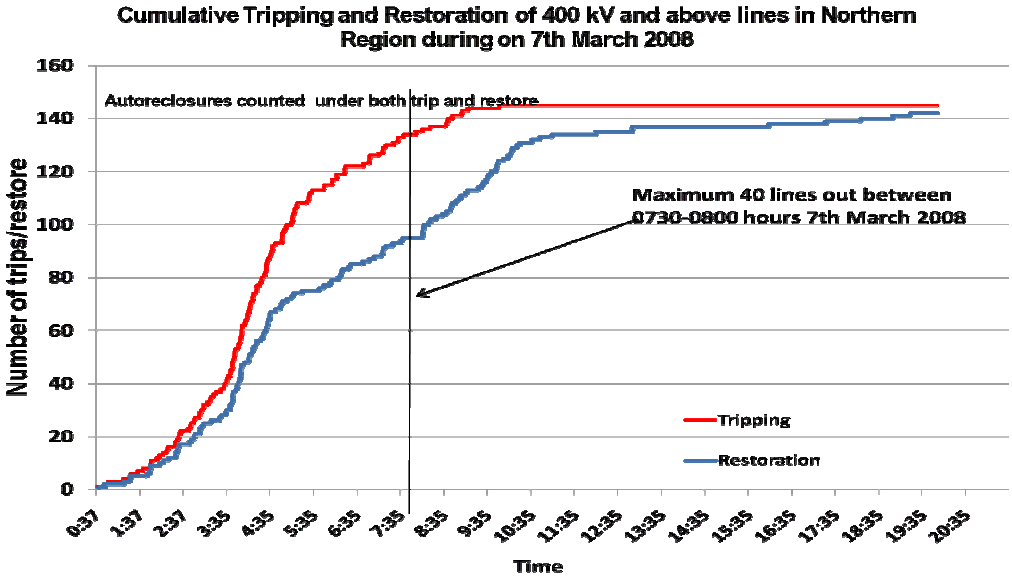
temperature falls below 15-17^0 C as been recorded on 7th to 9th March 2008. During this period, condensation takes place and condensation on the pollution laden insulators results in flashover and tripping of transmission lines.

3.2.3 Dense fog conditions were reported on above days in Delhi (Mandaula, Bawana, Maharani Bagh) Haryana (Bahadurgarh, Hissar, Ballabgarh,) and western UP (Meerut, Bareilly and Northern part of Rajasthan.

3.3 Disturbance on 7th March, 2008

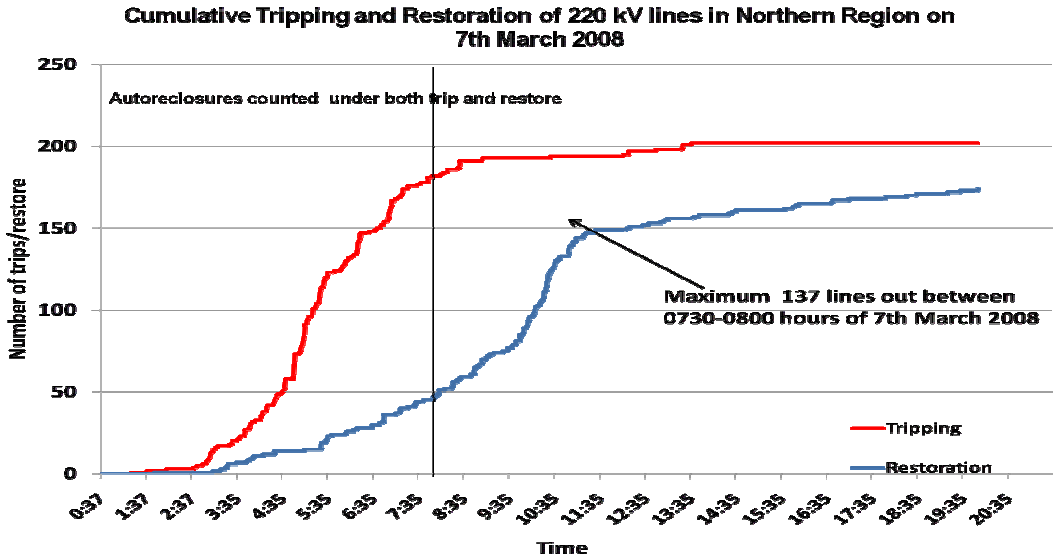
(Tripping in the night of 6/7th March, 2008)

3.3.1 First tripping reported was of 400 kV Ballabgarh –Mainpuri-II at 0038 Hrs on 7.3.08. Subsequently a large number of 400 KV and 220 KV lines tripped and most of them successfully auto re-closed at periodic intervals, however some of them were declared under breakdown. The tripping of various lines along with restoration time and relay indications has been tabulated at Annexure- **IV.** The tripping and simultaneous restoration of 400 kV lines is illustrated graphically below.



3.3.2 The most critical period was from 0730 – 0800 Hrs when about 40 lines of 400 kV network were out.

3.3.3 Similarly for 220 kV network also, the most critical period was from 0730 – 0800 Hrs when about 137 lines of 220 kV were out as shown in the graph placed below.



3.3.4 At 0440 hrs on 07.03.2008, bus bar protection operated at 220 kV BBMB Ballabgarh S/S which caused BTPS, Indraprastha, Pragati islanding (incidental islanding, due to tripping of all lines connecting to the rest of NR system) along with Mehrauli, Okhla, Sarita Vihar Load. The subsystem survived for 4 hours 17 minutes and was later synchronized with main Grid at 0856 hrs.

3.3.5 The last surviving 400kV AC line from Dadri (Dadri – Malerkotla) tripped at 05.26 hrs to isolate the Dadri stations. Dadri (Coal) & Dadri (GPS) islanded separately and Dadri (GPS) survived on house load for 2 hours 55 minutes. Dadri (Coal) units except unit #3 tripped later when all ICTs at Dadri tripped on over-fluxing protection.

3.3.6 Railway traction supply was disrupted on both days, on Delhi – Mugalsarai, Delhi-Ambala and Delhi-Chennai route affecting the movement of trains on these routes.

3.3.7 The severity of tripping of all affected 400 kV lines are given below:
(AR – nos. auto re-closer, T –nos. of trippings R –nos. of revival)

S. no	kV	From	To	AR	T	R	Recurring Fault locations	Remarks
1	400	Abdullapur	Bawana -I	3	1	1	17, 159, 177 km from Bawana	Y-N fault
2	400	Abdullapur	Bawana-II	0	1	1		
3	400	Abdullapur	Jhakri	0	1	1		
4	400	Agra	Ballabgarh	0	1	1		
5	400	Agra(UP)	Muradnagar	0	2	1		
6	400	Anpara	Mau	0	1	1		
7	400	Bahadurgarh	Bawana	4	4	4		
8	400	BahadurGarh	Bhiwani	0	1	1		
9	400	Ballabgarh	Bamnauli-I	0	2	2		
10	400	Ballabgarh	Bamnauli -II	0	3	3		

11	400	Ballabgarh	Bhiwadi	2	1	1		
12	400	Ballabgarh	Greater Noida	7	1	1	15 km from Ballabgarh	Y-n, B-n
13	400	Ballabgarh	Kanpur	2	2	2		
14	400	Ballabgarh	Maharani Bagh	2	8	8		
15	400	Ballabgarh	Mainpuri(PG)-I	2	2	2		
16	400	Ballabgarh	Mainpuri(PG)-II	0	1	1		
17	400	Bamnauli	Bawana -I	0	4	4		
18	400	Bamnauli	Bawana -II	0	1	1		
19	400	Bamnauli	Patiala	0	0	1		
20	400	Bareilly	Mandaula -I	2	3	3		
21	400	Bareilly	Mandaula -II	4	1	1	4.5 to 12 km from Mandaula	All 4 AR Within 8 minutes From 0423 to 0431 Hrs
22	400	Bassi	Bhiwadi	2	1	1		
23	400	Bawana	Hisar	6	4	4	34 , 79-89 km from Hissar	Y-n, B-n
24	400	Bawana	Mandola -I	0	1	1		
25	400	Bawana	Mandola -II	0	1	1		
26	500	Bhiwani	Dehar	0	2	2		
27	400	Dadri	Malerkotla	1	2	2		
28	400	Dadri	Mandola -I	5	2	2	3-13 km from Mandaula	All 5 AR in 42 minutes
29	400	Dadri	Mandola -II	3	1	1	4-8 km from Mandaula	All 3 AR in 31 minutes
30	400	Dadri	Muradnagar	0	1	1		
31	400	Dadri	Panipat -I	0	2	2		
32	400	Dadri	Panipat -II	0	2	2		
33	400	Dehar	Panipat	0	1	1		
34	400	Fatehabad	Hisar	0	1	1		
35	400	Hisar	Kaithal	5	3	3	83-84, 66-70,17 km from Hissar	
36	400	Hisar	Moga	0	1	1		
37	400	Hisar	Patiala	1	5	4		
38	400	Kaithal	Nalagarh	0	1	1		
39	400	Mandola	Meerut -I	5	1	1	Within 5 km from Mandaula	All 5 AR in 33 minutes
40	400	Mandola	Meerut -II	4	2	2	4-5, 17.5 km from Mandaula	All 4 AR in 64 minutes

41	400	Meerut	MuzaffarNagar	0	2	2		
42	400	Meerut	Tehri -I	0	2	1		
43	400	Moradabad	Muradnagar -I	0	1	1		
44	400	Muradnagar	MuzaffarNagar	0	1	1		
45	400	Muradnagar	Panki	0	1	1		
46	400	MuzaffarNagar	Rishikesh	0	1	1		
47	400	MuzaffarNagar	Vishnuprayag II	0	1	1		
48	400	Obra	Panki	0	1	1		
49	+500	Dadri HVDC	Rihand -I	0	1	1		
50	-500	Dadri HVDC	Rihand -II	0	2	2		
				60	88	86*		

* 400 kV Hissar –Patiala and Agra Muradnagar lines could not be restored on same day.

3.3.8 The severity would be evident from the fact that 400 kV Ballabgarh-Maharanibagh tripped 10 times, Bawana Hissar 10 times and Bahadurgarh – Bawana 08 times and Hissar- Khaithal 08 times from 0038 Hrs to 1100 Hrs on 7th March, 2008.

3.3.9 A total of 641 numbers of operations were carried out on 400 kV and 220 kV transmission lines on 7th March, 2008 between 0000Hours to 1700 Hours as under.

Sl No	Voltage (kV)	No. of lines affected	No. of Auto-reclose) (A)	No. of Tripping (B)	No. of restores (C)	Total line operations (A + B +C)
1	400 kV & above	50	60	88	86	234
2	220 kV	154	0	203	204	407
Total		204	60	291	290	641

3.3.10 Auto re-closing of important lines on 7th March, 2008

400 kV Ballabgarh –Greater Noida auto reclosed 7 times on 7th March, 08 on Y- N and B-N fault about **15 km** from Ballabgarh end. The important auto reclosures on 7th March, 2008 are given below.

Sl. No.	kV	From	To	AR	FL(km)	Remarks
1	400	Abdullapur	Bawana -I	3	16.91, 158.6, 176.7	Y-N fault
2	400	Ballabgarh	Greater Noida	7	15	Y-n, B-n
3	400	Bareilly	Mandaula -II	4	1.9 % to 4.9 % from Mandaula	Within 8 minutes From 0423 to 0431 Hrs
4	400	Bawana	Hisar	6	34, 79-89	Y-n, B-n
5	400	Dadri	Mandola -I	5	3-13 from Mandaula	In 42 min
6	400	Dadri	Mandola -II	3	4-8 from	In 31 min

					Mandaula	
7	400	Hisar	Kaithal	5	83-84, 66-70,17 from Hissar	
8	400	Mandola	Meerut -I	5	Within 5 from Mandaula end	In 33 min
9	400	Mandola	Meerut -II	4	4-5, 17.5 from Mandola	In 64 min

From the above it can be concluded that pollution level is high on the locations indicated by fault indicator (FL) readings.

3.3.11 The severity on important 400 kV Sub-stations on 7th Mar 08 is tabled below:

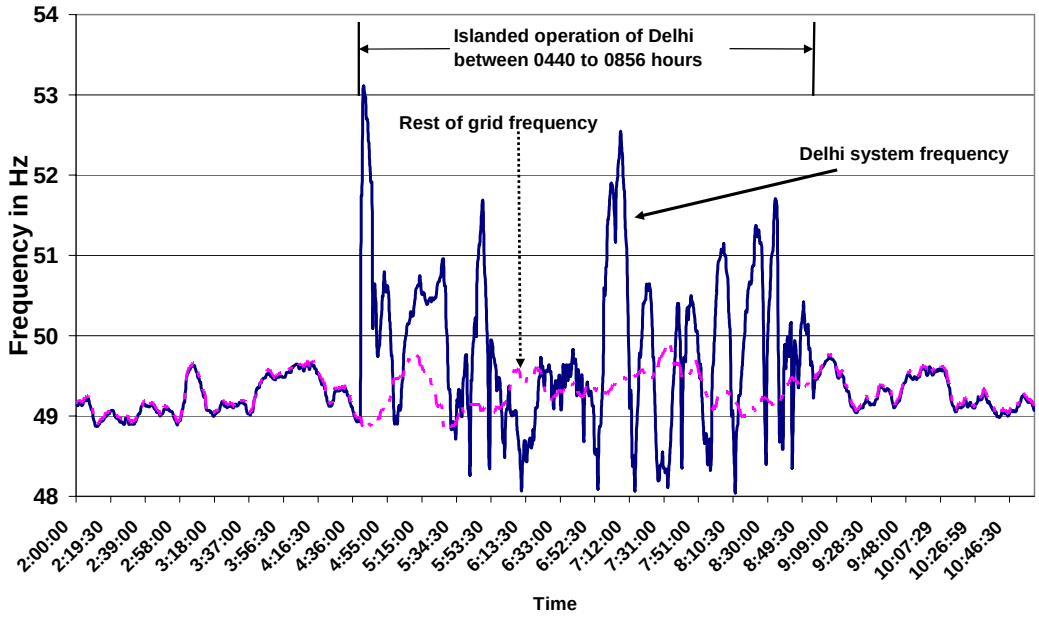
Sl. No.	Name of 400 kV Sub-station	Nos of tripping observed
1	Ballabgarh(PG)	57
2	Mandaula (PG)	47
3	Bawana (DTL)	46
4	Hissar (PG)	39
5	Dadri NTPC	29
6	Meerut (PG)	22
7	Bamnauli(DTL)	21
8	Maharani Bagh (PG)	18
9	Bahadurgarh (PG)	14
10	Bareilly (PG)	14

3.3.12 Delhi Sub System Islanding

220 kV BTPS –Alwar was already out (since0304 Hrs). 400 kV Maharanibagh-Ballabgarh tripped at 04:04 Hrs. 220 kV BTPS- Ballabgarh-I tripped from BTPS end. At 04:39:36.150 Hrs 220 kV BTPS- Ballabgarh-II tripped at Ballabgarh end due to operation of LBB of Bus -II. Now BTPS, Indraprastha and Pragati generators islanded with Mehrauli, Okhla , Sarita Vihar load. The subsystem survived for over 4 hours 17 minutes and later synchronized with main Grid around 08:56 Hrs.

The performance of above sub system was very satisfactory and highly appreciable during the islanding mode. The frequency graph of same is given below during islanded operation.

Frequency profile during islanded operation of Delhi system on 7th March 2008



3.3.13 Tripping at 220 kV Ballabgarh (BBMB)

At 0439 hrs, protection of BTPS- Ballabgarh –II operated but breaker failed to clear the fault from Ballabgarh end due to pole discrepancy. LBB operated and disconnected all the feeders connected to Bus –II as per scheme.

3.3.14 Islanding of Dadri (Coal 4X 210 MW) Power Station

Dadri station was surviving on 400kV Dadri – Malerkotla line which tripped at 05.26 hrs and isolated the Dadri station from rest of the Grid. This resulted in frequency rise and resulted in isolation of GTG units on house load. Dadri (Coal) Unit # 4, 1, tripped at 0526 and 0528 Hrs respectively on low drum level protection. Unit #2 was manually tripped at 0529 hrs, to enable Unit # 3 to operate in islanded mode. At this point, the voltage level at Dadri Bus touched 448 kV. Dadri (Coal) unit #3 continued to operate on house load even after all the five ICTs at Dadri had tripped on over fluxing protection.

As Unit # 3 came on house load operation with about 35MW (including radial load of Railways) after Unit#2 was hand tripped (05.29 hrs), it was noticed that that the unit was absorbing about 60 MVAR, which almost corresponds to its MEL (Minimum Excitation Limit). Inspite of this high absorption of reactive power, the voltage of the 400kV bus was more than 448kV, which resulted in tripping of all the 5 , 220/400 kV ICTs on over-fluxing protection and the last ICT (ICT#1) tripped at 05.53 hrs. The Over voltage on 400 kV bus was caused by the minimum filter bank of 80 MVAR which was in service as POWERGRID was attempting to energize Rihand Dadri HVDV Line. In mean time at around 0526 Hrs 400 kV Dadri- Malerkotla- Line also tripped. Since there was minimum filter bank (80 MVAR) in operation, it caused abnormally high voltage(446 kV) on the 400 kV bus despite of absorption of 60 MVAR by unit 3 (210 MW) of Dadri (th). POWERGRID has stated that minimum filter bank connection is mandatory to energize the poles and connection is done automatically by Reactive Power Controller**.** It is to mention that HVDC have all necessary protection to trip the filter bank in case of tripping of all 400KV lines (permanent rejection) from NTPC Dadri

station, so that no adverse effect should be there on the 400 kV Bus due to filter bank.

Reason of no tripping of minimum filter may be investigated by POWERGRID and suitable action may be taken accordingly. With HVDC both poles blocked AND bus voltage > 420kV, Minimum Filter bank may be switched off automatically as soon as the poles get blocked. However in case any of the HVDC pole needs to be taken in service even if the 400 kV Dadri bus voltage is above 420 kV, then this interlock might need to be defeated temporarily.

3.3.15 Islanding of Dadri (Gas) Power Station units:

At 0526 Hrs Dadri (GPS 4X131 MW + 2X146.5 MW), GTG units isolated themselves from the 220kV bus bar, on high frequency. ST #1 &2 tripped on loss of both WHRB (Waste Heat Recovery Boiler). GT #1, 3, 4 islanded and survived on house load for 2 hours 55 minutes. These GTs were synchronized with the Grid at 0816, 0854 and 0822 Hrs respectively.

3.3.16 House Load Operation of Faridabad GT units:

At 04:42 hrs, GT-1 & GT-2 Faridabad tripped due to high frequency consequent to loss of evacuating lines, resulting in frequency rise. The last lines to trip at Faridabad GPS were 220 kV Palla D/C. Steam Turbines tripped on "over speed" protection.

Considering the several incidents of tripping and re-closure of transmission lines from Faridabad during the night and the alert issued by NRLDC, the emergency DG set was kept running on no-load and on opening of the 10.5 kV GCB of GTGs, auxiliary power supply changed over to DG source on auto and the GTGs continued to spin.

Grid supply was established to Faridabad at 0959 hrs (Samaypur – Faridabad GPP) and GTG units were synchronized at 1207 hrs and 1249 hrs.

3.3.17 Railway Traction Power Failure:

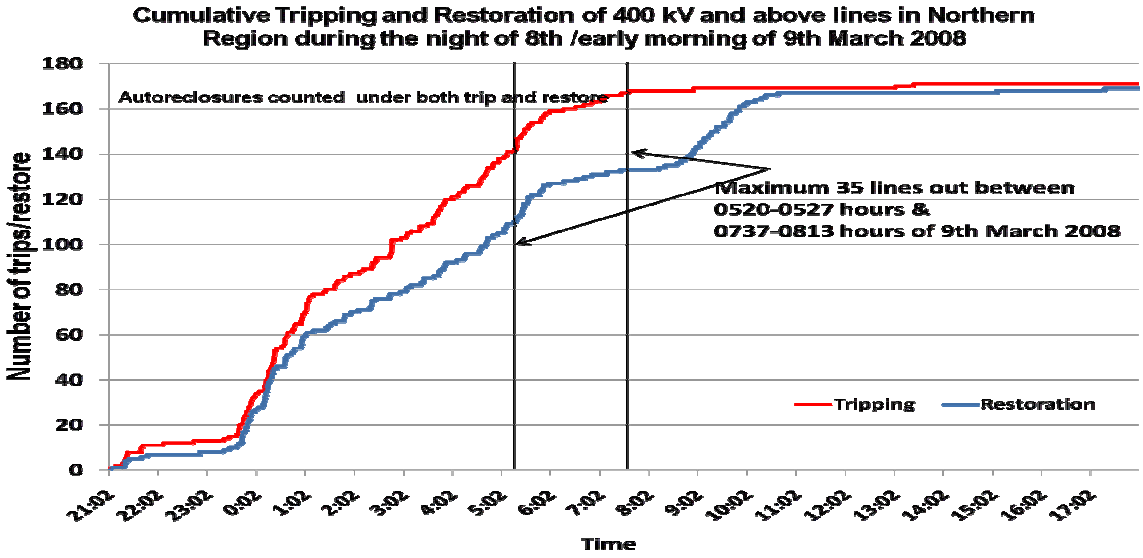
There was power failure on Delhi-Mugalsarai route due to tripping of 220 kV railway feeders I/II emanating from Dadri on earth fault **at 0533 hrs and 0535** hrs respectively. The tripping of Railway feeders on earth fault occurred after the islanding of Dadri (Coal) Unit-3. The high voltage of 446kV apparently caused this event also. On subsequent inspection by railways, the insulator strings at certain locations, were found damaged which were replaced. Traction supply from Dadri could be restored at **0708 hrs.** Supply had also failed on other two routes, namely Delhi-Ambala, Delhi-Chennai because of supply failure at railway feeding sub stations.

3.4 Disturbance on 9th March 2008

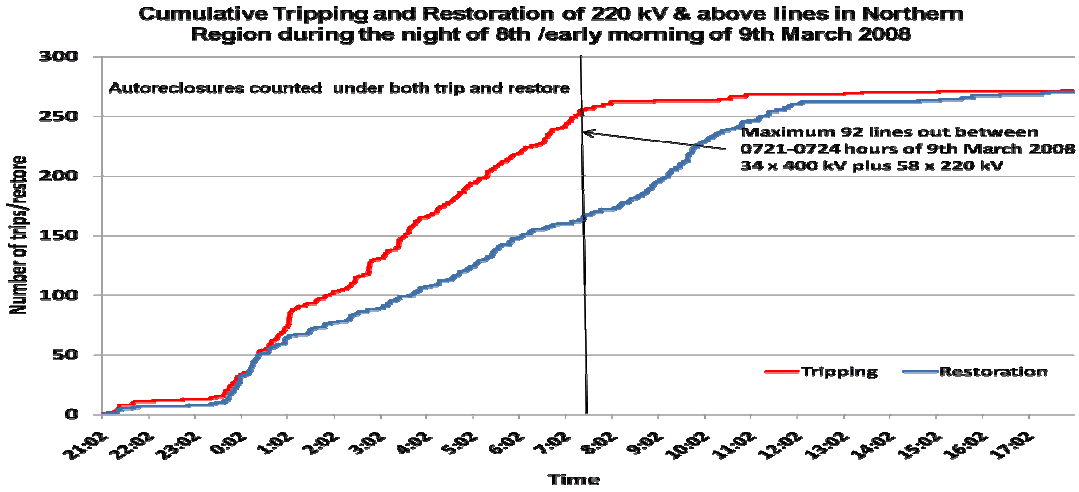
3.4.1 Tripping in the night of 8/9th March 2008

First tripping reported was 400 kV Mandaula -Bawana I at 0025 Hrs on 9.3.08. Subsequently a large number of 400 KV and 220 KV lines tripped and successfully auto reclosed at periodic intervals, with some of them declared under breakdown. The tripping of various lines along with restoration time and relay indications has been tabulated at **Annexure- V**

3.4.2 The tripping and simultaneous restoration of 400 kV is illustrated graphically below.



3.4.3 Similarly for 220 kV network also, the most critical period was from 0721 – 0724 Hrs when about 58 lines were out as shown in the graph given below.



3.4.4 The severity would be evident from the fact that 400 kV Dadri – Malerkotla tripped 32 times, Bawana- Mandaula –I, 11 times, Dadri- Mandaula-I, 12 times , Bareilly-Mandaula-II, 10 times and Bawana-Hissar 9 times on 9th March 2008. The most critical period was from 0737 – 0813 Hrs when about 35 lines of 400 kV network were out.

3.4.5 The severity of tripping of all affected 400 kV lines on 9th March 2008: are given below:

(AR – nos. auto re-closer, T –nos. of trippings R –nos. of revival)

S. no	kV	From	To	AR	T	R	Recurring Fault locations	Remarks

1	400	Abdullapur	Bawana -I	1	2	2		
2	400	Abdullapur	Bawana -II	0	3	3		
3	400	Abdullapur	Jhakri -I	0	1	1		
4	400	Abdullapur	Jhakri _II	0	2	2		
5	400	Agra	Ballabgarh	1	0	0		
6	400	Agra	Unnao	0	1	1		
7	400	Bahadurgarh	Bawana	1	1	1		
8	400	Bahadurgarh	Bhiwani	0	1	1		
9	400	Ballabgarh	Bamnauli-I	0	2	2		
10	400	Ballabgarh	Bamnauli _II	0	2	2		
11	400	Ballabgarh	Bhiwadi	2	1	1		
12	400	Ballabgarh	Kanpur	0	2	2		
13	400	Ballabgarh	Mainpuri -I	0	2	2		
14	400	Ballabgarh	Mainpuri -II	0	1	1		
15	400	Bamnauli	Bawana -I	0	4	4		
16	400	Bamnauli	Bawana -II	0	5	5		
17	400	Bareilly	Mandaula -I	7	2	2	5-14 km and 47 km Mandaula	
18	400	Bareilly	Mandaula -II	7	3	3	6 -41 km from Mandaula	
19	400	Bassi	Bhiwadi	0	2	2		
20	400	Bassi	Hisar	1	0	0		
21	400	Bawana	Hisar	6	4	3	103-115 km from Hisar	All AR Within 33 minutes
22	400	Bawana	Mandaula -I	4	7	7	16-17 km from Bawana	3 nos AR in 7 minutes
23	400	Bawana	Mandaula -II	4	3	3	17-18 km from Bawana	3 nos AR in 7 minutes
24	400	Dadri	Malerkotla	31	1	1	216 - 272km from Malerkotla	
25	400	Dadri	Mandaula -I	8	5	4		On B-N
26	400	Dadri	Mandaula -II	4	1	1		On R-N fault
27	400	Dadri	Muradnagar	0	1	1		
28	400	Dadri	Panipat -I	2	2	2		
29	400	Dadri	Panipat -II	2	2	2		
30	+500	Dadri	Rihand -I	0	1	1		
31	-500	Dadri	Rihand -II	0	2	2		
32	400	Mandaula	Meerut -I	8	2	2	16.3, 32-34 km and 50 to 59 km from Meerut	Mostly R-N fault

33	400	Mandaula	Meerut -II	3	1	1	53-61 km from Meerut	All AR Within 9 minutes
34	400	Meerut	Muzaffarnagar	0	1	1		
35	400	Meerut	Tehri -I	0	1	1		
36	400	Meerut	Tehri -II	0	1	1		
37	400	Moradabad	Muradnagar	3	1	1	2.6 km from Moradabad	
38	400	Muradnagar	Muzaffarnagar	0	1	1		
39	400	Muradnagar	Panki	0	1	1		
40	400	Muzaffarnagar	V' Prayag-II	0	1	1		
			Total	95	76	74*		

* Dadri Mandaula- I and Bawana – Hissar could not be revived on same day.

3.4.6 Auto re-closing of important lines on 9th March 2008

Sl. no	kV	From	To	AR	FL (km)	Remarks
1	400	Bareilly	Mandaula -I	7	1.9 5 -6.1 % , 19.8 % from Mandaula	
2	400	Bareilly	Mandaula -II	7	2.4 -17.3 % from Mandaula	
3	400	Bawana	Hisar	6	103-115 from Hisar	With 33 min
4	400	Bawana	Mandaula -I	4	16-17 from Bawana	3 time in 7 minutes
5	400	Bawana	Mandaula -II	4	17-18 from Bawana	3 time in 7 minutes
6	400	Dadri	Malerkotla	31	216 -272	
7	400	Dadri	Mandaula -I	8	B-N	3 time in 30 minutes
8	400	Dadri	Mandaula -II	4	R-N fault	3 time in 12minutes
9	400	Mandaula	Meerut -I	8	16.3, 32-34 km and 50 to 59 km from Meerut	Mostly R-N fault
10	400	Mandaula	Meerut -II	3	53-61 km from meerut	Within 9 min
11	400	Moradabad	Muradnagar	3	2 % from Muradabad	Within 26 min

400 kV Dadri- Malerkotla line auto reclosed 31 times, particularly on Y-N, B-N faults at 216 -272 km from Malerkotla end. Similarly 400 kV Meerut- Mandaula line- I line auto reclosed 10 times from 2346 Hrs on 8th March to 0122 Hrs on 9th March (in 1hour, 26 min) mostly on R-N fault. The fault locator indicates distance approximately 16.3 km, 32-34 km and 50 to 59 km from Meerut end.

3.4.7 The severity on important 400 kV Sub-stations on 9th Mar 08 is tabled below:

Sl. No.	Name of 400 kV Sub station	Tripping Recorded (nos.)
1	Mandaula (PG)	91
2	Bawana (DTL)	73
3	Dadri NTPC	70
4	Malerkotla (PG)	33
5	Bamnauli (DTL)	26
6	Bareilly(PG)	24
7	Ballabgarh (PG)	23
8	Meerut (PG)	22
9	Abdullapur (PG)	17
10	Hissar (PG)	14
11	Panipat (BBMB)	12
12	Muradnagar (UPPCL)	11

3.4.7.1 A total of 448 number of operation were carried out during the analysis period from 2100 hours on 8th March, 2008 to 1800 hors on 9th March, 2008 as under.

Sl No	Voltage (kV)	No. of lines affected	No. of Auto-reclose (A)	No. of Tripping (B)	No. of restores (C)	Total line operations (A + B +C)
1	400 kV and above	40	95	76	74	245
2	220 kV	101	1	101	101	203
Total		141	96	177	175	448

3.4.8 Islanding of Dadri (Gas) Power Station on 9.3.08:

At 0235 Hrs on 9th March 2008, 220 kV thermal and gas stations interconnection tripped on differential protection. 400/220 kV ICTs 3 &4 at Dadri NTPC tripped on directional over current (high set), resulting in house load operation of Dadri GT# 1,3 and 4. While Dadri Coal generating station continued to operate normally, the 220kV bus bar of Gas Station became dead due to inter- connecter tripping (**refer exhibit –III**)and railway supply (fed from Dadri-Gas 220kV bus bar) was interrupted.

Efforts to charge 220kV bus from Coal station was not successful and GT#4 of Gas station which was operating on house load was connected to the 220kV bus and Railway supply was restored from this unit at 0410 hrs. GT#4 however tripped at 0423 Hrs on negative phase sequence protection due to the severe load unbalance.

3.4.9 Failure of Railway supply

On 09.3.08 220KV Dadri - Railway Ckt.I & Ckt.II to tripped at 02.37 hrs. Ckt.I supply was restored at 04.13 hrs but tripped at 0423hrs charged again from Dadri (Coal) source at 0518 hrs to trip at 06.54 hrs, and Ckt.II supply restored at 05.54 hrs but tripped at 06.05 hrs charged again at 06.35 hrs but tripped. Due to fault in 220 kV Line between NTPC Dadri & Railway Grid Sub Station (at Dadri) the supply to railway could not be connected and finally Ckt.I was restored at 10.28 hrs and Ckt.II at 17.45 hrs after attending the breakdowns. This caused dislocation of railway traffic between Tundla and Ghaziabad. Tripping was also observed on 132KV TR-line of Railways also.

4. System Restoration

4.1 Grid Restoration on 7.03.08

The restoration of the following important lines was as given below.

Sl. no.	400 kV TRANSMISSION LINE	Time of tripping (Hrs)	Time of Final restoration(Hrs)
1	Ballabhgarh-Mainpuri-II	00:37	18.55
2	Agra-Ballabhgarh	00:54	18.10
3	Ballabhgarh-Mainpuri-I	00.27	10.21
4	Panki-Muradnagar	01:59	16.04
5	Bahadurgarh-Bawana	1:41	19:19
6	Agra-Muradnagar	02:01	19.44
7	Rihand-Dadri Pole-I	02:15	09:05
8	Ballabhgarh-Maharanibagh	02.29	09:55
9	Bassi-Bhiwadi	02:47	10:08
10	Muradnagar-Muzaffarnagar	02:54	10:47
11	Bahadurgarh-Bhiwani	03:12	09:33
12	Merrut-Mandola-I	03:17	10.31
13	Bamnauli-Ballabhgarh-II	03:35	06.20 (08.03.2008)
14	Hissar-Bawana	3:27	8:04
15	Dadri-Panipat-I	3:30	09.55
16	Muradabad-Muradnagar	03:32	07:29
17	Merrut-Mandola-II	3:43	08.56
18	Dadri-Panipat-II	3:41	20.20
19	Ballabhgarh-Noida	3.56	11.05
20	Ballabhgarh-Bhiwadi	03:46	10:03
21	Rihand Dadri Pole-II	03:46	Restored later
22	Merrut-Muzaffarnagar	03:51	09:48
23	Dadri-Malerkotla	4:01	09.40
24	Kanpur-Ballabhgarh	4:08	9:57
25	Bawana-Bamnauli-I	04:05	04.25
26	Bawana-Bamnauli-II	04:09	08:08

27	Bamnauli-Ballabhgarh-I	04.12	10:22
28	Mandola-Bareilly-I	04:23	06.21
29	Mandola-Bareilly-II	04:32	20.28(08.03.2008)
30	Muzaffarnagar-Rishikesh	05.30	08.14
31	Abdullapur-Bawana-I	05:04	06:15
32	Abdullapur-Bawana-II	05:04	10:07
33	Hissar-Patiala	0725	07:38
34	Vishnuprayag-Muzaffarnagar-I	05:07	09:01
35	Mandola-Bawana-II	05:09	07:09
36	Mandola-Bawana-I	05:08	08.24
37	Dadri-Malerkotla	5:26	09.46
38	Tehri-Merrut-I	05:29	09:22
39	Tehri-Merrut-II	04.39	09:55
40	Obra-Panki	06:03	13.52
41	Hissar-Kaithal	06:07,	0618
42	Hissar-Moga	06:19	12.55
43	Abdullapur-Jhakri-II	07:32	10:10
44	Nalagarh-Kaithal	07:56	08:06
45	Anpara-Mau	08.26	17.22
46	Dehar Panipat	04.51	12.55
47	Dehar Bhiwani	05.49	05.58
48	Muradnagar-Dadri	05.48	07.24
49	Hisar- fatehabad	06.17	06.26
50	Dadri-mandaula-I	06.36	08.52
51	Dadri-mandaula-II	04.54	09.55

Restoration of Railways supply at Dadri :

220kV Dadri (Gas) bus was energized from Coal Unit#3 source (operating on house load), through the 220kV Coal-Gas station inter- connector (for the first time ever) at 0645 hrs and Railway Feeder#2 was charged at 0708 hrs to establish traction supply.

Dadri bus was energised from NR system at 0800 hrs and Unit#1 was synchronized at 08.15 hrs. Unit#3 which had been operating in islanded mode feeding Traction load was successfully synchronized to the NR system using Transfer Bus Coupler at 08.50hrs.

4.2 Grid Restoration on 9.3.08

The restoration of the following important lines were as given below:

S. no.	400 kV TRANSMISSION LINE	Time of tripping (Hrs)	Time of Final restoration(Hrs)
1	Bawana- Bamnauli-I	21:27 (8.3.08)	09:42
2	Bawana- Bamnauli-II	21:10 (8.3.08)	09:42
3	Bahadurgarh- Bawana	21:24(8.3.08)	10:17
4	Mandaula- Bawana-I	00:24	08:45
5	Mandaula-Bawana-II	00:29	09:11
6	Ballabgarh- Bamnauli-I	01:05	09:22
7	Ballabgarh- Bamnauli-II	00:36	10.25
8	Muradnagar- Muzaffarnagar	00:43	10.06
9	Mandaula- Bareli-I	00:58	01.30
10	Mandaula-Bareli-II	00:00	09:40
11	Dadri- Malerkotla	01:07	05:50
12	Mandaula- Meerut-I	01:19	09:30
13	Mandaula- Meerut-II	01:04	09.25
14	Muradnagar-dadri	01.10	09.00
15	Muradnagar -Panki	01:52	10.40
16	Dadri-Panipat-I	01.43	02:32
17	Dadri Panipat-II	01.38	10:09
18	Meerut- Tehri-I	02:47	Restored later
19	Meerut- Tehri-II	02:47	09:00
20	Muradnagar-Moradabad	02:47	08.50
21	Rihand –Dadri Pole I	02:19	09:18
22	Rihand Dadri Pole II	02:50	08:55
23	Bhiwani- Bahadurgarh	03.08	09:53
24	Dadri- Mandaula- I	03:33	08:42
25	Dadri Mandaula-II	00.24	09.20
26	Ballabgarh- Bhiwadi	03:40	09:53
27	Mainpuri -Ballabgarh-I	03:41	09:38
28	Mainpuri Ballabgarh-II	03:47	09:42
29	Abdullapur-Jhakri-I	03:44	05:17
30	Abdullapur-Jhakri-II	03:44	Restored later
31	Kanpur- Ballabgarh	04:02	9.03
32	Bassi- Bhiwadi	04:20	10:00
33	Bawana-Hissar	05:55	08:31
34	Bawana-Abdullapur-I	05.20	22.53
35	Bawana-Abdullapur-II	05:20	08.45
36	Muzaffarnagar-Meerut	02.29	19.31
37	Muzaffarnagar- Vishnuprayag ckt -II	02.29	08.22
38	Unnao-Agra	07.37	08.14

Restoration at Railway supply and Dadri (Gas) Power Station on 9.3.08

ICT # 5 which is normally connected to the Coal station bus was taken out and the Gas station bus was energised from ICT # 5 through 220kV

interconnection line at 0517 hrs. GT #1 and 3 were synchronized with the Grid at 0521 and 0532 Hrs respectively.

Railway feeder #2 was charged at 0551 hrs but again tripped at 0605 hrs. Feeder #2 was again charged at 06.35 hrs but did not hold. Feeder # 1 was charged at 06.54 hrs but did not hold. Railway feeder #1 was eventually charged at 10.23 hrs after the damaged insulators were changed.

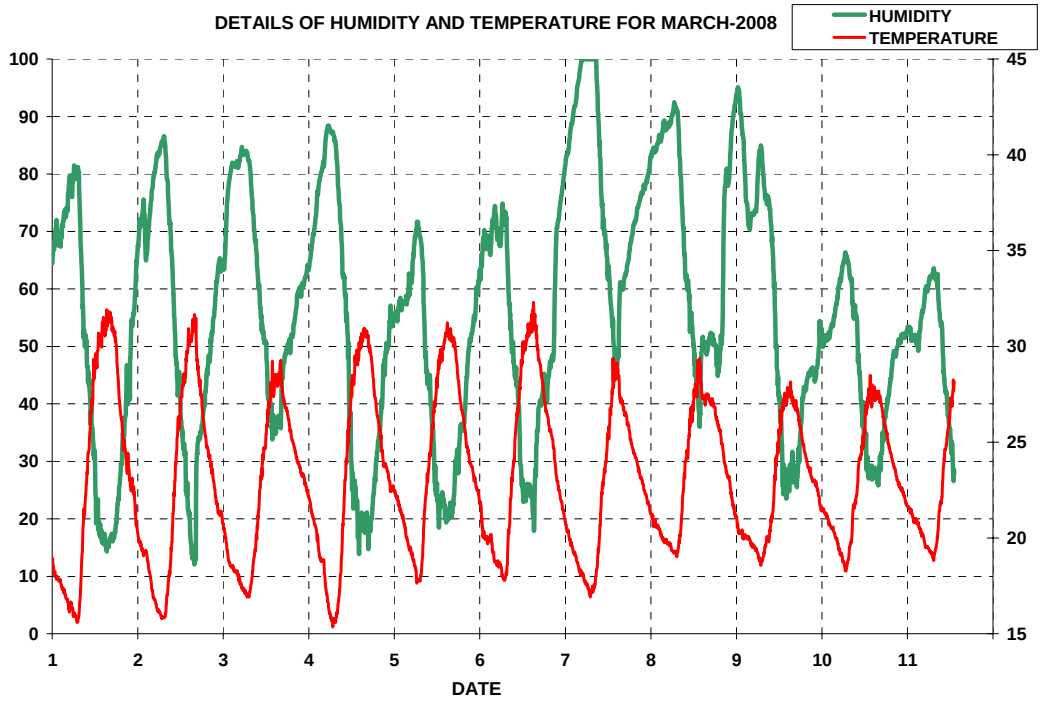
5. Analysis of tripping

5.1 The analysis of the data received from the concerned SLDCs and NRLDC indicates that the tripping of transmission lines started around mid night on both the days and subsequent trippings were in a random manner and there was no instant collapse of any part of the system due to sequential tripping. Most trippings were triggered by the phase to neutral fault and lines could not be restored on auto closing. However, when humidity levels decreased on rise of temperature, the lines could be energized.

5.2 In the Northern Region winter rains are preceded by heavy fog conditions usually in December – January. During heavy fog conditions in the winter season, there have been instances of a large number of trippings of transmission lines in Northern region on earlier occasions also notable on 02.01.2001, 23.12.2002, 23.12.2005 16.2.2006, 12, 23, 27, and 31.12.2006, 27, 28, 29.1.2007, 01.02.2007, 08.02.2007 and 09.02.2007. During the winter season of 2007-08, transmission line trippings were observed on 1.12.2007, 13.12.2007, 14.12.2007 7.1.2008, 11, and 24.01.2008, 4th and 5th Feb 2008, 4.3.2008, 7, 08.03.2008 and 09.03.2008.

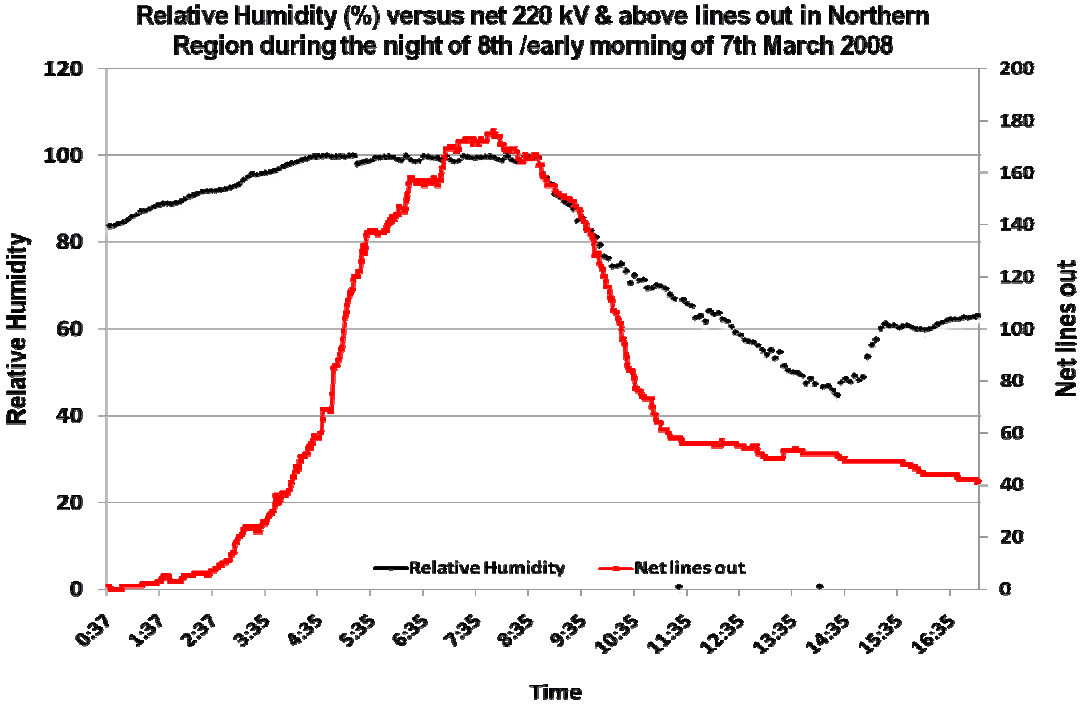
5.3 Pollution related flashovers of insulator strings can be considered as the prime reason for such trippings in the winter seasons. The observed reduction in number of trippings in foggy weather subsequent to the rains in the region establishes the fact that pollution deposits present on insulator surface could be the reason for flashovers during fog conditions and its frequency got reduced after rains possibly due to washing out of pollutants from the insulator surface by the rain water. Since there were no rains during the winter months i.e. Dec.'07 to Feb.'08, pollutants deposited on insulators during the winter months did not wash out. Heavy fog conditions on 7th and 9th March, 08 coupled with pollutants deposit on insulators caused flashover of insulator strings and can be considered as prime reason for such large trippings of lines as per the facts discussed in the succeeding paras.

5.4 Relative Humidity (RH) changes inversely with temperature as seen from the graph given below showing the relationship of humidity vs temperature as observed at Minto Road New Delhi for the period 1-11 March, 2008.



The humidity level of above 90% prevailed for longer duration during the early morning hours of 7th and 9th March, 2008. It is period of high humidity when the condensation takes place on the surface of insulators which dissolves the salts present in the deposited pollutants increasing the conductivity which through the process explained earlier results in flashover across the insulators.

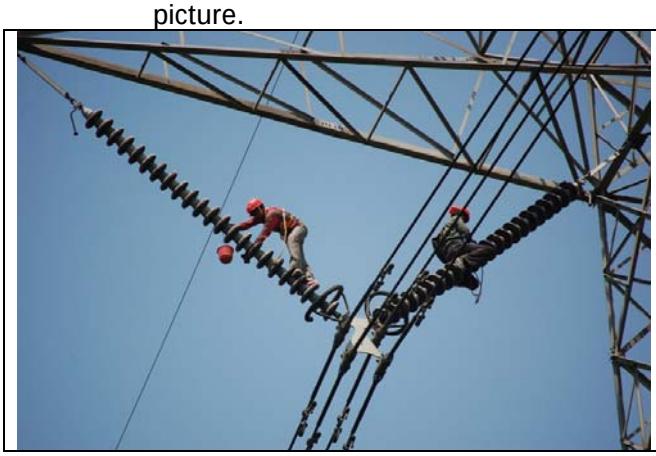
5.5 The number of lines under outage increased with the increase in the relative humidity levels on 6/7th March, 2008 as may be observed from the graph given below:



5.6 Most tripping was initiated with line to ground fault. Such large numbers of line to ground faults of the lines are possible with pollution related flashover mechanism. It observed from the above graph that most lines were out during the period of high humidity level and as the day progressed and relative humidity level reduced, the lines were restored without any corrective intervention. This is a typical characteristic of pollution related flashover of insulator strings triggering tripping of the line.

5.7 In light of the above facts, it can be concluded that grid disturbance on 7th & 9th March 2008 was caused by pollution related flashover of insulator strings leading to tripping of several 400 kV and 220 kV lines. Each tripping was a separate event unrelated to the other and in the nature of cross country faults.

5.8 Member (GO&D), CEA and Director MoP inspected affected lines of DTL on 16th March, 2008 and subsequently team comprising Chief Engineer (GM), CEA, Director(GM) and SE(OM), NRPC visited the affected lined of PGCIL near Dadri. Deposition of pollutants was observed on the surface of insulators and flashed insulators. The deposition of pollutants on the insulator could be seen in the picture.



Manual and hot line spray cleaning of the insulator strings could be seen in the picture which was taken up by DTL to cover all the 400 kV double circuit transmission line in Delhi. POWERGRID employed helicopter for hot line cleaning of insulators strings.

6. Performance of protection system:

6.1 During the disturbances, performance of protection system was analyzed by the committee. The committee observed that performance of the protective system was in order except the following.

6.2 At 0439 hrs , 220 kV BTPS- Ballabgarh –II tripped but breaker failed to clear the fault from Ballabgarh end due to pole discrepancy, LBB operated and disconnected all the feeders connected to Bus –II as per scheme. BBMB has reported that the contact resistances of breaker were taken which were found OK. The circuit was energized at 1007 Hrs. BBMB may look into the cause of problem and take appropriate action accordingly to avoid such reoccurrence.

6.3 At around 0506 hrs both poles of HVDC tripped and to keep the pole ready for charging minimum filter bank of 80 MVAR was connected in the system for carrying out On Line Testing (OLT) and charging the pole by POWERGRID. Minimum filter bank connection is mandatory to energize the poles and connection is also done automatically by Reactive Power Controller. In the mean time at around 0529 hrs all 400 KV lines emanating from Dadri 400 kV (NTPC) tripped and resulted in over voltage (448 kV) and tripping of all 400 KV ICT on over fluxing. It is to mention that HVDC have all necessary protection to trip the filter bank in case of permanent rejection i.e. tripping of all 400KV lines from NTPC so that no adverse effect should be there on the Grid due to HVDC system. In case the HVDC pole would have been in operation and tripping of all lines would have taken place from Dadri (NTPC), HVDC poles and filter banks disconnection would have taken place on operation of last 400 kV AC Line i.e Disconnected Protection Operation, but the minimum filter bank did not got disconnected . The reason of non tripping of minimum filter, in case when there is no 400 kV line connected to the Bus may be investigated by POWERGRID and suitable action may be taken accordingly.

7. Reasons for Fog in the NCR – IMD Report

7.1 In response to a letter from Member Secretary, NRPC to the DG, IMD, the IMD has given following reasons for fog in NCR on the eventful days: "*Sometimes, fog season extends up to March due to various reasons. Analysis of hourly visibility Fog data recorded by Meteorological Department from IGI Airport Tower for recent March, 2000-08 listed in Table 3 of IMD report shows morning of 9th March, 2008 (3 hours) is not the first time in records such a very prolonged very dense fog hours has been occurred, there are some earlier years when such prolonged hours were observed e.g. 2002 (2nd March), 2005 (5th March), 2006 (13 March) and 2007 (2nd March). Like 9th March, 2008, earlier it has been occurred as late as 13th March during 2006 between 0445 AM till 0830 AM (nearly 4 hours). Hence, present study confirms there is nothing unusual in occurrences of dense fog in the month of March. The reason mainly is due to passage of an active western disturbance over northern India and availability of high moisture from Arabian Sea due to deep westerly trough at upper level extending to the sea and*

cooling of the surface temperature. Then why this particular fog caused tripping to the power lines which is something unusual while other dense fog occurred in March of other earlier years has not caused such unusual tripping requires further study. In the next section, we attempted from other Meteorological perspective.

It is common that pollutants accumulated upon open materials which are open to air whether it is leaves of plants or daily households due to continuous exposure particularly during November to March when pollution level over the region near ground are very high. This pollution becomes more thicker and thicker day by day in case of prolonged dry spells and only washed out if good rains spells occurs at periodic intervals. Normally NCR Delhi experience rains from winter western disturbances. However, rain over NCR Dehi (as per IMD stations (Safdarjung and Palam) over Delhi was very subdued in winter 2008. Hence once can conclude that absence of significant rain spell from November, 2007 to March, 2008 led accumulation of pollutants on the power lines and its various structures which must be very high compared to other years. This further have been helped by occurrences of very dense fog resulting persisting high humidity level causing unusual tripping in power lines. Hence, monitoring of the pollution accumulations, rain spells in the period and occurrences of dense fog and suitable remedial incase pollutions accumulates because of prolonged lack of rain in the region might help in avoiding such unusual power tripping in future. In such cases, a close interaction of the power distribution sector with IMD on real time basis for getting such information is very much needed."

8. Phenomenon of Tripping of Transmission Lines during fog

8.1 The dust and other pollutants in the air settle on the insulators which under dry conditions do not impact the operation of the lines. However, during the occurrence of high relative humidity levels / fog conditions, the wetting of the surface of insulators / formation of water droplets on the surface of the insulators takes place which dissolves the chemicals present in the pollutants already settled on the insulators resulting in a creation of conditions conducive for the flow of leakage currents. These leakage currents result in heating of the insulators and initiates drying up of areas of the insulators having higher density of current leading to formation of dry ring on the smallest diameter part of the porcelain insulator. The voltage across the dry band could be high enough to ionize the air and result in flash over across it. This results in higher leakage current which accelerate the process of further formation of dry patches and the small flash over grows into the flash over across the insulators and the process culminates in flash over across the entire insulators resulting in tripping of the line.

8.2 At the time of design of the transmission lines in Delhi and NCR, the normal pollution levels were taken into consideration. However, the pollution levels have gone up considerably high due to reasons indicated below which has caused the problem of tripping.

(a) Increased construction activity commensurate with the development;

(b) Pollution from vehicular traffic ;

(c) Burning of agricultural waste;
(d) Burning of Baggasse;
(e) Pollution from Brick Kilns;
(f) Industrial activity.

8.3 The increase in the pollution levels due to vehicular traffic particularly from diesel driven vehicle needs special mention. The diesel fumes which settle on the insulators are sticky and difficult to wash with water jet spray and impact of these on the polymer insulators would need to be evaluated. As the number of diesel vehicles in the NCR has increased substantially over the years, the unchecked emissions from such vehicles could be a cause of concern. The emission norms for the vehicles particularly the diesel vehicles need to be enforced effectively particularly in respect of trucks and buses entering Delhi.

8.4 The Mechanism of flash over during the occurrence of fog and factors contributing to increased pollution levels have been discussed in detail in the report of the Inquiry committee constituted for grid incident on 27.01.2007. The relevant extract from the report are reproduced as **Annex-VI**.

9. Technological Options

9.1 Overhead power transmission lines require both cables to conduct the electricity and insulators to isolate the cables from the steel towers by which they are supported. The insulators have conventionally been made of ceramics or glass. These materials have outstanding insulating properties and weather resistance, but have the disadvantages of being heavy, easily fractured, and subject to degradation of their withstand voltage properties when polluted. There was therefore a desire to develop insulators of a new structure using new materials that would overcome these drawbacks.

9.2 The 1930s and '40s saw the appearance of the first insulators to replace inorganic materials with organic, but these suffered problems of weather resistance, and their characteristics were unsatisfactory for outdoor use. In the 1950s epoxy resin insulators were developed, but they were heavy, suffered from ultra violet (UV) degradation and tracking, and were never put into actual service. By the mid-1970s a number of new insulating materials had been developed, and the concept of a composite structure was advanced, with an insulator housing made of Ethylene Propylene Rubber (EPR), Ethylene Propylene Diene Methylene (EPDM) Linkage, Polytetrofluoro Ethylene (PTFE), Silicone Rubber (SR) or the like, and a core of Fiber-Reinforced Plastic (FRP) to bear the tensile load.

9.3 Since these materials were new, there were many technical difficulties such as adhesion between materials and penetration of moisture had to be remedied and the end fittings which transmit the load, had to be improved. Since 1980s, greater use has been made of silicone rubber due to its weather resistance, which is virtually permanent, and its hydrophobic properties, which allow improvement in the maximum, withstand voltage of pollution, and this had led to an explosive increase in the use of composite (polymeric) insulators.

9.4 Various technological options available are explained in **Annex-VII.**

10. Review of Implementation of Recommendations of the Inquiry Committee on Grid Incident of 27.01.2007

10.1 In order to expedite the implementation of recommendations of enquiry committee for grid disturbance on 27.1.07, a meeting was taken by Secretary (P), MoP on 9th March 08 and Chairperson CEA on 30th April 08 with the States of Northern Region for replacement of porcelain insulators with polymer/antifog insulators having higher creepage distance on transmission lines in the pollution affected areas. POWERGRID, DTL, BBMB, UP, HVPN, have identified the line sections where insulators have to be replaced and taking action on the same. The progress is being monitored by NRPC on regular basis. The minutes of the above meetings are placed at **Annexure –VIII(a) and VIII(b).**

10.2 The list of transmission lines identified by POWERGRID shall be taken up for replacement of insulators with polymer insulators in Phase-I, II & III as proposed by POWERGRID. POWERGRID will complete the work in 3 phases. The first phase was to be completed by Nov., 2008, given at **Annex –IX(a)** and the details by different constituents are given in **Annex–IX(b)**.

10.3 Review of the progress, by Member secretary NRPC, on manual cleaning of insulators, hotline cleaning, washing by helicopter and replacement of porcelain insulators by Polymer/ anti fog insulators are placed at **Annex-X.**

10.4 The committee feels that there has been a slow progress in the implementation of the recommendations of the committee specially the replacement of porcelain insulators by Polymer/ anti fog insulators by constituents, which needs to be expedited

10.5 DTL's has informed that quarrying and blasting activities causes damages to the insulators particularly in NCR.

10.6 Pollution severity measurements were carried out on insulator strings at different location of 400kV transmission lines where strings were posing problems due to pollution flashover. The report of testing done by CPRI is placed at **Annex – XI**. Tables 1 of the Report shows the results of the brush wash method at different locations. In general, the results show that the bottom surface ESDD of the string has higher accumulation of pollution compared to top surface. The measurement was done in Meerut-Mainpuri-Dadri-Mandola-Panipat—Ballabgarh stretches at 14 locations and found that pollution level is in light and medium zone. CPRI's chemical analysis states that pollutant contains predominantly ferrous contents. Contaminations of alkalis were also present predominantly. The average ESDD of the string is compared with the pollution levels, which are specified in IEC 815.

POWERGRID may take action accordingly.

11. Recommendations

11.1 Implementation of Recommendations of Inquiry Committee on Grid Incident of 27th January, 2007

The recommendations of the Inquiry Committee constituted to investigate the earlier grid incident of 27th January, 2007, which occurred due to fog in Delhi and neighboring states was reviewed. The recommendations (**Annex -XII**) made by the committee were considered comprehensive. The Committee re-emphasizes their implementation. Decision has already been taken for replacement of insulators with polymer/antifog insulators and periodical cleaning of insulators.

The recommendations of committee requiring immediate attention are:-

- Classification of pollution levels of lines /line stretches by measurement of ESDD on insulator.
- Notifications by the respective state government that no brick kiln or any industrial unit or biomass or diesel based power plant having chimney height up to 30 meters be set up within 0.5 km of the 220 kV or higher voltage transmission lines.
- Review of pollution standard.
- Provision of bird guards on all towers.

Constituents may expedite the implementation of these recommendations.

11.2 Replacement of existing insulators by Polymer / Anti fog Insulators

The decision has already taken for replacement of the existing porcelain insulators of lines passing through areas having high pollution levels with Polymer/ anti fog insulators by constituents. The committee observed that there has been slow progress in the implementation of the decision which needs to be expedited by the power utilities.

11.3 Cleaning of insulators

Since the maintenance of lines is a periodic process, power utilities may carry out maintenance particularly relating to cleaning of insulators of their lines especially during pre-winter every year to be completed by mid December. The constituents have already taken up the task of manual/hotline cleaning/washing of insulators. Helicopter has also been deployed by the POWERGRID for the first time.

11.4 Monitoring Mechanism

Tripping affects the reliability and security of the system and there is also a curtailment on STOA by NRLDC. Consumers, DISCOMS and generating companies suffer substantial loss though availability of the transmission system is not substantially affected due to these trippings.

The committee feels that the NRLDC and SLDCs may closely monitor the criticality of lines vis-à-vis cleaning / replacement process in Northern Region. NRPC may review the issues/constraints of those utilities who do not adhere to the

implementation of the recommendations of the committee in a time bound manner and accordingly take up with the respective state Govt./ Organization for ensuring its timely implementation or otherwise accountability.

11.5 Alertness During high RH and Low Temperature conditions

It has been found that whenever Relative Humidity (RH) increase to 85% or above and temperature falls below 15-17 degree Celsius, the chances of formation of fog increases in Northern Region, which causes tripping. The Committee recommends that at all critical locations, the data of RH and temperature should be captured by the CTU or the concerned STU/transmission licensee and made available to the SCADA system. For wider circulation, NRLDC/SLDCs shall uplink this data on their respective websites. All constituents should closely monitor these forecasts and ensure availability of suitable O&M staff in place and senior officers at all strategic locations in case forecasted RH exceeds 85 % and temperature likely to fall below 15-17 degree Celsius to control the situation and mitigating fog related tripping.

11.6 Railway supply reliability

To meet any such eventuality where essential services like Railways get affected alternative supply points should be made available to Railway. Railway has suggested having 132 KV supply points at Mehrawal (near Aligarh) and Shikohabad. The supply points are being taken as an alternative measure in case of NTPC supply failure from Dadri/ Auriaya. Railway may also prepare plan identifying additional supply points required by them from state transmission and distribution utilities in Northern Region. The tariff and O&M related issues could be sorted out separately. Also, action plan for ensuring reliable power supply to Railways may be implemented.

(a) Seasonal cleaning of insulators before onset of foggy weather i.e. in the month of Oct-Nov. every year to be ensured and report sent to NRPC periodically.

(b) Replacement of insulators of 132 kV/ 220 kV lines by polymer/antifog insulators in the areas where insulator failure during foggy weather has taken place.

11.7 Operation of Minimum filter bank at HVDC Rihand –Dadri Bi polar

HVDC have all necessary protection to trip the filter bank in case of tripping of all 400KV lines (permanent rejection) from NTPC Dadri station, so that no adverse effect should be there on the 400 kV Bus due to filter bank. Also it should also be ensured the minimum filter should not be brought into service when there is no line available to 400 kV Bus to evacuate power to avoid over voltage. Minimum filter bank may be arranged for automatic tripping if HVDC both poles are out of service and ac bus voltage exceeds 420kV.

11.8 Pollution control of diesel vehicle entering NCR area

It has been observed that pollution level particularly due to diesel fumes from the vehicles is high especially in NCR area. In order to control the pollution due to diesel fumes, the committee recommends that the respective Government enforce pollution check on all the vehicles strictly.

Also quarrying activities in the vicinity of the lines which causes pollution, should be curbed.

11.9 Developing a fog forecasting model for power system in NR

Indian Meteorological Department (IMD) has developed a fog forecasting model for IGI Airport, New Delhi under which forecast for fog and visibility is made for next 6hrs and 12 hrs respectively, predicting the extreme value during the said period. IMD may be approached by NRLDC to develop a suitable model for making on-line forecast at critical locations of power system of NR based on on-line information sharing among IMD, NRLDC, CEA, NRPC and PGCIL and making available the information at NRLDC and all SLDCs for taking corrective action. This may be discussed in the Operation Coordination Committee of NRPC.

11.10 Chemical Analysis of deposits on Insulator Strings

Chemical analysis of deposits on the insulator strings may be carried out at different location of 400kV/220 kV transmission lines where strings were posing problems due to pollution flashover. Power utilities may get the analysis done through CPRI. Accordingly, the area of power lines may be demarcated from the pollution levels as light, medium, heavy and very heavy zones for remedial measures including replacement of polymer/antifog insulators.

Results of chemical analysis of pollution deposits on insulators done by CPRI is given in their report and discussed in **para 10.6.** It is necessary to conduct such investigations by various utilities for identification of stretches with the classification of pollution levels along the length of transmission lines.

11.11 Insulation requirement of EHV transmission lines

A committee of expert was constituted under chairmanship of CE (SE & TD), CEA, to review the insulation requirement of EHV transmission lines of various voltages the recommendations of this committee is enclosed at **Annex XIII.** These recommendations of expert committee including power mapping may be implemented.

11.12 Pollution Mapping of the Country

The pollution mapping of the entire country may be done. POWERGRID may prepare complete proposal in association with CPRI and discuss for its implementation with power utilities in the RPCs forum.

Acknowledgement

The committee gratefully acknowledges the cooperation extended by the officials of BBMB, DTL, HVPNL, UPPCL, NTPC, NRLDC, Railways and POWERGRID in the collection of information pertaining to Grid incident and its analysis.

The committee places on the record its appreciation of the assistance provided by, Shri S R Narasimhan, Chief Manager, Shri Rajesh Kumar, Manager, NRLDC, Shri RP Aggarwal, SE(O), Shri Vikram Singh, Executive Engineer, and Shri Uma Maheswararao, AEE, NRPC, Shri Gautam Ghosh, Deputy Director, CEA in helping in the analysis and preparation of the report.

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