

**NATIONAL ELECTRIC POWER  
REGULATORY AUTHORITY  
(NEPRA)**



## **INQUIRY REPORT**

**PARTIAL SYSTEM COLLAPSE  
OCCURRED ON OCTOBER 13<sup>th</sup>, 2022**



**INQUIRY INTO THE MATTER OF PARTIAL SYSTEM COLLAPSE OCCURED ON  
OCTOBER 13<sup>th</sup> 2022**

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**PART-1**  
**BACKGROUND**



## 1. PARTIAL POWER COLLAPSE (BACKGROUND):

On October 13, 2022 at 09:33 Hrs. breakdown of the power supply system occurred, which plunged a significant region of the country into dark. In view thereof, the National Electric Power Regulatory Authority (NEPRA) took notice of the incident and decided to conduct an inquiry into the matter. For this purpose, an Inquiry Committee was constituted.

### 1.1 Composition of the Inquiry Committee:

The Inquiry Committee (IC) was constituted vide office Orders No. MON-1/2023/279 dated April 11, 2023 to probe into the subject matter **Annex. 1**. The composition of the IC is given below.

1.	Mr. Imran Kazi	Senior Advisor, M&E, NEPRA	Convener
2.	Mr. Nadir Ali Khoso	Market Expert	Member
3.	Mr. Ghulam Abbas Memon	Market Expert	Member
4.	Syed Safeer Hussain	Market Expert	Member
5.	Mr. Manu Ram	Market Expert	Member
6.	Syed Aqib Ali Shah	Dy. Director, M&E, NEPRA	Secretary

### 1.2 Terms of Reference (TORs)

- To determine, the causes and the faults which resulted in the cascaded trippings and partial system collapse;
- To fix the responsibility for the partial system collapse occurred on 13/10/2022;
- To review, whether the restoration efforts were adequate and the power supply was restored within the reasonable time;
- To check/update the implementation status of the findings/recommendations of inquiry reports furnished thereof for such break downs in the past;
- To recommend, the remedial measures to be taken in order to avoid recurrence of such events in future;

## 2. POWER SYSTEM OF PAKISTAN:

- 2.1 The power sector of Pakistan is divided into three (03) segments i.e. Generation, Transmission & Distribution.
- 2.2 K-Electric being vertically integrated utility is responsible for Generation, Transmission & Distribution of power in Karachi & Lasbela district of Balochistan.
- 2.3 For areas other than K-Electric jurisdiction, generation of power is carried out by WAPDA, PEDO, GENCOS & IPPs. NTDC is responsible for transmitting electric power at 220kV & above, while NPCC is responsible for dispatch of power. Eleven (11) number of Distribution Companies (DISCOs) i.e. PESCO, TESCO, IESCO, LESCO, FESCO, GEPCO, MEPCO, SEPCO, HESCO, QESCO are responsible for distribution of electricity to the end consumers.

## 3. NATIONAL POWER CONTROL CENTRE (NPCC) – SYSTEM OPERATOR (SO):

NPCC/NTDC is discharging the duties under the Grid Code approved by the NEPRA. The NPCC/System Operator (SO) is responsible to operate the system in an economic manner without compromising the system stability, reliability and safety.



#### 4. GENERATION:

Breakup of total power generation (including KE) is as under:

i.	Hydro Electric:	10,452 MW
ii.	Thermal (RFO + Gas + Oil + Coal):	24,011 MW
iii.	Renewable (Wind + Solar + Bagasse):	2,725 MW
iv.	Nuclear:	3,345 MW
Total:		40,533 MW

#### 5. TRANSMISSION OF POWER (NTDC):

Breakup of NTDC's T/Lines and G/Stations is as under;

i.	Length of 500kV T/Line:	8388 km
ii.	Length of 220kV T/Line:	11611 km
iii.	Grid Stations:	

Sr. No.	No of G/Station	Voltage Level (kV)	Capacity (MVA)
1	17	500	32700
2	50	220	28160

#### 6. TRANSMISSION OF POWER (K-ELECTRIC):

Breakup of KE T/Lines and G/Stations is as under;

i.	Length of 220kV T/Line:	364 km
ii.	Length of 132kV T/Line:	838 km
iii.	Grid Stations:	

Sr. No.	No of G/Station	Voltage Level	Capacity
1	11	220 kV	4580 MVA
2	69	132 kV	7465 MVA

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**PART-2**  
**PROCEEDINGS**



## 7. INQUIRY PROCEEDINGS:

- 7.1 All the concerned entities/licensees and offices were informed regarding the constitution of the IC and were further advised to be available, update/facilitate and supply the relevant/authentic data/information. The concerned entities/licensees were further directed to nominate a Focal Person for visit/provision of information/documents as required by the Committee. (Annex-2)
- 7.2 In the process of Inquiry, a visit to each of the following formations was made by the IC to secure the information/documents and deliberate upon issue of cascaded trippings resulting in partial blackout in the country which occurred on October 13, 2022 and subsequent restoration:

- National Power Control Centre (NPCC), Islamabad;
- Ghazi Barotha HPP;
- K-Electric, Karachi;
- Lucky Power Plant, Karachi;
- NTDC 500 KV / 220 KV NKI grid station;
- Breakdown Site at 500kV K2/K3 - Jamshoro Circuit-I & 500kV K2/K3-NKI T/Line Tower Location 26 & 26A;
- Office of GM (AM) South, NTDC, Jamshoro;
- Thar Energy Limited (TEL); (Meeting held at Karachi)
- K-2 & K-3 Nuclear power plants, Karachi;
- HUBCO;
- NTDC Head Office (WAPDA House), Lahore;

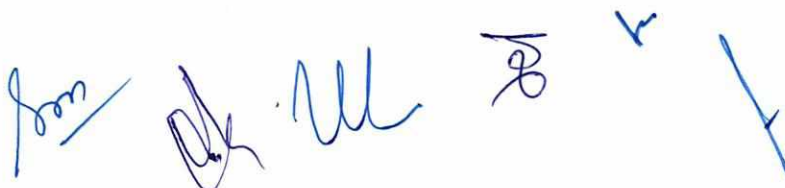
The summary of above presentations/briefings and discussions is given below;

### 7.3 National Power Control Centre (NPCC), Islamabad (Annex-3)

- NPCC informed that the power system was normal till 09:14:58 Hrs., however, the system was disturbed and following sequence of trippings occurred on 13/10/2022;

Sr. No	Sequence of Events of Trippings	Time of event (PST)
1.	Tripping of 500kV NKI-k2/3 (Both Ends)	9:14:58
2.	Tripping of 500kV Jamshoro-K-2/K3 Cct-I	9:16:42
3.	Tripping of 500kV Jamshoro-K-2/K3 Cct-II	9:16:45
4.	Tripping of 500kV HUBCO- K2/K3 T/Line	9:16:45
5.	Tripping of K-2 & K-3 (2072 MW)	9:16:45
6.	Tripping of China Hub	9:16:45
7.	Tripping of TEL Units (300 MW)	9:16:45
8.	Runback of Lucky Unit Started	9:16:44
9.	ROCOF (908 MW)	9:16:45
10.	Under Frequency (1431 MW).	9:16:45
11.	K-Electric Under Frequency (600 MW).	9:16:45
12.	220kV Gatti- Jaranwala Cross trip (232 MW).	9:16:57
13.	Lucky Power Runbacked and Generator Tripped.	9:17:45

- At 09:16:45 due to tripping of Lucky, K2 & K3, TEL, China Hub power plants there was generation loss of 3952 MW.



- Due to generation loss, the system frequency dropped, which resulted in Under Frequency Load Shedding of 1431 MW in NTDC system & 600 MW in KE system. Further, Rate of Change of Frequency Load Shedding (ROCOF) scheme operated which resulted in rejection of 931 MW load in NTDC system and following trippings;

Sr. No	Sequence of Events of Trippings	Time of event (PST)
1.	500kV Gatti- Barotha Cct-II tripped from Gatti end at DTT signal	9:33:36
2.	500kV Gatti- Bhikki cct tripped from Gatti end on O/C, RYB-Phase (Power Swing)	9:33:37
3.	500kV Guddu- D. G. Khan tripped from Guddu end on Out of Step protection	9:33:38
4.	500kV Guddu- Muzaffargarh tripped from both ends at Out of Step protection	9:33:38
5.	Tripping of Foundation Units	9:33:38
6.	Tripping of Guddu & Guddu-747 Units	9:33:38
7.	Tripping of CHASHNUP 1, 2, 3 & 4 in over frequency	9:33:42
8.	Tripping of Port Qasim Units	9:33:46
9.	Tripping of Engro Thar Units	9:33:46
10.	Supply Failure of HVDC	9:33:46
11.	Tripping of UCH-I Units	9:33:46
12.	Tripping of UCH-II Units	9:33:46

- At 09:33:38 Hrs., the system split into North & South zones.
- At 09:33:50 Hrs., due to above tripping events, around 4439 MW generation tripped in following sequence;

Sr. No	Power Plant	Generation at the time of tripping (MW)	Remarks
1	Port Qasim	621	Tripped on under Frequency
2	Engro Thar	600	Tripped on under Frequency
3	UCH	520	Tripped on under Frequency
4	UCH	350	Tripped on under Frequency
5	CHASHNUP-1	314	Isolated from system and went on house load
6	CHASHNUP -2	304	Tripped due to over-frequency
7	CHASHNUP -3	315	Isolated from system and went on house load
8	CHASHNUP-4	315	Isolated from system and went on house load
9	Guddu-Old	240	Tripped on under Frequency
10	Guddu-747	240	Tripped on under Frequency
11	Foundation	170	Tripped on under Frequency
12	Wind	150	Tripped on under Frequency
13	Solar	300	Tripped on under Frequency
Total Generation Tripped		4439	

- At 09:33 Hrs. partial blackout occurred and southern region plunged into darkness. However, the system remained intact in Northern Region to Centre.



- **North and South regions** got isolated due to above trippings. In **Southern region**, under-frequency was observed.
- In southern region, Port Qasim, Engro Thar, Guddu-747, Guddu Old, UCH-I, UCH-II got tripped on under frequency.
- In **Northern region**, over-frequency was observed. CHASHNUP-1, 3 & 4 isolated from the system and went on house load while CHASHNUP-2 tripped on over-frequency.

### 7.3.2 Sequence of Restoration:

Sr. No.	Grid Station	Restoration Time
1.	500kV Gatti	09:46 Hrs
2.	500kV Faisalabad West	09:50 Hrs
3.	220kV Jaranwala	10:00 Hrs
4.	220kV Kassowal & Vehari	10:10 Hrs.
5.	220kV Multan	10:31 Hrs.
6.	220kV T.T Singh	10:33 Hrs.
7.	500kV Muzaffargarh	10:41 Hrs.
8.	220kV Nishatabad	10:54 Hrs.
9.	220kV Samundri Road	11:10 Hrs.
10.	500kV Guddu-747	11:18 Hrs.
11.	220kV Bahawalpur	11:22 Hrs.
12.	220kV Lal Sohanra	11:35 Hrs.
13.	500kV Guddu	11:58 Hrs.
14.	500kV Shikarpur	12:15 Hrs.
15.	220kV UCH	13:05 Hrs.
16.	500kV Rahim Yar Khan	13:10 Hrs.
17.	220kV Chishtian	13:33 Hrs.
18.	500kV Moro	13:54 Hrs.
19.	500kV Dadu	14:05 Hrs.
20.	220kV Sibbi	15:04 Hrs.
21.	500kV Jamshoro	15:15 Hrs.
22.	220kV Quetta Industrial	15:29 Hrs.
23.	220kV Jhimpir-II	15:34 Hrs.
24.	220kV NKI	15:54 Hrs.
25.	220kV KDA	16:04 Hrs.
26.	220kV Hala Road	16:21 Hrs.
27.	500kV K-2/3	16:33 Hrs.
28.	220kV Khuzdar	16:35 Hrs.
29.	220kV Dera Murad Jumali	16:37 Hrs.
30.	220kV T. M. Khan	16:50 Hrs.
31.	220kV China Hub	18:09 Hrs.

- At 16:04 HRS, K-Electric-NTDC interlink established.

• **7.3.3 Sequence of Power Plant Restoration:**

S.No.	Power Plant	Generation at the time of tripping (MW)	Supply Failure Time	Supply Restoration Time	Synchronization Date & Time
1	China Hub	621	9:16	18:16	02:39 Hrs. on 14-10-2022
2	TEL	300		23:31	23:31 Hrs. on 13-10-2022
3	K-2	1040		16:54	05:37 Hrs. on 17-10-2022
4	K-3	1040		16:54	23:31 Hrs. on 15-10-2022
5	Lucky Coal	606		16:52	05:12 Hrs. on 13-10-2022
6	Port Qasim	621	9:34	16:33	20:59 Hrs. on 18-10-2022
7	Engro Thar	600		17:40	05:50 Hrs. on 14-10-2022
8	UCH-1	520		15:33	22:17 Hrs. on 13-10-2022
9	UCH-2	350		16:03	21:00 Hrs. on 14-10-2022
10	C-1	314		10:13	10:13 Hrs. on 13-10-2022
11	C-2	304		10:13	07:25 Hrs. on 16-10-2022
12	C-3	315		10:12	10:13 Hrs. on 13-10-2022
13	C-4	315		10:12	10:13 Hrs. on 13-10-2022
14	Guddu-Old	240		13:21	18:42 Hrs. on 13-10-2022
15	Guddu-747	240		13:21	18:30 Hrs. on 13-10-2022
16	Foundation	170		16:40	22:12 Hrs. on 13-10-2022
17	Wind	150		15:55	-
18	Solar	300		11:30	-
Total Generation Tripped		8046			

**7.4 Ghazi Barotha HPP (Annex 4);**

**7.4.1** Briefing of Ghazi Barotha is summarized below;

13/10/2022:

- Installed capacity = 1400 MW.
- 500kV Gatti-Ghazi Barotha – I was under shutdown.
- At 09:33:36 Hrs. 500kV Gatti-Ghazi Barotha – II tripped at Gatti end on DTT signal received from Ghazi Barotha end.
- No event of fault appeared at DCS system installed at Barotha end. The said issue was taken up with NTDC for ascertaining the reason of unwanted DTT signal received at Gatti.
- On 15/10/2022, the same phenomena/tripping was repeated at 500kV Gatti – Ghazi Barotha – II.
- The cause of the fault/DTT signal is yet to be shared by NTDC, Telecom.

**7.5 K-Electric, Karachi (Annex 5);**

**7.5.1** Briefing/Presentation of K-Electric is summarized below;

- Prior to event breakdown, KE and NTDC networks were running in synchronism. KE network was being operated in split mode i.e., major portion of KE network including generation was connected at 500kV NKI and another island was connected to 220kV Jhimpir.

Station	Dependable Capacity MW	Available Capacity MW	Planned Outage MW	Forced Outage MW	Dispatch MW
(IPP)	2185	1781	14	51	1202
NTDC	1000	1000	-	-	1018
Total	3185	2781	14	51	2210
Load Shed	-	-	-	-	391
Total Demand	-	-	-	-	2611

- Sequence of Breakdown Events of K-Electric (**Annex-6**)
- At 09:14 Hrs. 500kV Ckts tripped which caused de-synchronization of K2/K3 and China Hub Power Plants.
- Severe frequency depressions caused operation of UFR and rejected 601 MW.
- After stabilization of frequency 220kV Bus Coupler at 220kV KDA G/Station was closed and network changed to mesh.
- At 09:33 Hrs., voltage and frequency oscillations resulted in rejection of 429 MW on UF and 174 MW on UV protections resulting in complete breakdown in KE network.

#### **Restoration Process:**

- Immediate restoration process was initiated through islanded GT-2 at BQPS-2 and black start of CCPP. Simultaneous restoration process also started through black start from Tapal Energy Limited
  - At 10:25 Hrs. restoration started and by 12:21 Hrs. 80% of KE Grids were energized through 132kV network.
  - At 12:22 Hrs. due to operation by NPCC, tripping of generators occurred, thus plunging 550MWs load of KE network into dark again.
  - Restoration process was again started and at 15:16 Hrs., all grids of KE were energized through KE own generation and around 519 MW R&C load was connected.
  - At 17:25 Hrs., KE system synchronized with national grid.
  - At 01:21 Hrs. (14<sup>th</sup> Oct, 2022) complete R&C load was normalized.
  - At 05:15 Hrs. (14<sup>th</sup> Oct, 2022) Industrial feeders also normalized.
- Compliance of Recommendation of Breakdown dated January 09, 2021;

S.No	Recommendations by NEPRA	Actions by KE
1	The islanding facility available at KCCPP and BQPS-II could not be utilized as KCCPP was off due to low gas pressure whereas only one machine out of the two machines of BQPS-II came on island for short interval but could not survive.	<p>With the commissioning of HSD at CCPP, black start facility is also available at KCCP. Also, with integration of PLL gas, BQ2 complex now also possess Black start facility.</p> <p>Also, BQPS III will have black start option post commissioning on secondary fuel (HSD).</p>



2	The quantum of load to be rejected through under frequency relays along with time and setting coordination between those of transmission lines and machines needs to be reviewed for making those efficient and effective. The feeders which were supposed to but did not trip on under frequency shall be checked and kept healthy.	Detailed study was conducted by consultant and under frequency and under voltage schemes were revised which responded accurately in the recent breakdown. Details of UFLS and UVLS are annexed.
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#### 7.7 Lucky Power Plant, Karachi (Annex-6)

From the data provided by Lucky Power Plant and discussions, following has been submitted;

- Power System Stabilizer (PSS) is ready and data shared with CPPAG but it is yet to be made operational.
- Generator tripped at over-excitation as it was trying to support and maintain the network.
- There was no run-down of the power plant as alleged by NTDC/NPCC.

#### 7.8 Visit to Breakdown Site at Tower No. 26A of K2/K3 – NKI & K2/K3 – Jamshoro T/Line;

Brief given by NTDC at the site is summarized below (Annex-7);

- Interim arrangement was made for evacuation of power through 500kV K2/K3 - NKI & 500kV K2/K3 – Jamshoro T/Line.
- The conductor is old and number of droppers and T-Clamps were used for transmitting the power.
- The conductor and droppers are bulging which may cause problem.

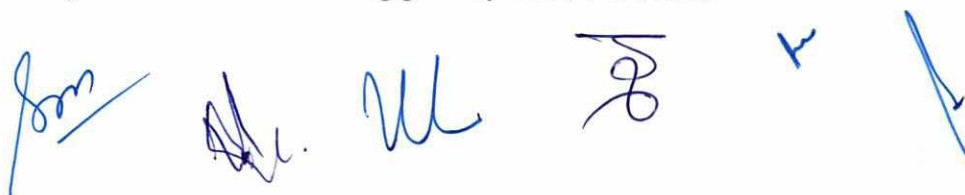
#### 7.9 Office of GM (AM) South NTDC, Jamshoro (Annex-8)

Summary of the briefing and discussions with GM (AM), South, NTDC is as under;

- Interim arrangements were made for evacuation of power through 500kV K2/K3 - NKI & 500kV K2/K3 – Jamshoro Circuits as the proper arrangement was not ready.
- Fault occurred on the red phase of 500kV NKI-K2/K3 Circuit-I, where 2 sub-conductors of quad bundling were broken between Location No. 26A-27. Dead end body of sub-conductor B was broken, which damaged sub-conductor C during the ground fault. Bulging occurred on yellow phase of sub-conductor B.
- Sub-conductor B & C of 500kV Jamshoro – K2/K3 Circuit - I were broken between location No. 26A-26 along with T-Clamps.
- 3 No. spacer dampers of Quad Bundled Red phase of 500kV Jamshoro – K2/K3 Circuit-I and 500 kV NKI-K2/K3 Circuit were broken between Location No. 26A-26.
- Proposal for the interim interconnection of K2/K3 power plant with HUB-NKI-Jamshoro & HUB – CPHGC - Jamshoro T/Line was prepared by NESPAK consultant and approved by NTDC design department, WAPDA House, Lahore.
- Material was allocated by design department, WAPDA House, Lahore where it was noted that the jumper assemblies and conductor droppers T-Clamps were not available and to be arranged by the EHV-Islamabad at their own.

#### 7.10 Thar Energy Limited (TEL) (Annex-9)

Summary of the documents/briefing given by TEL, is as under;



- At 09:14:57 Hrs. abnormal asymmetrical voltage drop resulted in corresponding increase in TEL machine parameters. Corresponding increase was observed in generator current which rose to more than 6% of the rated current and caused machine tripping at 09:16:42 Hrs.
- At 09:33 Hrs. abnormal voltage swing was observed on both lines which resulted in blackout.
- Power System Stabilizer (PSS) is built-in part of the generator and was operational.

#### 7.11 K-2 & K-3 Nuclear Power Plants, Karachi (Annex-10)

Brief of K2 & K3 submissions is as under;

- At 09:14:57:866 Hrs. 500kV NKI - K2/K3 tripped due to ground fault on red phase.
- At 09:16:42:781 Hrs. 500kV Jamshoro – K2/K3 Circuit-I tripped due to ground fault on red phase.
- At 09:16:43:868 Hrs., 500kV Jamshoro – K2/K3 – Circuit II tripped due to loss of voltage.
- At 09:16:44:075 Hrs. 500kV HUBCO – K2/K3 tripped due to DTT signal received from HUBCO end.
- At 09:16:44:626 Hrs. K2 plant tripped due to over-voltage/over-excitation.
- At 09:16:44:666 Hrs. K3 plant tripped due to over-voltage/over-excitation.

#### 7.12 HUBCO

Summary of the HUBCO is as under (Annex-11);

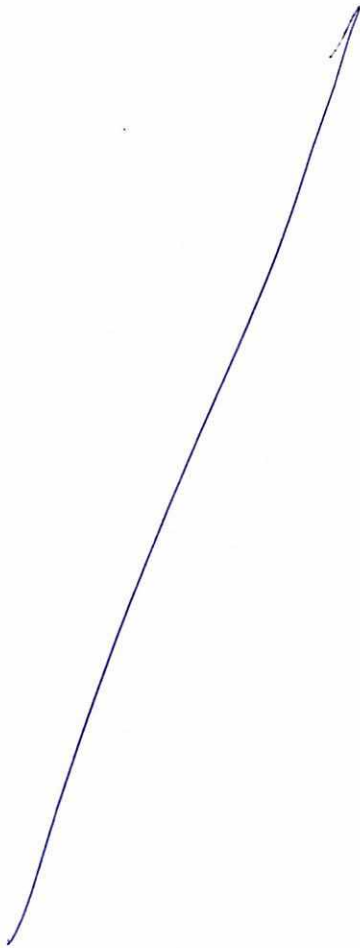
- At 09:16 Hrs. station blackout occurred.
- Both T/Lines tripped on under voltage due to 500kV system disturbance. No indication received on 500kV T/Line – I while 500kV T/Line – II tripped due to phase to ground fault.
- At 17:40 T/Line – II charged from K2/K3 side but tripped again at 17:41 Hrs on High Voltage.
- At 09:06 Hrs., station energized through 500kV T/Line – I CPHGC Circuit.
- 3 units of the power plant were on standby, whereas 1 unit was under outage.
- DTT signal received at K2/K3 end causing tripping of HUBCO-K2/K3 T/Line was not generated/sent from HUBCO end. No indication at HUBCO end.
- Server time is GPS synchronized.







#### 7.13 NTDC Head Office, Lahore (Annex-12)

Event description provided by NTDC Head Office, Lahore is given below;

- Following 500kV Circuits were on scheduled shutdown on 13/10/2022, when the partial blackout occurred at NTDC network:
  - 500kV CPHGC – Jamshoro T/Line
  - 500kV Guddu-747 – Muzaffargarh T/Line
  - 500kV Rahim Yar Khan – Multan T/Line
  - 500kV Y/Wala – Multan T/Line
  - 500kV Gatti – Rousch T/Line
  - 500kV Gatti – Barotha T/Line
- At 09:14 Hrs. 500kV K2/K3 – NKI T/line tripped due to conductor breakdown.
- At 09:16 Hrs. 500kV K2/K3 – Jamshoro Circuit - I tripped due to conductor breakdown.

- At 09:16 Hrs. 500kV K2/K3 – Jamshoro Circuit - II tripped at Jamshoro end on over current.
- From 09:16 Hrs. to 09:33 Hrs. severe fluctuations in the system continued which resulted in partial blackout.
- After islanding, over frequency was observed in Northern region which was controlled through regulations from hydel generation by System Operator and the northern system remained intact.
- HVDC Converter Station, Lahore was importing 1800 MW from Matiari end prior to the incident. Unlike, HVAC system, HVDC system is incapable to change the direction of power flow during continuous operation. Thus, it did not support the system during this disturbance.
- Response of Lucky and Thar Energy Limited against the disturbance was not supportive. Tripping of such huge quantum of generation affected system frequency adversely. The operation of Existing System Protection schemes i.e. Under Frequency Load Shedding, Cross Trips, Rate of Change of Frequency & Out of Step played a major role to save the system from total collapse.





**PART-3**  
**EVENT OCCURRENCE**  
**FINDINGS**  
**CONCLUSION**

## 8. Event Occurrence:

8.1 Total Power System collapse in Southern as well as in part of the Northern Region occurred on 13.10.2022 at 09:33 hrs. Before occurrence of the said partial system collapse, the power system in Southern region experienced tripping of some 500 kV transmission lines as well as the forced outage of power plants from 09:14:57:866 to 09:17:46:607 Hrs.

## 8.2 Pre-event Power System Position:

Prior to the event of 09:14 Hrs. all system parameters remained within the permissible limits. NTDC and KE networks were running in synchronism mode and the load in the system was with rising trend. The pre-fault power system parameters at 09:00 Hrs. were as follows:

Total System Generation	14138 MW
Total Hydel	3434 MW
GENCOs + IPPs	10704 MW
KE Drawl	1050 MW
HVAC	1530 MW
HVDC	1800 MW
System Frequency	49.7 Hz

## 8.3 Status of Generation at 09:00 Hrs.

South	
Generation (MW)	6,456
Load (MW)	3,126
Power Surplus/ Deficit (MW)	3,330
<b>Southern Region:</b>	<b>MW</b>
GUDDU 5-13	236
GUDDU 747	262
UCH-I	525
ENGRO	0
FOUNDATION	171
UCH-II	367
PORT QASIM COAL	621
CHINA HUB	583
ENGRO THAR COAL	607
Lucky Coal	607
Thar Energy	309
Kannupp-2	1,020
Kannupp-3	1,043
Total Baggass	99
Total Wind	6

HVDC = 1,800 MW  
HVAC = 1,530 MW

North	
Generation (MW)	7,682
Load (MW)	11,012
Power Surplus/Deficit (MW)	-3,330
<b>Northern Region:</b>	<b>MW</b>
TARBELA	790
G/BROTHA	960
KARROT	163
OTHER HYDEL PLANTS	1,521
AGL	51
KEL	0
SAHIWAL (COAL)	0
NANDIPUR	165
SAIF	208
HALMORE	100
BALLOKI	1,142
BHIKKI	1,067
CHASHNUPP - I	304
CHASHNUPP-II	312
CHASHNUPP-III	315
CHASHNUPP-IV	317
Total Solar	267

500 kV Transmission System Position at 09:00 Hrs.

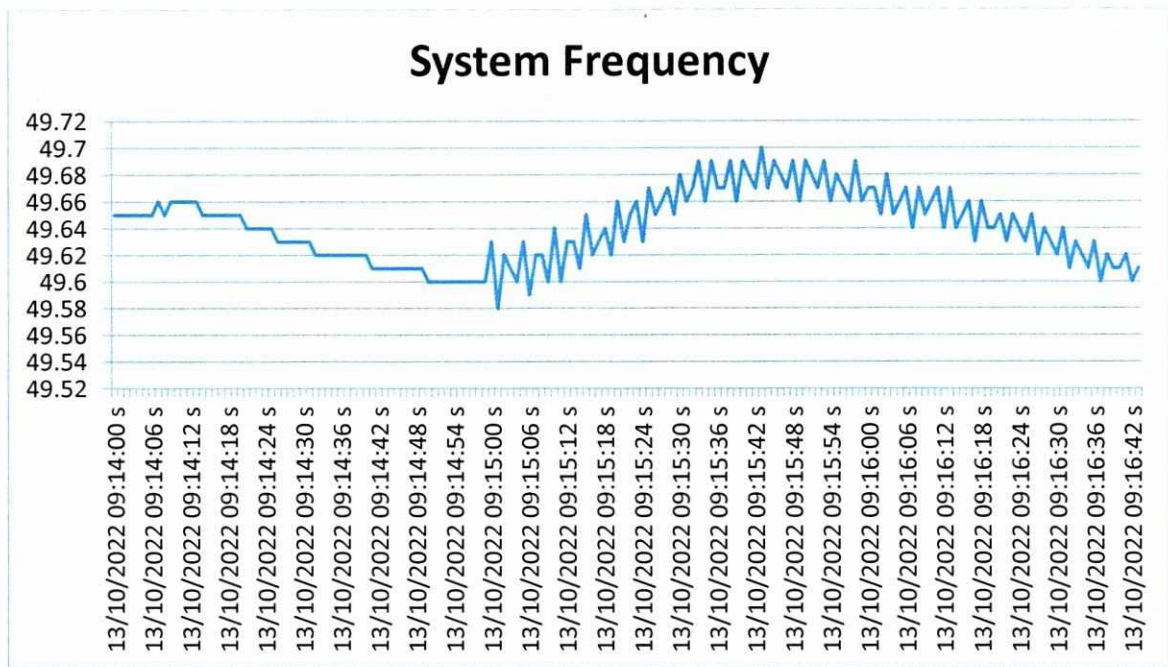
The diagram illustrates the 500 kV Transmission System in Pakistan at 09:00 Hrs. It shows two main 500 kV hubs, Lahore and Matiari, connected by a 1800 MW transmission line. Both hubs are connected to ±660 kV lines. The Lahore hub is connected to a network of 500 kV and 507 kV lines, including connections to LSP, Gatti, Roush, Multan, and various sub-stations like Ghazi Barotha and DG Khan. The Matiari hub is connected to a larger network of 500 kV lines, including connections to Moro, Dadu, Jamshoro, China, and various sub-stations like Lucky, Port Qasim, and K-2/3. The diagram also shows numerous other sub-stations and their interconnecting lines, with power flow values in MW indicated on many of the lines.

### 8.5 First Occurrence:

for /



## Frequency Oscillations



- 8.6 At 09:16:42:742 Hrs. Thar Energy Limited 300 MW (TEL) power plant tripped on “**Stator Overload Protection**” event log attached as **Annex 13**. During the meeting with TEL it was learnt that the PSS is **Active**, whereas as per NPCC record it’s **in-Active**.
- 8.7 At 09:16:42:781 Hrs., **500kV Jamshoro-K2/K3 Circuit-I (1300MW)** tripped from both ends on Distance Protection, Zone-I (11.4 km), Red Phase to Ground fault from K2/K3 end and from Jamshoro end on Distance Protection, Zone-II (176 km), Red Phase to Ground fault i.e. after about 350 ms (09:16:43:131 Hrs.). Relay Fault Record Recorder data is attached at **Annex 14**.
- 8.8 At 09:16:44:075 Hrs., **500kV HUBCO – K2/K3 Circuit** tripped from K2/K3 end on receiving **DTT (Direct Transfer Trip)** signal from HUBCO end resultantly CPHGC Power Plant (620 MW) isolated and tripped. The severe oscillations / hunting was being observed on the system. Meanwhile, **500kV Jamshoro – K2/K3 circuit-II (1340 MW)** tripped from Jamshoro end on **Over Current Protection**, as this was the only available circuit for evacuation of K2/K3 Generation. Ultimately this lead to the de-synchronization of power plants K2 (1040 MW) and K3 (1032 MW) which tripped on “**Over Voltage, Over Excitation**” indications at 09:16:44:626 Hrs. and 09:16:44:666 Hrs. respectively.
- 8.9 Due to the loss of about 2992 MW generation, the severe frequency dip, from 49.9 Hz to 48.6 Hz was observed. In order to balance the System Parameters the following protection schemes operated. The details are as under;

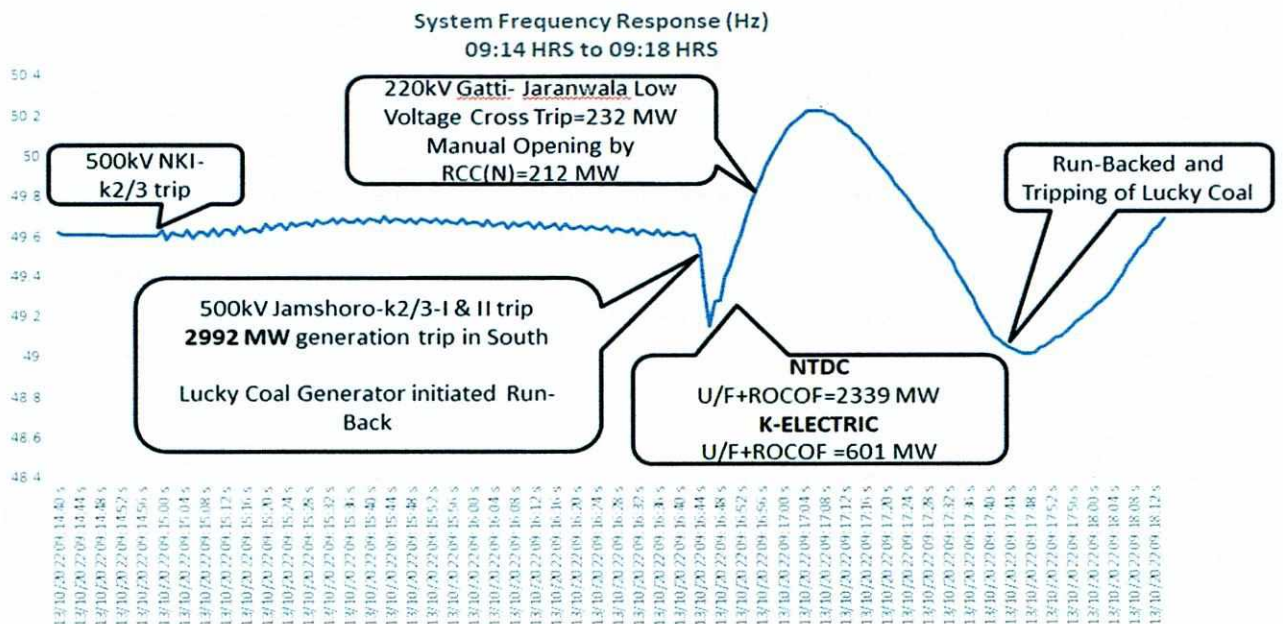
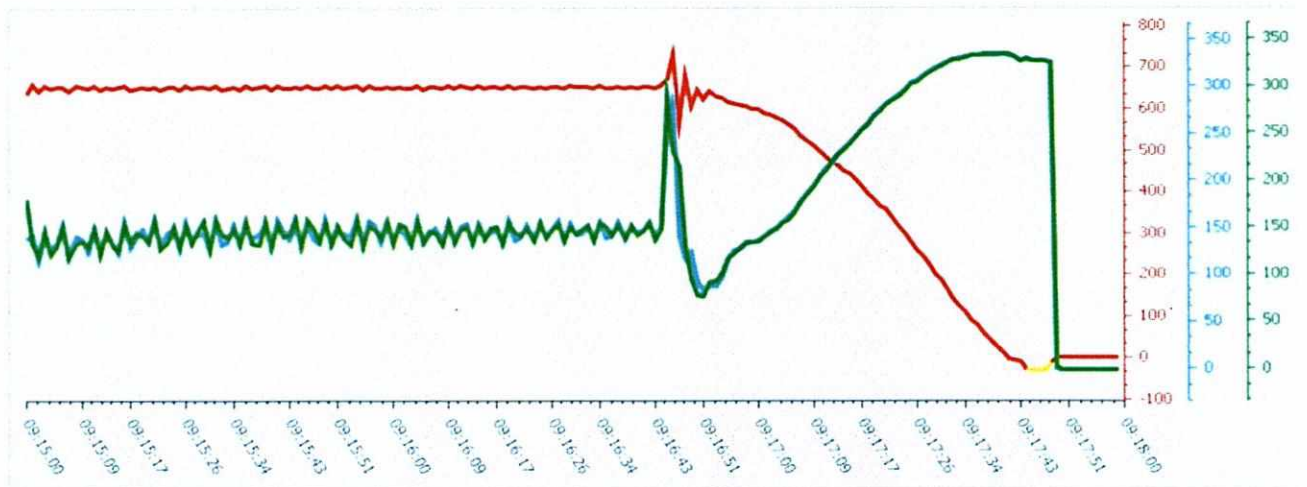
**w.e.f 09:16:44:232-590 Hrs.**

- ✓ **K-Electric:**
  - UF + ROCOF = 601 MW
- ✓ **NTDC:**
  - U/F + ROCOF = 2339 MW
  - Cross Trip = 232 MW
  - Manual Opening (by RCC) = 212 MW
  - Total Load rejected through Protection Schemes = 3384 MW.

**8.10** During the above load rejection process at about 09:16:46 Hrs., the Lucky Power Plant (600 MW) also started decreasing generation and tripped at 09:17:46:607 Hrs. on **Over Excitation** indication, event log attached as **Annex 15**. It's worth mentioning here that the PSS of Lucky power plant is still **In-Active**.

#### 8.11 Tripping Lucky Power System Frequency Response:

	G	Point Name	Historian	Processing Type	Description	End Val	Units	S	Low	High
1	<input checked="" type="checkbox"/>	(A) 10MKA01XQ013.UNIT1@NET0	Auto Historian	Actual	GEN ACTIVE PWR	-0.330	MW	<input checked="" type="checkbox"/>	-104	806
2	<input checked="" type="checkbox"/>	(A) 10MKA01XQ015.UNIT1@NET0	Auto Historian	Actual	GEN REACTIVE PWR FORWARD	-0.330	MVar	<input checked="" type="checkbox"/>	-33.7	367
3	<input checked="" type="checkbox"/>	(A) 10MKA01XQ016.UNIT1@NET0	Auto Historian	Actual	GEN REACTIVE PWR REV	-1.291	MVar	<input checked="" type="checkbox"/>	-34.7	366



**8.12** In the above scenario, NPCC (System Operator) controlled the System Parameters through quick and right actions in due course of time and saved the system from Partial / Total collapse.

*[Handwritten signatures]*

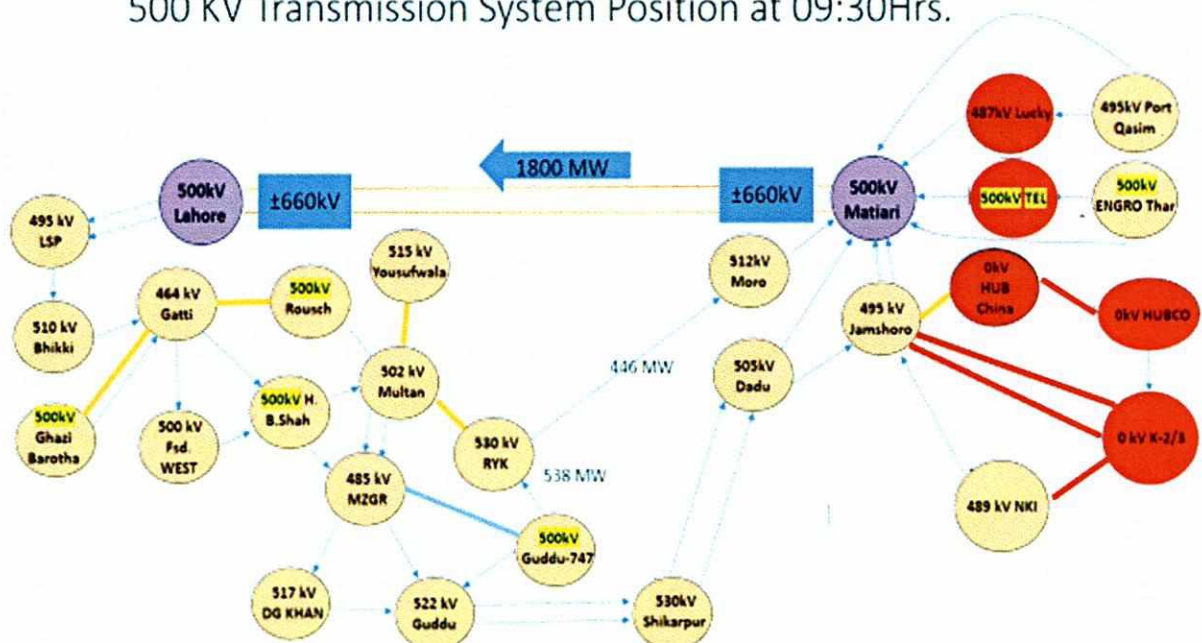


South	
Generation (MW)	2,758
Load (MW)	1,747
Power Surplus/ Deficit (MW)	1,011
Southern Region:	MW
GUDDU 5-13	372
GUDDU 747	202
UCH-I	512
ENGRO	0
FOUNDATION	171
UCH-II	344
PORT QASIM COAL	615
CHINA HUB	583
ENGRO THAR COAL	607
Lucky Coal	0
Thar Energy	0
Kannupp-2	0
Kannupp-3	0
Total Baggass	99
Total Wind	6

HVDC = 1,800 MW  
HVAC = -789 MW

North	
Generation (MW)	8,242
Load (MW)	9,253
Power Surplus/ Deficit (MW)	-1,011
Northern Region:	MW
Tarbela	681
G/Brotha	1450
Karrot	163
Other Hydel Plants	1,559
AGL	50
KEL	109
SAHIWAL (COAL)	0
NANDIPUR	165
SAIF	205
HALMORE	100
BALLOKI	1,135
BHIKKI	1,055
CHASHNUPP - I	304
CHASHNUPP-II	317
CHASHNUPP-III	318
CHASHNUPP-IV	317
Total Solar	320

500 KV Transmission System Position at 09:30Hrs.



*[Handwritten signatures and marks]*



#### 8.14 Second Occurrence:

Until 09:33 Hrs. all of the consumer supply through NTDC and K-Electric network was intact, although with some fluctuations, which was efficiently managed by the system operators, both, NTDC and KE. At 09:33:36 Hrs., DTT signal was received at 500 KV Gatti grid station on 500 KV Gatti - Ghazi Barotha circuit-II causing the Circuit Breakers of this T/Line to trip at Gatti end. As the 500 KV Gatti - Ghazi Barotha Circuit - I was already under scheduled outage since 06:05 Hrs. dated 13-10-2022 so this tripping resulted in heavy voltage and frequency fluctuations on the system and activated the Out of Step protection Scheme which tripped the 500 KV Guddu - Muzafar Garh circuit (from both ends) and 500 KV Guddu-DG Khan circuit (from Guddu end). Thus the HVAC was split into Southern and Northern Regions causing the blocking of HVDC Poles.

8.15 Meanwhile 500 KV Gatti - Bhikki circuit tripped on over-current due to which Gatti and Multan Grid Stations were isolated from 500 kV supply causing the load rejection of about 1900 MW. Resultantly, the North region experienced over voltage / over frequency. Thus CHASHNUPP-I, III and IV isolated from the system and came on House Load whereas CHASHNUPP-II tripped on Over Frequency. With this most of the North region survived and remained energized through which the restoration process was quickly started.

8.16 As far as Southern region is concerned it experienced severe under-frequency due to less generation against the load demand. Although some load was rejected in the K-Electric network on under frequency but being insufficient, could not be able to stabilize the frequency. As a result the remaining power plants in this region, including those of K-Electric, tripped on under frequency ultimately at about 09:33:50 Hrs. Southern region went under dark.

#### 8.17 Status of Generation Rejection at 09:33:50 Hrs. after splitting:

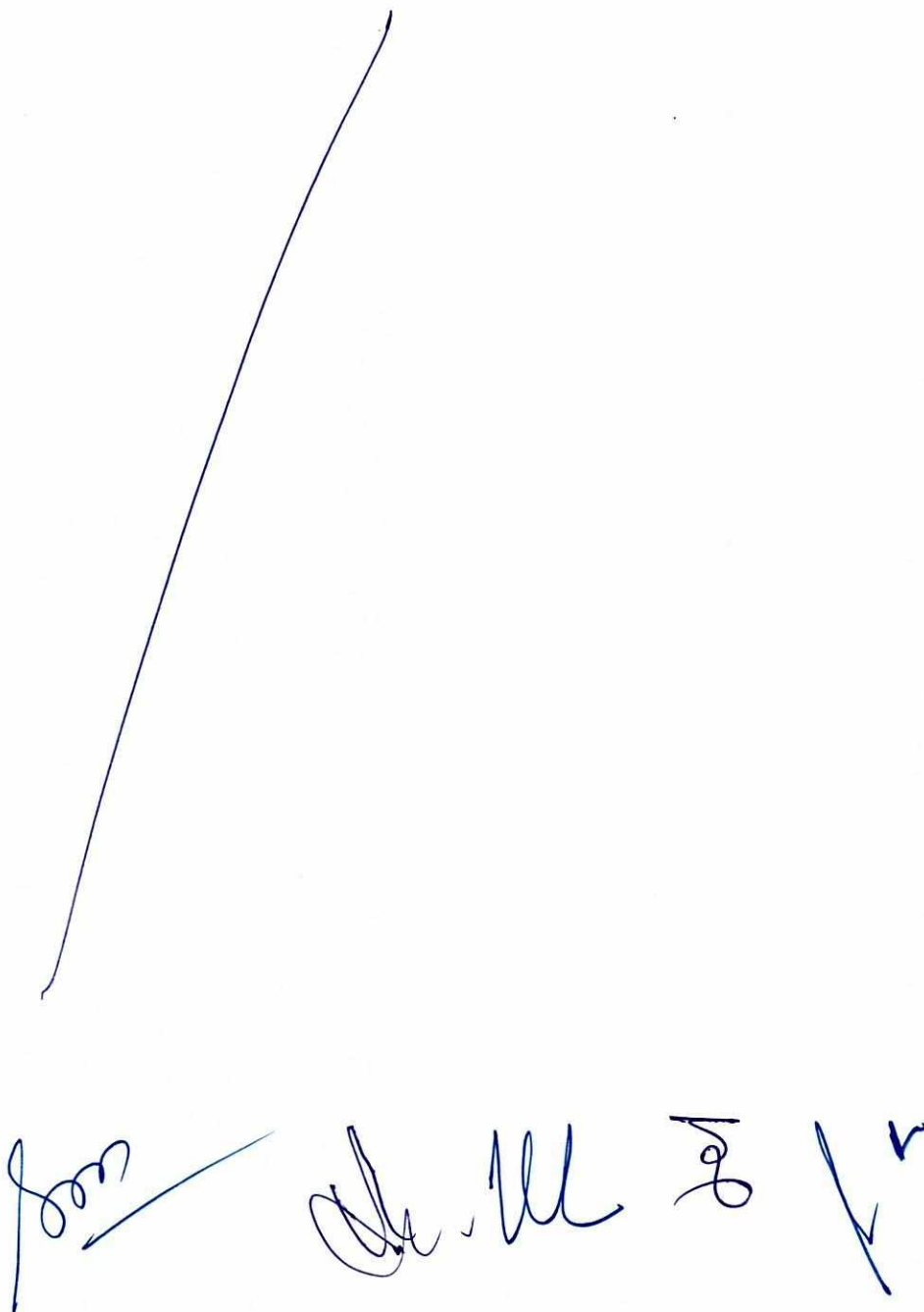
Sr. No	Power Plant	Generation at the time of tripping (MW)	Remarks
1	Port Qasim	621	Tripped on under Frequency
2	Engro Thar	600	Tripped on under Frequency
3	UCH-1	520	Tripped on under Frequency
4	UCH-2	350	Tripped on under Frequency
5	C-1	314	Isolated from system and went on house load
6	C-2	304	Tripped due to over-frequency
7	C-3	315	Isolated from system and went on house load
8	C-4	315	Isolated from system and went on house load
9	Guddu-Old	240	Tripped on under Frequency
10	Guddu-747	240	Tripped on under Frequency
11	Foundation	170	Tripped on under Frequency
12	Wind	150	Tripped on under Frequency
13	Solar	300	Tripped on under Frequency
<b>Total Generation Tripped</b>		<b>4439</b>	

## 9. Restoration of Power System

9.1 The network restoration process almost took about 07:40 hrs.

- 09:46 Hrs. NTDC started the restoration process.
- 10:25 Hrs. KE started the restoration process.
- 15:16 Hrs. KE energized all K-Electric Grid Stations through KE own generation.
- 17:25 Hrs. KE system synchronized with NTDC/National Networks at BQPS-I.

9.2 Details of restoration process in NTDC and K-electric system is attached as **Annex. 16**. However, the delay observed in synchronization of some Generation Plants details attached as **Annex. 17**

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## 10. Findings:

- 10.1** The initial cause of tripping is overheating and consequently damage of T-clamps and conductor at the temporary diversion between location number 26A and 27 of 500KV K2/K3-NKI circuit for the evacuation of power of K2/K3 plants. Since the construction of dedicated T/Line for evacuation of power from K2/K3 could not be completed by NTDC, the interim arrangement was made which is continuing for indefinite period as the dedicated T/Line is still incomplete. It is relevant to mention that the interim arrangement was vetted by M/S NESPAK + BARQAAB (JV) being the consultant while the contractor for the project is M/S Potential Engineers (Pvt.) Limited.

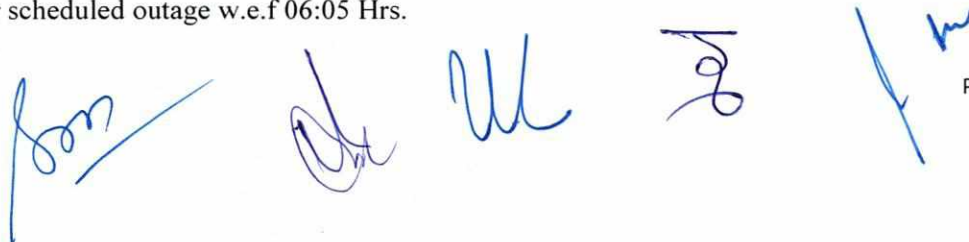
The interim arrangement involves a number of joints, that too with different types of clamps, such as T-clamps and L-clamps, as per availability at the time of execution. It may be added here that conductor of transmission lines being used for interim arrangement is about 26 years old and installed in heavily coastal polluted area, is deteriorated. The SLD of an existing network of the area is attached here as **Annex-18**.

At first, the fault developed on 500kV NKI - K2/K3, circuit due to overheating and breakage of T-clamps of jumper which resultantly tripped from both ends. This caused the shifting of load, about 2700 MW of CPHCL and K2/K3, on remaining two circuits between K2/K3 and Jamshoro, as CPHGCL-Jamshoro circuit was already under scheduled outage with effect from 08:48 hrs.

Additional load affected 500kV K2/K3 - Jamshoro circuit 1, being old one, where a sub conductor of Red phase heated up at dead-end body at location number 26A, which consequently was detached and fell on the ground. This fault was cleared timely from K2/K3 instantaneously on distance protection zone-1 whereas from Jamshoro end it tripped on distance protection zone 2, that is, after a delay of 350ms, relay fault recorder data attached as **Annex-14**. The tripping should have occurred instantaneously through tele-protection scheme instead of zone-2.

The relay indications and its fault recorder data at Jamshoro end shows that tele-protection signal (permissive) has not been received at Jamshoro from K2/K3 end. This needs to be checked and attended. So far as failure of hardware within three years of commissioning is concerned, it's because of improper interim arrangement, with non-standard/non-specified hardware/material and lack of periodic maintenance of transmission lines as per SOP.

- 10.2** The tripping of TEL on 'stator overload', in view of system position, provided relay settings and Generator name plate data **Annex-19**, seem not to be convincing. This could have been checked more precisely from "Fault Recorder Data" of the relay, which could not be provided by TEL.
- 10.3** The tripping of circuit breakers of 500kV HUBCO-K2/K3 circuit at K2/K3 on receipt of DTT signal, which isolated CPHGCL was due to false signal, as verified through telecom log during visit to HUBCO, from where no any signal was transmitted. This false telecom signal therefore needs to be checked and attended.
- 10.4** Lucky Power Plant tripped on 'Over Excitation Protection' due to depressed frequency. Its PSS, however, is yet to be brought in service to stabilize the system.
- 10.5** Until this time the system survived, of course with vigilant and timely actions by NTDC/KE system operators and auto load shedding schemes.
- 10.6** Afterwards at 9:33 Hrs. a false DTT signal at Gatti from Ghazi Barotha on circuit-2 caused the tripping of circuit breakers of this circuit at Gatti end. The Ghazi Barotha circuit-1 was already under scheduled outage w.e.f 06:05 Hrs.





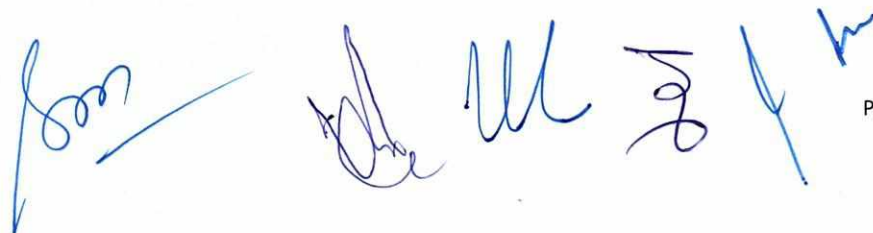
- 10.7** So, the above tripping aggravated the situation which resulted in Power Swing on the system. As such the Out of Step protection scheme was activated, resulting in splitting of HVAC system into North and South regions along with pole blocking of HVDC system, which ultimately caused over voltage/over frequency in North region and under-frequency in the South region.
- 10.8** In the North region CHASHNUP I, III and IV isolated from system and came on house load, whereas, CHASHNUP II tripped, on over-frequency. Thus, some parts of North came under darkness and the rest of the system remained energized, through which the restoration process was quickly initiated.
- 10.9** As regard the South region, the system did not survive due to less generation as compared to load demand, although some load was shed automatically through under frequency schemes. This region, however, was subsequently restored through KE power plants and NTDC supply and NTDC-KE system synchronized at 17:25 hrs.
- 10.10** Although the system was restored within reasonable time, but restoration of KE system was slightly delayed as about 60% of their restored network tripped through cross trip schemes. This could have been reduced if KE, who was well aware of the situation, should have taken care by blocking the cross trip scheme before initiating the restoration process.
- 10.11** During the visit of breakdown/interim arrangement site, the Inquiry Committee noticed that even after rehabilitation, the condition is risky specially that of conductor which is bulged at some points. It needs to be attended at the earliest possible time to avoid any unforeseen eventualities.



**11. Implementation status of the findings/recommendations of inquiry reports furnished thereof for such break downs in the past.**

**11.1 Implementation status of Recommendation of Inquiry Committee of NTDC i.r.o Partial Blackout occurred on October 13, 2022**

Sr. #	Actions proposed	Implementation Status
8.1	During planning and design phases, condition on aged transmission lines shall be assessed while interconnecting with new power plants	Under implementation
8.2	During execution stage, quality of the material/workmanship shall be ensured as per International Standards	Under implementation
8.3	O&M activities of transmission lines including thermography needs to be carried out as per SOP with available resources	Implemented
8.4	Ongoing projects of permanent network for evacuation of power in general and in particular from K2/K3 shall be	Under implementation
8.5	Implementation of SCADA-III shall be ensured as per timelines to enhance the live visibility of system parameters to System Operator	Under implemented
8.6	Phasor Measurement Units is required to be installed to timely indicate the oscillations in the system	Under implemented
8.7	Stability Control System shall be activated at the earliest to enhance the system stability	Partially Implemented
8.8	For more effective maintenance of T/Line, a yardstick for creation of new T/Line Divisions/ Sub-Divisions be developed so that with the addition of new T/Line, the requisite posts be got sanctioned accordingly	Partially Implemented
8.9	T/Line maintenance staff shall be equipped with proper PPEs, T&P, spare material/hardware and vehicles to ensure healthiness of NTDC's T/Lines as per NTDC maintenance SOPs	Partially Implemented
8.10	Condition assessment of the section of old 500 kV T/Lines near coastal/polluted areas should be carried out on war footing basis and remedial measures may be taken accordingly	Under implemented
8.11	Based on the visual inspection and documentary evidences, the Enquiry Committee is of the opinion that if deemed necessary, disciplinary action under the relevant rules may be initiated against the technical teams from project delivery south involved in execution of interim arrangement and asset management south for lack of O&M activities as per SOP keeping in view the criticality of said arrangement.	Partially Implemented



### 13. Conclusion:

#### 13.1 Causes and Faults which resulted in Partial System Collapse

Mechanical failure of hardware/conductor of 500kV K2/K3 – NKI T/Line & 500kV K2/K3 – Jamshoro T/Line and false signal generated from 500kV Gatti G/Station caused tripping of 500kV T/Lines in the South and partially in North, which resulted in the tripping of power plants on account of under-frequency & over-voltage.

#### 13.2 Responsibility for partial blackout

National Transmission Dispatch Company (NTDC) is responsible for partial system blackout in the country on October 13, 2022 on account of following;

- i. Receiving of false DTT signal at 500kV Gatti G/Station from Ghazi Barotha end which initiated the tripping of 500kV Gatti Ghazi Barotha Circuit – II
- ii. Failure to complete the dedicated T/Line for evacuation of power from K2 & K3 power plants.
- iii. Tripping of 500kV K2/K3 – NKI T/Line & 500kV K2/K3 – Jamshoro T/Line due to mechanical failure of hardware/conductor, because of improper interim arrangement, with non-standard/non-specific hardware material and non-periodic maintenance of transmission lines as per SOP.

#### 13.3 Restoration of Power Supply within reasonable time

The system was restored within reasonable time

#### 13.4 Status of previous inquiry report findings/recommendation

Recommendation given in the Inquiry Report of NEPRA regarding Total Power Collapse occurred on January 09, 2021 & NTDC Inquiry Report dated October 13, 2022 regarding Partial Shutdown are still under implementation.

#### 13.5 Remedial measures/recommendations:

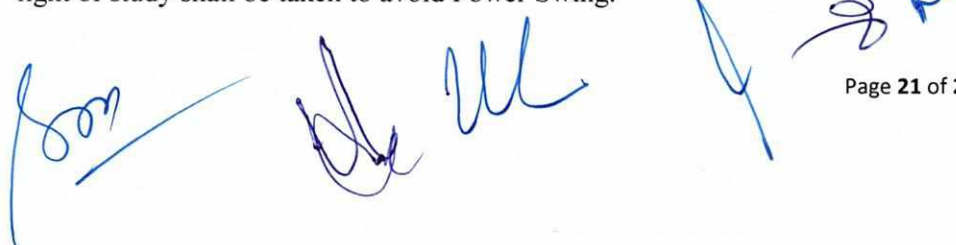
**13.5.1** The existing interim arrangement may immediately be reinforced with standard hardware.

**13.5.2** Aging factor of conductor and quality of material before and proper workmanship during the execution of interim arrangement must be ensured.

**13.5.3** Periodic maintenance/monitoring activities, specially the interim arrangement designed K2/K3 Circuits, must be ensured as per SOP

**13.5.4** Pending work of dedicated transmission lines for evacuation of power from K2 and K3 plants must be completed on top priority.

**13.5.5** VAR compensations study shall be carried out and required measures in light of study shall be taken to avoid Power Swing.





- 13.5.6 Fully functional SCADA** facility for complete system related to NTDC, GENCOS, IPPs and DISCOs is essentially required for system operator in order to ensure the on line monitoring of system parameters in all respect for sake of system security, stability and analysis of events through GPS synched time event recorder.
- 13.5.7** To ensure the **healthiness of Power System Stabilizers (PSS)** at power plants to damp intra-area oscillations
- 13.5.8** To ensure the installation of modern technologies device such as **Wide Area Management (WAM) including Phasor Management Units (PMU)** to detect oscillations instability which can be mitigated by Remedial Action Scheme (RAS).
- 13.5.9** Availability of required professionals and staff as per approved yard stick, along with required T&P including Thermo vision camera, especially in southern region must be arranged on urgent basis in order to ensure timely maintenance of existing network for system stability, reliability and security.
- 13.5.10** It must be ensured that all transmission line approved projects are completed on scheduled times. The work on delayed projects shall be accelerated on priority basis in order to evacuate cheaper power generation stably.
- 13.5.11** NTDC Telecom department deficiencies must be addressed to ensure proper communication of inter grid signals and avoid transmission of false signals.
- 13.5.12** Execution work of dedicated transmission lines shall be completed before the energization of transformation equipment (or) COD of Power Plants in order to avoid the LDs resultantly reduce the basket price for end consumer.
- 13.5.13** During the meeting with Thar Energy Power (TEL) Plant team it is learnt that PSS is Active, however, NPCC has confirmed that PSS is in-active at TEL, necessary verification in this regard is essential.
- 13.5.14** Implementation of coordinated over-frequency/over-speed trip schemes on newly synchronized generating units (i.e. Lucky Energy, Shanghai Electric, Thal Nova and TEL) after system study shall be expedited in order to ensure the system reliability.
- 13.5.15** Automatic tripping to be implemented through SCS on Lucky Energy Ltd, Shanghai Electric, Thal Nova and TEL in case of outage of outage on mono-pole/bi-pole HVDC system at Matiari Converter Station.

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**13.5.16** Protocols/SOPs to be developed in order to streamline the operational co-ordination between KE & NPCC

**13.5.17** Quantum of load to be shed through under-frequency and ROCOF schemes in South region needs to be increased for survival of the region whenever the region experiences under-frequency situation.

**13.5.18** It is noticed that there is a practice of switching off transmission lines to control the over voltage on system, which is neither prudent nor recommended. Therefore, the Committee is of the view that a study shall be carried out to install additional Shunt Reactors at appropriate locations i.e. may be on Grid Station Busbar.



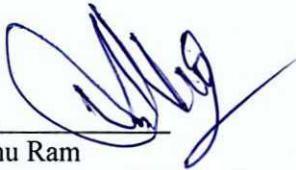
Nadir Ali Khoso  
Market Expert (Member)



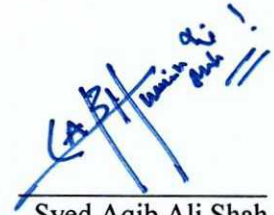
Ghulam Abbas Memon  
Market Expert (Member)



Syed Safeer Hussain  
Market Expert (Member)



Manu Ram  
Market Expert (Member)



Syed Aqib Ali Shah  
DD (M&E) NEPRA (Secretary)



Imran Kazi  
Senior Advisor (M&E) NEPRA  
Convener

**Date: May 11, 2023**



**K2/K3-NKI, Red Phase,  
C-Sub-Conductor (broken)**





01 No  
Sub-conductor  
Broken from  
T-Clamp, 500kV  
K2-NKI. (Loc#  
26A-27) of old T/  
Line.

Tower No. 26A.

02 No  
Sub-conductor  
broken from  
T-Clamps, 500kV  
K2K3-JMSR, (Loc#  
26A-26) of old T/  
Line.





**K2/K3-NKI, Red Phase,  
B-Sub-Conductor (broken)**





