



सत्यमेव जयते
भारत सरकार
विद्युत मंत्रालय
केंद्रीय विद्युत प्राधिकरण
राष्ट्रीय विद्युत समिति प्रभाग

No. CEA-GO-15-14/1/2021-NPC Division/

दिनांक: 15.11.2022

विषय: एन. पी. सी. की 12वीं बैठक के Minutes के सम्बन्ध में।

उपरोक्त विषय से सम्बन्धित दस्तावेज आपकी जानकारी एवम आवश्यक कार्यवाही हेतु संलग्न है।

संलग्नक : यथोपरि

भवदीय,
(हस्ताक्षर)
15/11/2022
(ऋषिका शरण)

मुख्य अभियंता एवं सदस्य सचिव, रा. वि. स.

सेवा में :

1. अध्यक्ष, उत्तर पूर्वी क्षेत्रीय विद्युत समिति
2. अध्यक्ष, उत्तर क्षेत्रीय विद्युत समिति
3. अध्यक्ष, पश्चिम क्षेत्रीय विद्युत समिति
4. अध्यक्ष, दक्षिण क्षेत्रीय विद्युत समिति
5. अध्यक्ष (टी सी सी), पूर्वी क्षेत्रीय विद्युत समिति
6. अध्यक्ष (टी सी सी), उत्तर पूर्वी क्षेत्रीय विद्युत समिति
7. अध्यक्ष (टी सी सी), उत्तर क्षेत्रीय विद्युत समिति
8. अध्यक्ष (टी सी सी), पश्चिम क्षेत्रीय विद्युत समिति
9. अध्यक्ष (टी सी सी), दक्षिण क्षेत्रीय विद्युत समिति
10. अध्यक्ष (टी सी सी), पूर्वी क्षेत्रीय विद्युत समिति
11. सदस्य सचिव, उ क्षेत्र वि स, नई दिल्ली - 110 016
12. सदस्य सचिव, प क्षेत्र वि स, मुम्बई - 400 093
13. सदस्य सचिव, द क्षेत्र वि स, बेंगलुरु - 560 009
14. सदस्य सचिव, पु क्षेत्र वि स, कोलकता - 700 033
15. सदस्य सचिव, उ पु क्षेत्र वि स, शिल्लोंग - 793 006

विशेष आमंत्रित:

1. मुख्य कार्यपालक अधिकारी, उ म प्र, रा भा प्रे के, नई दिल्ली - 110 016.
2. सीओओ, सीटीयू, सौदामिनी, प्लॉट नंबर 2, सेक्टर-29, गुडगांव-122001.
3. सीएमडी, पावरग्रिड, सौदामिनी, प्लॉट नंबर 2, सेक्टर-29, गुरुग्राम-122001.
4. सीएमडी, एनटीपीसी, एनटीपीसी भवन, स्कोप कॉम्प्लेक्स, इंस्टीट्यूशनल एरिया, लोधी रोड, नई दिल्ली - 110003

प्रति सूचनार्थ:

1. अध्यक्ष, के. वि. प्रा., रा. वि. स.,
2. सदस्य, (ग्रिड प्रचालन एवं वितरण), के. वि. प्रा.



Government of India
Ministry of Power
Central Electricity Authority
National Power Committee Division
1st Floor, Wing-5 ,West Block-II, RK Puram, New Delhi-66

No. CEA-GO-15-14/1/2021-NPC Division/

Date: 15.11.2022

To
(As per distribution list)

Subject: Minutes of the 12th Meeting of NPC held on 17.10.2022 through video conference -Reg.

The Minutes of the 12th meeting of NPC held on 17.10.2022 through video conference is enclosed herewith for your kind information and necessary action, please. The same is also available on CEA website.

Yours faithfully,

- Sd -

Enclosure: As above.

(Rishika Sharan)

Chief Engineer & Member Secretary, NPC

Distribution List (Members of NPC):

1. Shri Jishnu Dev Varma, Hon'ble Dy. Chief Minister & I/c Power, Govt. of Tripura, New Civil Secretariat, Room No. 6301, 3rd Floor, Agartala – 799010, [Email: deputycmtripura@gmail.com]
2. Shri Shurbir Singh, IAS, Chairperson, NRPC & Chairman & Managing Director, Delhi Transco Limited (DTL), Shakti Sadan, Kotla Marg, New Delhi-110002, [Email: cmd@dtl.gov.in]
3. Shri M. Chaitanya Prasad, IAS, Chairman (WRPC) & Secretary (Power), DNH & DD Secretariat C/o, 2nd Floor, Kachigam, Daman-396 215 [Email : chaitanya.prasad88@ias.nic.in & secretarypower2020@gmail.com]
4. Shri D Prabhakar Rao, IAS, Chairperson (SRPC) & CMD, Transmission Corporation of Telangana Ltd. 6th floor, Vidyut Soudha, Khairatabad, Hyderabad-500082 [e-mail: cmd@tstransco.in]

5. Shri Avinash Kumar, IAS, Chairperson (ERPC) and Chairman-cum-Managing Director, Jharkhand Urja Vikas Nigam Ltd(JUVNL), Engineering Building, HEC Dhurwa, Ranchi-834004, Jharkhand [Email:cmdjuvnl@gmail.com]
6. Shri C.A. Parmar, Chairman –TCC (WRPC) & Chief Engineer- DNHPDCL, Room No. 312, 3rd floor, Vidhyut Bhavan, 66 kV Road, Near Secretariat, Amali, Silvassa: 396 230 [Email: caparmar1956@gmail.com]
7. Shri K K Verma, Chairperson, TCC (ERPC) & Managing Director, Jharkhand Urja Sancharan Nigam Ltd.(JUSNL) Engineering Building, HEC Dhurwa, Ranchi-834004, Jharkhand [Email: mdjusnl@gmail.com, md@jusnl.in]
8. Shri T Jagath Reddy, Chairperson, TCC (SRPC) & Director (Transmission), TSTRANSCO, Vidyut Soudha, Khairatabad, Hyderabad-500082 e-mail: dir.trans@tstransco.in
9. Shri Mukesh Kumar Sharma, Chairperson, TCC(NRPC) & Director (Operations), Delhi Transco Limited (DTL), Shakti Sadan, Kotla Marg, New Delhi-110002, [Email: dir.opr@dtl.gov.in]
10. Shri Debasish Sarkar, Chairperson, TCC (NERPC), Managing Director, TSECL, Corporate Office, Agartala- 799003 email: managing.director@tsecl.in
11. Shri Naresh Bhandari, Member Secretary, NRPC, 18-A, Shaheed Jeet Singh Marg, Katwaria Sarai, New Delhi-110016.[Email: ms-nrpc@nic.in]
12. Shri Satyanarayan S., Member Secretary, WRPC, Plot No. F-3, MIDC Area, Marol, Opp. SEEPZ, Central Road, Andheri (East), Mumbai-400093. [Email: ms-wrpc@nic.in]
13. Shri Asit Singh, Member Secretary, SRPC, No.29, Race Course Cross Road, Bengaluru-560009. [Email: mssrpc-ka@nic.in]
14. Shri N. S. Mondal, Member Secretary, ERPC, 14, Golf Club Road, ERPC Building, Tollygunje,Kolkata-700 033.[Email: mserpc-power@nic.in]
15. Shri B. Lyngkhoi., Member Secretary, NERPC, NERPC Complex, Dong Parmaw, Lapalang, Shillong-793006. [Email: ms-nerpc@gov.in]

Special Invitees:

1. CMD, POSOCO, B-9, Qutab Institutional Area, Katwaria Sarai, New Delhi -110016.
2. CEO, CTU, Saudamini, Plot No.2, Sector-29, Gurugram-122001.
3. CMD, POWERGRID, Saudamini, Plot No.2, Sector-29, Gurugram-122001.
4. CMD,NTPC, NTPC Bhawan, SCOPE Complex, Institutional Area, Lodhi Road, New Delhi – 110003

Copy for kind information to:

1. Chairperson, CEA, New Delhi
2. Member (G&OD), CEA, New Delhi

Minutes of 12th Meeting of National Power Committee (NPC) held on 17.10.2022 through Video Conference (VC)

1. Introduction

- 1.1. The 12th Meeting of the National Power Committee (NPC) was held on 17.10.2022 (Monday) at 11:00 AM through VC. The List of Participants is at **Annexure-I**.
- 1.2. Shri Ghanshyam Prasad, Chairperson, Central Electricity Authority & National Power Committee welcomed the participants. He appreciated the fruitful decisions taken by NPC in its previous meetings. He stated that in this meeting also, many important agenda would be discussed, and among them one agenda item is about National level Optimization of Surplus Generation Capacity. He opined that the proposed scheme may be very helpful during power crisis as happened last year due to increase in coal and gas prices. He further informed that this issue was also deliberated during Conference of Power Ministers, held on 14th and 15th October 2022, chaired by Hon'ble Minister of Power at Udaipur, Rajasthan. He also emphasized on the need of development of Resource Adequacy Plan of DISCOMs and visibility of these resources for their proper utilization. Thereafter, he requested Member Secretary, NPC to take up the agenda of the meeting.

2. Confirmation of Minutes of 11th Meeting of NPC

- 2.1. The Minutes of 11th Meeting of NPC held on 28.02.2022 through video conference was circulated vide letter No. 4/MTGS/NPC/CEA/2021/199-218 dated 19.04.2022. The Minutes of Special meeting of NPC held on 24.06.2022 through video conference was circulated vide letter No. CEA-GO-15-14/1/2021-NPC Division dated 19.07.2022.
- 2.2. No comments received on Minutes of both the meetings from the members.
- 2.3. MS, NPC requested the members and the participants to confirm the minutes of the two meetings.
- 2.4. The Minutes of the meetings was confirmed.

3. Action Taken Report of previous meeting of NPC

- 3.1. Chairperson, CEA had desired to get the Action Taken Report (ATR) on decisions of the 11th meeting and special meeting of NPC.
- 3.2 ATR received from RPCs as on date attached at **Annexure-II**.

4. National Level Optimization of Surplus Generation Capacity

- 4.1. Central Electricity Authority vide letter dated 13.09.2022 circulated the draft proposal of National Level Optimization of Surplus Generation Capacity to the concerned stakeholders, states, UTs, DISCOMs, SLDCs, RPCs, POSOCO, state sector and central sector Generator companies for their comments. The last date for comments to be received on the proposal was 30.09.2022.
- 4.2. A meeting was also taken by Chairperson, CEA to discuss the same with all stakeholders at national level on 22.09.2022.

- 4.3. As per the proposal, the scheme is to utilize the generating capacities in an optimal way so that during crisis period it may not happen that some generating units are under RSD/ and on the other hand some states do power cuts.

Deliberations and decisions in the meeting

- 4.4. MS, NPC briefed the agenda to the Committee.
- 4.5. Chairperson, CEA/NPC requested members of the committee for their comments on the proposal.
- 4.6. Chairperson, SRPC welcomed the proposal and stated SRPC views on the proposal may be communicated to NPC after discussing the proposal at SRPC level.
- 4.7. MS, NRPC, informed that various stakeholders like Dhariwal Infrastructure limited, MSSEDCL, NTPC, POSOCO, PTC India, PXIL, PSPCL, Tata Power and HPPC have already sent their comments on the circulated proposal. The comments are being scrutinized and would be incorporated in the proposal suitably. He further stated that under this scheme a National portal would be created where temporary allocation of power from surplus (Seller) entity to deficit (buyer) entity would be made online amongst constituents in the country. In the scheme none of existing arrangements shall be disturbed, rather an additional avenue shall be provided to stakeholders for optimal use of surplus power. The scheme envisages paperless working for maturing transaction; and shall be subject to willingness of seller and buyer, confirmation of transmission corridor by NLDC and payment security by the seller before scheduling of such power. He further added that generating stations would be permitted to revise its schedule for surplus power from its original beneficiary to any other beneficiary. The new beneficiary shall be liable to pay both variable charge (VC) and fixed cost (FC) for full requisition and original beneficiary shall have no right to recall as entire FC liability is shifted to the new beneficiary because power being temporarily reallocated to him. Further, the temporary allocation will be based on regulatory tariff of appropriate commission.
- 4.8. MS, NPC requested RPCs and all stakeholders to submit their comments within 10 days, so that the scheme may be finalized much before the next crisis period being envisaged in April- May 2023.

5. Telemetry of real time active power (MW) data to SLDCs

- 5.1. MS, NPC informed that NPC Secretariat vide letter no. CEA-GO-15-24/6/2020-NPC Division/297-309 dated 06.07.2022 circulated the final Technical Specifications (TS) and the same was also uploaded on the CEA website.
- 5.2. RPCs were requested to take further necessary action at their end.

6. Review of Status of Islanding schemes

- 6.1. MS (NPC) informed the status of implementation/In service / Review of new and old Islanding Schemes ((as on 13.09.2022) as informed by respective RPCs) given below:-

Overview of the status of Islanding Scheme in all Regions									
Regions	Number of Islanding Schemes			Implemented/ Inservice IS	Existing IS (Cat-A) which are Under Implementation/ under review	Newly proposed IS (Cat-B) which are under design/Under Implementation stage)	Newly proposed IS (Cat-B) which are Implemented/ Inservice	IS having SCADA visibility	Remarks
	Cat-A (Old IS)	Cat-B (New IS)	Total						
SR	4	3	7	7	0	0	3	7	-
ER	7	2	9	4	4	2	0	5*	*1-under Implementation IS KBUNL IS discontinued.
NR	4	7	11	2	2	7	0	4*	*2-under implementationIS /IS in design stage
WR	7	5	12	6	1	5	0	6	All In service IS are made available at SLDC/WR LDC except Uran Islanding Scheme
NER	2	1	3	1	1	1	0	3*	*2-under implementationIS /IS in design stage
Total	24	18	42	20	8	15	3	25*	5-under implementationIS /IS in design stage

Deliberation in the meeting

- 6.2. MS, SRPC informed that all the IS of SR have been implemented and are In Service. SCADA visibility of all the 7 IS have also been made.
- 6.3. MS, ERPC informed that 2 number of new IS for Ranchi and Patna are still under implementation stage. It was informed to the committee that implementation of Ranchi IS depends upon the completion of under construction NTPC Patrattu thermal plant. For Patna scheme, GE raised concerns about technical viability of the scheme which would be discussed with GE. ERPC was requested to expedite the process of finalizing the IS in consultation with entities involved.
- 6.4. MS, NRPC informed that, initially, 7 number of new islanding schemes were proposed for NR region. However, in due course of time, some of the States were not showing willingness and raising concerns on technical feasibility of the newly proposed IS. As in case of Dehradun islanding scheme, it was informed by Uttarakhand that there was non-availability of generation in proportion to the load. He further informed that feasibility of such scheme is still under the discussion. He added that NRPC has set a timeline for Dec 2022 for finalising the Islanding Schemes of NR. NRPC was requested to expedite the process of finalizing the IS in consultation with constituent states.

- 6.5. MS, WRPC informed that 5 number of new islanding schemes were proposed for WR region. DPR for newly proposed Islanding Schemes of Jabalpur is completed and sent to NLDC for PSDF funding. Nagpur IS DPR is in the final stage of approval of competent Authority of MSETCL .WRPC is to follow TATA model of load management used for Mumbai IS. DPRs from state of Gujarat is awaited. He informed that review meeting for these newly proposed IS would be taken by WRPC for completion of DPRs by the end of October. He further informed that for Uran IS, SCADA visibility may be completed within one month time.
- 6.6. MS, NERPC informed that DPR old Islanding Scheme of Guwahati would be completed by October 2022. . He also informed that the Tripura Islanding Scheme is old IS which was reviewed on 29.09.2021 and the reviewed scheme will be implemented by November, 22.
- 6.7. NERPC was also requested to expedite the process.

Decisions in the meeting

- 6.8. Chairperson, NPC/CEA suggested that in case of Mumbai IS, local generation of Mumbai shall be made available for ensuring sustainability of Mumbai Island since in case of non-availability of local generation, the Mumbai load will be heavily dependent on import generation. He suggested WRPC to periodically review the situation.

[Action: WRPC]

- 6.9. RPCs were again requested to expedite the implementation of new islanding schemes and review of old Islanding schemes, as per SOP. Islanding Schemes which are under implementation shall be reviewed and discussed in next NPC meeting

[Action-All RPCs]

- 6.10. RPCs were requested to send the updated MIS report on monthly basis to NPC. The updated MIS is attached at **Annexure III**.

[Action-All RPCs]

7. National Energy Account (NEA)

- 7.1. MS (NPC) informed followings in regard to National Energy Account (NEA) to the committee:

- a) MoP vide letter No.A-60016/24/2012-Adm-I dated 30.11.2016 observed that considering the changing scenarios, the functions of NPC may also be broadened including the functions to maintain the National Energy Account (NEA) involving the trans-national and inter-regional transmission transactions.
- b) NLDC vide letter dated 09th November 2018 furnished the Agenda Note on National Energy Account & National Deviation Pool Account. NLDC was of the view that there is a need for implementing a National Deviation Pool Account based on the National Energy Account, for streamlining the accounting and settlement at national level. Further, suitable changes/modifications were required to be effected in the Indian Electricity Grid Code (IEGC) and Deviation Settlement Mechanism (DSM) Regulations apart from recognizing the functions of NPC in the regulatory framework.
- c) The issue of National Energy Account was deliberated in various meetings (8th, 9th, 10th and 11th) of NPC and in the 11th meeting of NPC held on 28.02.2022, NPC and RPCs

agreed that in future, if NEA would be mandated by CERC, the directions may be followed accordingly. It was also decided that, **the mock accounting of the proposed National Energy Accounting (NEA) may be carried out by NLDC for RPCs and NPC in order to have a clear understanding of NEA.**

- d) In this regard, the amendment in the functions of National Power Committee in its Conduct of Business Rule (CBR) will be required. The amended CBR of NPC is attached as **Annexure-IV** and the same is required to be forwarded to the MoP for issuance of necessary orders.

Deliberations in the meeting

- 7.2. ED, NLDC highlighted the importance of NEA for smooth settlement of accounts in case of inter-regional transactions by avoiding circular fund flow between the regions. It was also suggested that NEA can be functioned in parallel with the Regional Energy Account (REA) mentioning inter-regional and cross border transactions, and if there seems no concerns in NEA, it can be adopted fully at national level and inter-regional & cross border transaction may be removed from REA.
- 7.3. MS, NRPC endorsed the view of ED, NLDC. He further added that RPCs have concerns on NEA since there is no directions from CERC on NEA.
- 7.4. MS, SRPC informed that presently NLDC issued the mock accounts based on REA accounts issued by RPCs by merely adding and subtracting the inter-regional and cross border transaction of DSM account only. He opined there is no value addition in the mock accounts issued by NLDC since it considers DSM account only. He suggested that NLDC may include accounts like RRAS and AGC in the mock NEA accounts.
- 7.5. ED, NLDC informed that currently the mock exercise include DSM accounts and gradually the other accounts like RRAS, AGC etc. as suggested by SRPC may be included.
- 7.6. Chairperson, CEA opined that keeping in mind the future requirements, priority has to be given for seamless inter-regional transactions and NEA is one of such mechanism. He advised **NLDC to analyse the modifications required in the CERC regulations for NEA and send it to NPC, which can be taken up further with CERC. RPCs can also give comments on mock accounting of NEA and send them to NPC within two month and accordingly, the mock accounting can be modified.**
- 7.7. It was also suggested that amendments in the functions of National Power Committee (NPC) in its Conduct of Business Rule (CBR) can be taken up with MoP simultaneously.

Decisions in the meeting

- 7.8. POSOCO shall analyse the modifications required in the CERC regulations for NEA and send it to NPC, which can be taken up further with CERC.

[Action-POSOCO/NPC Secretariat]

- 7.9. RPCs may give comments on mock accounting of NEA and send them to NPC within two month and accordingly, the mock accounting can be modified.

[Action-All RPCs]

- 7.10. NEA requires amendments in the functions of National Power Committee (NPC) in its Conduct of Business Rule (CBR) which can be taken up with MoP simultaneously.

[Action-NPC Secretariat]

8. Guidelines for locating PMU for URTDSM Phase II project

- 8.1. MS (NPC) informed that Unified Real Time Dynamic State Measurement (URTDSM) project was agreed for implementation in a Joint Meeting of all the five Regional Standing Committees on Power System Planning held on 5th March, 2012. During the meeting, following PMU placement philosophy was decided:
- a) All 400 kV stations in State and ISTS grids.
 - b) All generating stations at 220 kV and above.
 - c) HVDC terminals and inter-regional and inter-national tie lines.
 - d) Both ends of all the transmission lines at 400kV and above: State and ISTS sector.
- 8.2. In addition to the PMU deployment, six (6) analytical software such as Line Parameter Estimation, Online Vulnerability Analysis, Linear State Estimation, CT/CVT Calibration, Supervised Zone-3 Distance Protection and Control Schemes for Improving System Security were also proposed to be developed by IIT Bombay.
- 8.3. A Detailed Project Report (DPR) was prepared in 2012 for implementation of URTDSM on Pan -India basis. Based on communication availability, URTDSM Project has been taken up in two phases as follows:
- Phase-I: 1186 PMUs at 351 substations (communication existing) - Rs. 278.89 crore.
 - Phase-II: 554 PMUs at 301 substations (with installation of 11,000 Kms OPGW) - Rs.377 crore.
 - Phasor Data Concentrators with 6 Analytical Software at 32 Control centres considering requirement of both i.e. Phase-I & Phase-II.
- 8.4. CERC granted in-principle approval for the project in Sept'2013 with 70% funding from PSDF & 30% equity from POWERGRID.
- 8.5. POWERGRID has taken up the implementation of URTDSM Project in Jan'2014 and 1409 PMUs were installed under the Project. The increase in quantity of PMUs is due to addition of new bays etc.at the substations.
- 8.6. The feedback on URTDSM Phase-I performance is received from POSOCO.
- 8.7. During the discussion on finalization of PMU quantity for URTDSM phase-II, requirement of additional locations for PMU installation was raised by NRLDC (in 45th TCC, 48th NRPC meeting) and SRLDC (in TCC & 37th SRPC meeting)
- 8.8. In the 10th meeting of NPC, it was decided that a Sub-Committee would be formed under the chairmanship of Member Secretary, WRPC with representatives from POSOCO, CTU, POWERGRID, and all RPCs/NPC to discuss on the uniform philosophy of PMU locations, new analytics and requirement of up gradation of Control Centre under URTDSM project and submit its recommendations to the NPC.

Deliberations & Decisions in the meeting:

- 8.9. MS, NPC briefed the members about the agenda item. She requested MS, WRPC to update the committee regarding the progress of the report.

- 8.10. MS, WRPC informed that the sub-committee has finalised its report. He presented a presentation highlighting the salient features of the report on philosophy of PMU Placement and Analytics under URTDSM Phase II. The report and presentation is attached at **Annexure-V**.
- 8.11. Chairperson, CEA/NPC appreciated the sincere efforts of the subcommittee and advised that the report of sub-committee may be examined at RPCs level. RPCs may give their suggestions/recommendations within one month time and subsequently based on the suggestions/recommendations of RPCs, the report would be accepted by NPC. **MS WRPC may take a lead and coordinate for the same and revise the report if required.**
[Action-All RPCs/WRPC]

9. Automatic Under Frequency Load Shedding (AUFLS) Scheme and Mapping of Feeders

(A) Review of AUFLS Settings

- 9.1. As per the decision in the 2nd meeting of NPC held on 16th July 2013, the following AUFLS scheme at four (4) stages of frequency viz. 49.2 Hz, 49.0 Hz, 48.8 Hz & 48.6 Hz had been implemented in all the regions

AUFLS	Frequency (Hz)	Load relief in MW					
		NR	WR	SR *	ER	NER	Total
Stage-I	49.2	2160	2060	2350	820	100	7490
Stage-II	49.0	2170	2070	2360	830	100	7530
Stage-III	48.8	2190	2080	2390	830	100	7590
Stage-IV	48.6	2200	2100	2400	840	100	7640
Total (MW)		8720	8310	9500	3320	400	30250

**SR grid not integrated with NEW grid at that point of time*

- 9.2. In the 10th meeting of NPC it was decided that the AUFLS scheme (with 4 stages) viz. 49.4, 49.2, 49.0 & 48.8 Hz with existing quantum of load shedding shall be implemented in all the Regions. A subcommittee was also constituted with members from CEA, RPC, POSOCO to review of AUFLS scheme and the quantum of load shedding.
- 9.3. In the 11th meeting of NPC, it was informed that SR, WR and ER constituents have already raised the settings of UFR of AUFLS scheme by 0.2 Hz.

Deliberations/Decisions in the meeting:

- 9.4. MS, NPC briefed the agenda item and requested MS, WRPC to update the progress of report of sub-committee on AUFLS.
- 9.5. MS WRPC informed the Committee that report on AUFLS and df/dt has been finalised by the sub-committee. He gave a presentation (PPT) briefing the highlights of reports. The report and presentation is attached at **Annexure-VI**.
- 9.6. MS, SRPC raised the concern on the quantum of load shedding in the reports and suggested that it needs to be reviewed considering the Islanding Schemes of SR.

- 9.7. Chairperson, CEA/NPC appreciated the efforts of the members of the subcommittee for bringing out a very good technical report. **He requested that Member Secretaries of all RPCs may have a meeting to discuss the report and shall strive to reach at a working consensus especially for SR. MS WRPC may take a lead and coordinate for the meeting. NPC may be appraised in the next meeting.**

[Action-WRPC/All RPCs]

(B) Mapping of Feeders under AUFLS schemes:

- 9.8. MS, NPC reiterated that each RPC would submit the details/progress of feeder mapping under AUFLS scheme on SCADA to NPC Secretariat regularly on a quarterly basis. It was again suggested that for improving the mapping of feeders following similar procedure as adopted by SRPC may be followed by all RPCs.

“Generally the 66 kV and 33 kV lines are connected at 132 kV level or 220 kV level, therefore, the communication system available at 132 kV level and 220 kV level can be utilized for these lines. For 11 kV and 33 kV level, the DISCOMs data may be integrated with their control centers. From the control centre it could be picked up to SLDC.”

- 9.9. The status of mapping of feeder under AUFLS as intimated by RPCs are as below:

RPCs	Status Updates from RPCs as on 17.10.2022
NRPC	UP-89 %, Punjab-38%, Haryana-85%, Delhi-73%, HP-63%, Rajasthan, UK, J&K & Chandigarh-0%.
ERPC	95% mapping of feeders achieved. The matter is being regularly taken up with the state utilities in Test meeting of ERPC for 100 % mapping of the feeders under AUFLS scheme.
NERPC	Assam-100 %, Meghalaya-100%, Nagaland-80%, Arunachal Pradesh, Manipur, Mizoram & Tripura – 0%. The issue is being reviewed/discussed in monthly OCC meeting of NERPC and 50% will be mapped by October, 2022.
WRPC	The recommendation of NPC regarding the mapping of feeders was taken in 560th OCC and the utilities were advised to expedite the mapping of feeders. Regular status of mapping would be taken up in upcoming OCC meetings.
SRPC	SCADA mapping status is being updated/reviewed in monthly OCC Meetings. The status update was taken in the 194th Meeting of OCC held on 12.09.2022 As on 31.08.2022 mapping was 93% in SR.

- 9.10. Chairperson, CEA/NPC emphasized that mapping of the feeders is very much required for smooth operation of the grid. He requested WRPC, NRPC and NERPC to conduct meetings with their DISCOMs to find solutions for feeder mapping and expedite it in their regions. The method suggested by SRPC may be explored.

[Action-NRPC/WRPC/NERPC]

10. Ensuring Proper Functioning of Under Frequency Relays (UFR) & df/dt Relays.

- 10.1. The updated status of ensuring Proper Functioning of Under Frequency Relays (UFR) & df/dt Relays as submitted by RPCs are as follows:

RPCs	Status Updates from RPCs
NRPC	Utilities submit report of mock exercises for healthiness of UFRs on quarterly basis to NRPC Secretariat. The compliance is monitored in monthly OCC meetings. Further, NRPC has also conducted UFR inspection of 220 kV Park Street S/s of DTL on 10.08.2022.
ERPC	Certificate of healthiness of UFR relay is being submitted by respective STU/SLDC in given format in every month and the same is monitored in monthly OCC meeting of ERPC. UFR audit of 3 substations in Bihar was carried out in April-22. Further UFR audit of 7 no of substations in West Bengal would be carried out in November'2022
NERPC	8 Substations and 16 feeders for UFR inspection have been identified for inspection. The inspection/test would be completed by 31st December 2022.
WRPC	In the 560th OCC States confirmed that they are ensuring healthiness of AUFLS and df/dt relays and detailed report will be submitted shortly.
SRPC	12 Substations each for UFR & df/dt inspection have been identified for inspection. The inspection/test would be completed by 31 st December 2022.

- 10.2. Chairperson CEA suggested that RPCs shall periodically conduct the periodic inspection of UFR and df/dt relays to ensure proper functioning of UFR and df/dt relays. He also advised NPC Secretariat to regularly follow-up the status update from RPCs on the agenda item.

Decision in the meeting:

- 10.3. RPCs shall periodically conduct the inspection of UFR and df/dt relays to ensure proper functioning of UFR and df/dt relays.
- 10.4. NPC Secretariat shall regularly follow-up the status update from RPCs on the agenda item.

[Action-All RPCs and NPC Secretariat]

11. Power System Stabilizers (PSS) tuning

- 11.1. The Enquiry Committee constituted by Govt. of India to enquire into the grid disturbances of July, 2012, had inter-alia recommended proper tuning of electronic devices and PSS of generators.
- 11.2. In the 9th meeting of NPC, it was decided that a Sub-group may be constituted comprising of representatives of Protection Sub-Committee of respective RPCs, NPC, NLDC, CTU, NTPC and NHPC, to finalize a common procedure for Power System Stabilizers (PSS)

Tuning. Accordingly, NPC Secretariat vide letter dated 08.02.2021 has formed the Sub-Committee under the chairmanship of MS, WRPC to finalize a common procedure for Power System Stabilizers (PSS) Tuning.

11.3. MS WRPC briefed the ongoing works of the committee. He informed that within a month time the report will be finalised.

11.4. **Chairperson, CEA advised that before finalizing the reports, it must be ensured that views and comments of RPCs and other stakeholders may be incorporated suitably in the final report.**

[Action-All RPC]

12. Issuance of Regional Energy Account (REA)

12.1. The status update received to NPC regarding the issuance of Regional Energy Account from RPCs, NLDC and NTPC are as follows:

RPCs	Status Updates from RPCs
NRPC	REA Issued till 4 th day of the month.
ERPC	ERPC Secretariat issues REA on the same day or by next day of receiving the input data from ERLDC.
NERPC	NERPC Secretariat issues REA (Provisional) on 1 st or 2 nd working day of the month.
WRPC	REA Issued till 2 nd of the month.
SRPC	SRPC Secretariat issues REA (Provisional) on 1 st or 2 nd of the month.
NTPC	From last six months REAs are being generally issued on 2 nd day of the month from NERPC, ERPC, SRPC, and WRPC. NRPC also issued it timely but sometimes till 4 th day of the month. He informed that overall the situation has been improved in the past six months
NLDC	The works related to preparation of data for REA is always dealt on priority, however, sometimes it may be delayed due to generation of errors in data which requires cross checking of data

12.2. Chairperson CEA stated that as informed by NTPC it appears that the issue has been resolved and REA is being issued by RPCs in a timely manner. He suggested that this agenda may be dropped from next meeting until any issue arises further in issuance of REA.

13. Implementation of Automatic Generation Control (AGC) in India (at Inter-State level)

13.1. In the 11th meeting of NPC, it was observed that progress of implementation of AGC is slow especially in intra-state AGC implementation. RPCs were requested to monitor the status of intra-state AGC implementation regularly and to suggest states to approach SERC for the financial implication of AGC implementation.

13.2. The status update received from RPCs are at as below:

RPCs	Status Updates from RPCs
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NRPC	NLDC has given the status of AGC implementation 34 Generators in NR. Out of 34, in 22 nos of Generator AGC has been implemented and in rest of the Generators, it was under implementation stage. The detailed list is at Annexure-D of Annexure-II.	
ERPC	Implemented: Barh I & II Farakka I & II Farakka-III KhSTPP-II MPL MTPS-II NPGC Teesta-V	Under Implementation: Rangit DSTPP BRBCL TSTPP KhSTPP-I
NERPC	Completed at BgTPP and Loktak HEP.	
WRPC	The recommendation of NPC regarding implementation of AGC was taken in 560th OCC and Regular status of implementation of AGC would be taken up in upcoming OCC meetings.	
SRPC	The status of AGC in ISGS and Intra-state generators was discussed in 194th OCC meeting. The detail list at Annexure-D of Annexure-II.	
NLDC	Status awaited from NLDC	

- 13.3. **It was suggested that this Agenda may be dropped from next meeting with a request to all RPCs to take up the monitoring of implementation of AGC at regional level. However, the status report will be presented in the NPC meetings for information of the members.**

14. Utilization of PSDF fund for the next 5 years and Monitoring of Schemes Sanctioned Grant from PSDF

- 14.1. MoP has sanctioned grant of around ₹ 12234.16 Crore (171 Schemes as on 31.08.2022) to States/ Central Power utilities/RPCs from Power System Development Fund (PSDF).
- 14.2. It has been observed that the utilization of grant by state utilities in different regions (particularly WR and NR) was not satisfactory vis-a-vis central sector utilities.
- 14.3. In the 17th meeting of Monitoring Committee of PSDF held in Jan, 2022, the performance of utilities for execution of the projects was also evaluated and put up to MoP. The utilities were categorized as very good, good, average and poor performance.

Deliberations in the meeting:

- 14.4. MS, NPC briefed the agenda to the Committee. MS, NPC also briefed the identified projects as per 18th meeting of Monitoring Committee, which are to be funded from PSDF in order to utilise the outlay of the amount Rs. 11,000/- crore.

Sr. No.	Identified Project name	Estimated cost of the project	Sector/ utilities	Fund required for next five years	Remarks
EFC Meeting Recommendations					
1	Setting up of SLDC cum REMC at Ladakh	106	Ladakh	106	100% may be funded
2	Setting up of New REMCs at 3 more locations	39		39	100% may be funded
RPC Meeting recommendations					
3	Pilot Project for Dynamic Line rating in each region.	80	All India Basis	75	90% may be funded
	10 Cr – 15 crores per region				
4	Development /converting Islanding scheme with adaptive load management	100	All India Basis	90	90% may be funded
5	Security Operation Centre at SLDCs for real-time cyber monitoring	525	All India Basis	525	100% may be funded (Already recommended in the EFC meeting)
6	Communication for AMR and Real-time Telemetry & 100% visibility of Grid.	600	All India Basis	300	50% may be funded
7	Capacity Building for central/state utilities	20	All India Basis	100	100% may be funded

- 14.5. Chairperson, NPC/CEA was of the view that RPCs are not directly assigned for monitoring of PSDF projects and suggested that monitoring of PSDF sanctioned projects may be done through the Project Monitoring Group of PSDF which has been created for the same. All RPCs endorsed the view of Chairperson, CEA.
- 14.6. MS NPC was of the view that the Project Monitoring Group of PSDF conducts various meetings at regional levels for monitoring the implementation of sanctioned scheme and these meetings were impactful in terms of reduction in delay in completion of projects and also improves the disbursement of fund to project entities. The purpose of bringing this agenda in NPC meetings was to sensitise the states for timely completion of projects through RPCs
- 14.7. Chairperson, NPC/CEA raised concern on delay in sanctioning of the projects under PSDF. On this MS, NRPC suggested for a dedicated online portal for PSDF for uploading of DPR, comments of TESSG, and inputs of project entities so that the project may be sanctioned in limited time period.
- 14.8. ED, NLDC informed the committee that the portal was already developed one year back but it has not been utilised by the entities. NLDC stated that they would again request the utilities /states to utilise the portal.
- 14.9. Chairperson, NPC/CEA advised NLDC that the portal to be revived and to be made fully operational. NLDC shall also informed states/utilities regarding the portal and suggest them to utilise it for early sanctioning of projects in limited time period.

Decisions in the meeting:

- 14.10. NLDC shall revived the portal again and made it functional completely. POSOCO shall also disseminate the information to states/utilities regarding the portal and suggest them to utilise it for early sanctioning of projects through PSDF.

[Action-POSOCO/NLDC]

- 14.11. It was decided that the agenda item may be dropped as the monitoring of PSDF sanctioned projects is done through Project Monitoring Group (PMG) of PSDF.

15. Membership of RPC forum (ERPC- Agenda)

- 15.1. Government of India has a vision of achieving Renewable Energy installation target of 150 GW and 450 GW by 2022 and 2030 respectively. The major challenge before the government is the RE integration to the Indian Electricity Grid and smooth running of the Grid in the Real Time operation. For resolving the issues of RE generators, smooth integration and proper real time dispatch of RE generation, ERPC proposed a suitable provision for inclusion of RE generators with threshold of 200 MW and above as a membership of RPC forum.
- 15.2. In the 11th meeting of NPC, it was observed that the issue needs deliberation at the RPC level first and afterward may be discussed at NPC level.
- 15.3. SRPC vide letter dated 05.07.2022(**Annexure-VII**) informed that the issue was discussed in the 42nd meeting of SRPC. SRPC recommended that membership of two RE generators

with threshold of 1000 MW (and above) installed capacity in the region on rotational basis. The participation of such generators would be limited to technical and operational issues.

Deliberations & decisions in the meeting

- 15.4. ERPC briefed the agenda to the Committee.
- 15.5. MS, NPC informed that SRPC had sent their recommendation to consider membership of two RE generators with threshold of 1000 MW (and above) installed capacity in the region on the rotational basis. The participation of such generator would be limited to technical and operational issues.
- 15.6. Chairperson, CEA/NPC suggested that all RPCs may share their views to NPC Secretariat. The views of all RPCs may be analysed and a holistic recommendation may be prepared by NPC Secretariat for approval.

[Action-All RPCs and NPC Secretariat]

16. The meeting ended with Vote of thanks to the Chair.

List of Participants in the 12th Meeting of NPC held on 17th October, 2022 through Video Conference

Central Electricity Authority (CEA)

1. Shri Ghanshyam Prasad, Chairperson ,CEA/NPC(in chair)
2. Smt. Rishika Sharan , Member Secretary, NPC
3. Shri R.M.Rangarajan, Director, NPC
4. Shri Himanshu Lal, Dy. Director, NPC
5. Shri Ravi Shankar Singh, Dy. Director, NPC
6. Shri Kotthapally Satishkumar, Assistant Director-I, NPC
7. Shri Nikul Rohin, Assistant Director-I, NPC

Northern Regional Power Committee (NRPC)

1. Shri Naresh Bhandari, Member Secretary, NRPC
2. Shri Santosh Kumar, Superintending Engineer, NRPC
3. Shri Reeturaj Pandey, Executive Engineer, NRPC
4. Shri Kaushik Panditrao, Assistant Executive Engineer, NRPC

Southern Regional Power Committee (SRPC)

1. Shri D Prabhakar Rao, Chairperson, SRPC & CMD, TSTRANSCO & TSGENCO
2. Shri T. Jagath Reddy, Chairperson TCC, Director/Transmission
3. Shri Asit Singh, MS, SRPC
4. Shri NRLK Prasad, SE(PCS), SRPC
5. Shri Meka Ramakrishna, SE(C), SRPC
6. Shri K P Madhu, SE(O), SRPC
7. Shri B. Narsinga Rao, Director, Grid Operation
8. Shri P. Suresh Bebu, CE/SLDC
9. Shri R. Srinivasa Rao, SE/T to CMO TSTRANSCO
10. K Hema, SE/Transmission
11. Shri T. Durga Prasad, DE/Transmission
12. Shri M.L.S.V. Prasada Rao, CE/Transmission
13. Shri V.Venkateswar Reddy, DE/Transmission

North Eastern Regional Power Committee (NERPC)

1. Shri Debashish Sarkar, Chairperson (TCC, NERPC) & MD, TSECL
2. Shri B. Lyngkhohi, Member Secretary, NERPC
3. Shri Abhijit Agarwal, Executive Engineer, NERPC
4. Shri Shivam Chaturvedi, Assistant Engineer, NERPC

Western Regional Power Committee (WRPC)

1. Shri C.A. Parmar, Chairman –TCC (WRPC) & Chief Engineer- DNHPDCL
14. Shri Satyanarayan S., Member Secretary, WRPC
15. Shri P D Lone, Superintending Engineer (Comm.), WRPC
16. Shri Deepak Sharma, Executive Engineer, WRPC
17. Shri Sachin K Bhise, Executive Engineer, WRPC
18. Shri Vikas Mundotia Executive Engineer, WRPC

Eastern Regional Power Committee (ERPC)

1. Shri M.K. Karmali, Director (Projects) , JUSNL
2. Shri N. S. Mondal, Member Secretary, ERPC
3. Shri S. Kejriwal, SE , ERPC
4. Shri P.P. Jena, EE, ERPC
5. Shri A. De, EE, ERPC
6. Shri S. Pradhan, AEE, ERPC

Special invitee:

National Thermal Power Corporation (NTPC)

1. Ajay Dua, NTPC
2. Rajesh Jain, AGM
3. Achal Kumar Arora, NTPC

Power System Operation Corporation Ltd. (POSOCO)

1. Shri Debasis De, ED, NLDC
2. Vivek Pandey, GM,NLDC
3. Surajit Banerjee, NLDC

Power Grid Corporation of India Ltd. (PGCIL)

1. Smt. Sunita Chauhan, Sr. GM(LD&C)
2. Shyam Goyal, PGCIL
3. Sunil Aggarwal, PGCIL

Central Transmission Utility of India Ltd.(CTUIL)

1. Shri H S Kaushal, Sr.GM
2. Smt. Sangeeta Sarkar, Chief Manager
3. Shri Rajesh Kumar, CTU

Other participants:

1. S C De, NERLDC
2. Palash Borah, Manager, NERLDC

Action Taken Report (ATR) of all RPCs on the decisions taken in 11th meeting of NPC and special meeting of NPC.

1. Telemetry of Real time active power Data to SLDCs

RPCs	Status Updates from RPCs
NRPC	Status Update still awaited.
ERPC	The matter was discussed in 194th OCC Meeting of ERPC held on 23.08.2022 wherein OCC advised PowerGrid to implement the scheme on pilot basis in a meter not connected with AMR first and simultaneously study the technicalities of carrying out the scheme in AMR connected meters.
NERPC	Under Pan India 5 min Meter, AMR project by NPC
WRPC	No update received regarding this.
SRPC	<ul style="list-style-type: none"> ➤ In the 52nd meeting of Commercial Sub-Committee of SRPC held on 14.07.2022, it was recommended that a detailed plan of implementation of AMR-MDP system in SR may be furnished by PGCIL to SRPC before the next Meeting of Commercial Sub-Committee. PGCIL agreed the same. ➤ The item has been put up for deliberation the 41st TCC/ 43 rd. SRPC to be held on 20.09.2022 & 23.09.2022

2. Review of the Islanding Schemes

RPCS	Status Updates from RPCs
NRPC	7 new IS are under design stage i.e. scheme design is being finalized and will be submitted to CPRI for study.
ERPC	2 new islanding schemes for Ranchi and Patna are still under implementation process. It was informed that implementation of Ranchi IS depends upon the completion of under construction NTPC Patratu thermal plant. For Patna scheme, GE raised concerns about technical viability of the scheme which may be discussed in a meeting with GE.
NERPC	<ul style="list-style-type: none"> ➤ Islanding Scheme of Upper Assam has been implemented. ➤ Islanding Scheme of Tripura will be implemented by November, 22 ➤ New Islanding Scheme of Guwahati- DPR sent to NLDC/NPC. ➤ MIS report is being regularly sent to NPC.
WRPC	<p>Comprehensive logic to be implemented was discussed in a special meeting held on 2nd August 2022 in Nagpur. In the meeting the guidelines were given to the implementing Agencies and requested to submit the DPRs by 31.08.2022.</p> <ol style="list-style-type: none"> 1. Jabalpur IS: Detailed engineering done; DPR is submitted to NPC/NLDC PSOSCO on 6th Oct. 2022. 2. As informed telephonically, Nagpur IS DPR is in the final stage of approval of competent Authority of MSETCL. 3. For Bhuj IS, Participating generator, APMuL has raised concern about compromising reliability and possibility of losing entire generation at APMuL on tripping of ICTs in Bhuj S/s during island condition. 4. Jamnagar and Raipur IS: The DPR preparation work is in progress. <p>In 150th PCM meeting, all existing IS in category A are reviewed and concerned Utilities confirmed the healthiness of IS.</p> <p>All the in-service Islanding Scheme except Uran IS have SCADA visibility. The SCADA visibility of Uran IS may be completed within one month time.</p>

SRPC	All 7 Islanding schemes has been implemented in SR including 4 old IS and 3 new IS.
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3. National Energy Account (NEA)

RPCs	Status Updates from RPCs
SRPC	<ul style="list-style-type: none"> ➤ Mock accounting of the proposed National Energy Accounting (NEA) is carried out by NLDC based on the weekly DSM statements issued by RPCs. ➤ SRPC is in receipt of the weekly NEA from NLDC for the week's 09.05.2022-15.05.2022, 16.05.2022 to 22.05.2022, 23.05.2022 to 29.05.2022, 30.05.2022 to 05.06.2022, 06.06.2022 to 12.06.2022, 13.06.2022 to 19.06.2022 & 20.06.2022 to 26.06.2022. ➤ The details of NEA issued by NLDC for SR is at Annexure-A.
	<ul style="list-style-type: none"> ➤ It is observed that there is no value addition in NEA account statements. ➤ Requirement of NEA by NLDC is not coming out evidently. ➤ Present system of Regional Accounting may be continued. ➤ It is also brought to notice that DSM, RRAS & AGC accounts by RPCs are revised based on the schedule/actual revisions by RLDC and the same would lead to different NEA as and when RPCs revise the accounts.

Note- No input received from other RPCs.

4. Review of AUFLS Settings and Mapping of Feeders under AUFLS

RPCs	Status Updates from RPCs
NRPC	In compliance of NPC decision, NR states/constituents agreed to raise the AUFR settings by 0.2 Hz in 47th TCC/49th NRPC meetings. The compliance of revised setting is being monitored in monthly OCC meetings. The state-wise details of mapping of feeders in NR at Annexure-B
ERPC	The matter is being regularly taken up with the state utilities in TeST meeting of ERPC for 100 % mapping of the feeders under AUFLS scheme.
NERPC	<ul style="list-style-type: none"> ➤ Implemented in all States except Arunachal Pradesh(Stage-I)&Tripura (stage -I/II/III) ➤ Mapping of feeder: Assam-100 %, Meghalaya-100%, Nagaland-80%, Arunachal Pradesh, Manipur, Mizoram & Tripura – 0%. The issue is being reviewed/discussed in monthly OCC meeting and 50% will be mapped by October, 2022.
WRPC	<ul style="list-style-type: none"> ➤ Final report of sub committee on AUFLS was submitted to NPC on 13th October, 2022. ➤ The recommendation of NPC regarding the mapping of feeders was taken in 560th OCC and the utilities were advised to expedite the mapping of feeders. Regular status of mapping would be taken up in upcoming OCC meetings.
SRPC	SCADA mapping status is being updated/reviewed in monthly OCC Meetings. The status update was taken in the 194th Meeting of OCC held on 12.09.2022 As on 31.08.2022 mapping was 93% in SR. The state-wise details of mapping of feeders in SR at Annexure-B

5. Ensuring Proper Functioning of UFR relays and df/dt relays

RPCs	Status Updates from RPCs
NRPC	Utilities submit report of mock exercises for healthiness of UFRs on quarterly basis to NRPC Secretariat. The compliance is monitored in monthly OCC meetings. Further, NRPC has also conducted UFR inspection of 220 kV Park Street S/s of DTL on 10.08.2022.
ERPC	<ul style="list-style-type: none"> ➤ Certificate of healthiness of UFR relay is being submitted by respective STU/SLDC in given format in every month and the same is monitored in monthly OCC meeting of ERPC. ➤ UFR audit of 3 substations in Bihar was carried out in April-22. ➤ Further UFR audit of 7 no of substations in West Bengal would be carried out in November'2022
NERPC	8 Substations and 16 feeders for UFR inspection have been identified for inspection.

	<ul style="list-style-type: none"> ➤ The inspection/test would be completed by 31st December 2022. ➤ The details of sites identified for Periodic inspection of Under Frequency Relays (UFR) & df/dt Relays in North-Eastern Region at Annexure-C.
WRPC	In the 560th OCC States confirmed that they are ensuring healthiness of AUFLS and df/dt relays and detailed report will be submitted shortly.
SRPC	<ul style="list-style-type: none"> ➤ 12 Substations each for UFR & df/dt inspection have been identified for inspection. ➤ The inspection/test would be completed by 31st December 2022. ➤ The details of sites identified for Periodic inspection of Under Frequency Relays (UFR) & df/dt Relays in Southern Region at Annexure-C.

6. Issuance of REA

RPCs	Status Updates from RPCs
NRPC	REA Issued till 4 th day of the month.
ERPC	ERPC Secretariat issues REA on the same day or by next day of receiving the input data from ERLDC.
NERPC	NERPC Secretariat issues REA (Provisional) on 1 st or 2 nd working day of the month.
WRPC	REA Issued till 2 nd of the month.
SRPC	SRPC Secretariat issues REA (Provisional) on 1 st or 2 nd of the month.

7. Implementation of Automatic Generation Control (AGC)

RPCs	Status Updates from RPCs		
NRPC	Status received from NLDC is at Annexure -D		
ERPC	<table border="1"> <tr> <td> Implemented: <ul style="list-style-type: none"> ➤ Barh I & II ➤ Farakka I & II ➤ Farakka-III ➤ KhSTPP-II ➤ MPL ➤ MTPS-II ➤ NPGC ➤ Teesta-V </td><td> Under Implementation: <ul style="list-style-type: none"> ➤ Rangit ➤ DSTPP ➤ BRBCL ➤ TSTPP ➤ KhSTPP-I </td></tr> </table>	Implemented: <ul style="list-style-type: none"> ➤ Barh I & II ➤ Farakka I & II ➤ Farakka-III ➤ KhSTPP-II ➤ MPL ➤ MTPS-II ➤ NPGC ➤ Teesta-V 	Under Implementation: <ul style="list-style-type: none"> ➤ Rangit ➤ DSTPP ➤ BRBCL ➤ TSTPP ➤ KhSTPP-I
Implemented: <ul style="list-style-type: none"> ➤ Barh I & II ➤ Farakka I & II ➤ Farakka-III ➤ KhSTPP-II ➤ MPL ➤ MTPS-II ➤ NPGC ➤ Teesta-V 	Under Implementation: <ul style="list-style-type: none"> ➤ Rangit ➤ DSTPP ➤ BRBCL ➤ TSTPP ➤ KhSTPP-I 		
NERPC	Completed at BgTPP and Loktak HEP.		
WRPC	The recommendation of NPC regarding implementation of AGC was taken in 560 th OCC and Regular status of implementation of AGC would be taken up in upcoming OCC meetings.		
SRPC	The status of AGC in ISGS and Intra-state generators as discussed in 194th OCC. The details at Annexure-D		

8. Membership of RPC forum of RE

RPCs	Status Updates from RPCs
SRPC	<ul style="list-style-type: none"> ➤ The issue was discussed in the 42nd SRPC Meeting (04.06.2022) where following was recommended “Membership of two (02) RE generators with a threshold of 1000 MW (and above) installed capacity in the region on rotational basis. The participation of such generators would be limited to technical and operational issues”. ➤ The same was communicated to NPC vide letter dated 05.07.2022

Note- No input received from other RPCs.

Annexure -A**Details of NEA issued by NLDC in Southern Region**

Amount in (Rs Lakhs)

	Net All India Inter- Regional	DSM Surplus (+)/ Deficit (-)	RRAS Charges paid from DSM Pool a/c	RRAS Charges received in DSM Pool a/c	AGC Net Charges paid from DSM Pool a/c	Net Surplus (+)/ Deficit (-)
09.05.2022 to 15.05.2022	426	5,829.79	18,204.23	3,427.44	- 1,181.91	-7,765
16.05.2022 to 22.05.2022	636	12,430.06	27,586.94	3,333.75	- 1,138.37	- 10,685
23.05.2022 to 29.05.2022	805	8,250.00	5,505.00	2,956.00	-700.00	6,401
30.05.2022 to 05.06.2022	1156	14,250.00	11,284.00	514.00	- 1,482.00	- 4,962
06.06.2022 to 12.06.2022	1740	13,059.00	54,306.00	4,247.00	- 1,992.00	- 35,008
13.06.2022 to 19.06.2022	2250	13,517.00	38,759.00	3,807.00	- 1,141.00	- 20,294
20.06.2022 to 26.06.2022	-1019	12,927.00	6,042.00	3,011.00	-249.00	10,146

Annexure -B**Status of Mapping of Feeders under AUFLS in Northern Region**

State Name	Defense Scheme	Planned Relief	Main feeders Mapped (%)	Main feeders realtime availability (%)	Altrnate feeders Mapped (%)	Alternate feeders realtime availability (%)
UP	UFR	5250.3	89%	80%	98%	89%
	df/dt	2237.5	96%	83%	95%	89%
Rajasthan	UFR	1935	0%	0%	100%	62%
	df/dt	776	100%	93%	100%	68%
Punjab	UFR	1616	38%	37%	81%	73%
	df/dt	1410	53%	52%	95%	81%
Haryana	UFR	1243	85%	78%	99%	92%
	df/dt	900	86%	73%	98%	85%
Delhi	UFR	4603	73%	5%	0%	0%
	df/dt	809.36	84%	0%	0%	0%
HP	UFR	419.64	63%	27%	100%	51%
	df/dt	190	100%	100%	66%	33%

Status of Mapping of Feeders under AUFLS in Southern Region

State			AP	TS	KAR	KER	TN	PUD	SR
Recommended	MW	A	1582	1686	2328	826	2993	91	9506
Implemented	MW	B	1602	1826	2384	962	3121	91	9986
	%	B/A	101	108	102	116	104	100	105
Mapped Quantum as on 31 st August 2022	MW	C	1528	1581	2357	942	2765	82	9255
Mapped Quantum & wrt Implemented	%	C/B	95	87	99	98	89	90	93

Annexure -C

Sites identified for Periodic inspection of Under Frequency Relays (UFR) & df/dt Relays in North-Eastern Region.

SN	Name of State	Total Quantum of Load Shedding required (MW)	Location of UFR installed (Feeder's Name)	Stage	Load shedding required (MW)	Load in each feeder (MW)
1	Assam	360	132kV Samaguri-Khaloigaon Line at Samaguri	Stage -I (49.4 Hz)	90	50
2			132kV Sankardevnagar-Diphu Line at Sankardevnagar			20
3			132kV Mirza-Azara Line at Mirza			20
4			132kV Tinsukia-Ledo Line at Tinsukia	Stage - II (49.2 HZ)	90	30
5			132kV Tinsukia-Rupai Line at Tinsukia			40
6			132kV Panisokuwa-Bokakhat Line at Panisokuwa			20
7			132kV CTPS-Baghjap Line at CTPS	Stage - III (49.0 Hz)	90	35
8			132kV Nalkata-Dhemaji Line at Nalkata			35
9			132kV Garmur-Panisokuwa Line at Garmur			20
10			132kV Dhaligaon-Gossaigaon Line at Dhaligaon	Stage - IV (48.8 Hz)	90	28
11			132kV Dhaligaon-APM Line at Dhaligaon			50
12			132kV Bilasipara-Gauripur Line at Bilasipara			
						25
4	Manipur	20	AtYurembam (33 KV Yurembam - Mantripukhri)	Stage - I (49.4 Hz)	5	

			AtYaingangpokpi (33 KV Yaingangpokpi - Napetpalli)	Stage - II (49.20Hz)	5	
			At Kongba (33 KV Kongba - Mongsangei)	Stage - III (49.0Hz)	5	
			At Kakching (33 KV Kakching - Wangjing)	Stage - IV (48.8Hz)	5	

Sites identified for Periodic inspection status of Under Frequency Relays (UFR) & df/dt Relays in Southern Region.

AUFR & df/dt functionality testing 2022-23 in SR		
State / Utility	AUFR S/S	df/dt S/S
Andhra Pradesh/ APTRANSCO	220/132/33 kV Nuzuvid	220/132/33 kV Bhimadolu
	132/33 kV Kambhampadu	132/33 kV Bhimavaram
Karnataka/ KPTCL	220/66 kV Anthrasanahalli	220/66 kV Anthrasanahalli
	220/66 kV Anchipalya	220/66 kV Anchipalya
Kerala/ KSEBL	110kV Vennakkara	220 kV Nallalam
	110kV Kuthuparamba	110 kV Ottappalam
Tamil Nadu/ TANTRANSCO	230/110 kV Palladam	230/110 kV Palladam
	230/110 kV Pudansandai	230/110 kV Pudansandai
Telangana/ TSTRANSCO	132 kV Borapatla	132 kV Alair
	132 kV Janagon	220/132 kV Kosigi
Puducherry/ PED	110/22/11 kV Marapalam	110/22/11 kV Marapalam
	110/220 kV Eripakkam	110/220 kV Eripakkam

Status of Implementation of Automatic Generation Control (AGC) in Northern Region**Inter-State Level :**

S. No.	States	NLDC/SLDC	Participating Generators (MW)	Status of Implementation: Operational/Planned	Remarks, if any
1	Uttar Pradesh	NLDC	Dadri-2 (980 MW)	Operational	Migrated to new AGC software from Jun 2022
2	Uttarakhand	NLDC	Koteshwar (400 MW)	Operational	Added to new AGC software from Nov 2020
3	Himachal Pradesh	NLDC	Nathpa Jhakri (1500 MW)	Operational	Added to new AGC software from Feb 2021
4	Himachal Pradesh	NLDC	Chamera-3 (231 MW)	Operational	Added to new AGC software from Feb 2021
5	Jammu & Kashmir	NLDC	Dulhasti (390 MW)	Operational	Added to new AGC software from Feb 2021
6	Uttarakhand	NLDC	Tehri (1000MW)	Operational	Added to new AGC software from Mar 2021
7	Himachal Pradesh	NLDC	Chamera-II (300MW)	Operational	Added to new AGC software from Mar 2021
8	Rajasthan	NLDC	Anta Gas Power Project GF (419.33MW)	Operational	Added to new AGC software from Mar 2021
9	Uttarakhand	NLDC	Dhauliganga (280MW)	Operational	Added to new AGC software from Mar 2021
10	Uttar Pradesh	NLDC	Rihand TPS Stage – II (1000MW)	Operational	Added to new AGC software from Mar 2021
11	Uttar Pradesh	NLDC	Rihand TPS Stage – I (1000MW)	Operational	Added to new AGC software from Mar 2021
12	Uttar Pradesh	NLDC	Rihand TPS Stage – III (1000MW)	Operational	Added to new AGC software from Mar 2021

13	Himachal Pradesh	NLDC	Chamera-I (540MW)	Operational	Added to new AGC software from Mar 2021
14	Uttar Pradesh	NLDC	Unchahar TPS Stage – IV (500MW)	Operational	Added to new AGC software from June 2021
15	Uttar Pradesh	NLDC	Unchahar TPS Stage – III (210MW)	Operational	Added to new AGC software from June 2021
16	Uttar Pradesh	NLDC	Singrauli STPS (2000MW)	Operational	Added to new AGC software from Dec 2021
17	Himachal Pradesh	NLDC	Bairasiul (180MW)	Operational	Added to new AGC software from Sep 2021
18	Uttar Pradesh	NLDC	Unchahar TPS Stage – II (420MW)	Operational	Added to new AGC software from Nov 2021
19	Haryana	NLDC	Indra Gandhi STPS (1500MW)	Operational	Added to new AGC software from Dec 2021
20	Uttar Pradesh	NLDC	Auraiya Gas Power Project GF (663.36MW)	Operational	Added to new AGC software from Aug 2021
21	Uttar Pradesh	NLDC	Tanda TPS Stage – II (660MW)	Operational	Added to new AGC software from Sep 2021
22	Uttar Pradesh	NLDC	Dadri Gas Power Project GF (829.78MW)	Operational	Added to new AGC software from Jun 2022
23	Uttar Pradesh	NLDC	Unchahar TPS Stage – I (420MW)	Planned	Planned for Oct-Dec 2022
24	Uttar Pradesh	NLDC	Dadri TPS Stage – I (840MW)	Planned	Planned for Oct-Dec 2022
25	Jammu & Kashmir	NLDC	Uri Stage – I (480MW)	Planned	Planned for Jan-Mar 2023
26	Jammu & Kashmir	NLDC	Salal (690MW)	Planned	Planned for Jan-Mar 2023
27	Uttarakhand	NLDC	Tanakpur (94.2MW)	Planned	Planned for Jan-Mar 2023
28	Himachal Pradesh	NLDC	Pārbati III (520MW)	Planned	Planned for Jan-Mar 2023
29	Jammu & Kashmir	NLDC	Sewa-II (120MW)	Planned	Planned for Jan-Mar 2023
30	Jammu & Kashmir	NLDC	Uri Stage – II (240MW)	Planned	Planned for Jan-Mar 2023

31	Uttarakhand	NLDC	Koldam (800MW)	Planned	Planned for Jan-Mar 2023
32	Himachal Pradesh	NLDC	Pong (396MW)	Planned	Planned for Jan-Mar 2023
33	Himachal Pradesh	NLDC	Dehar (990MW)	Planned	Planned for Jan-Mar 2023
34	Himachal Pradesh	NLDC	Bhakra complex (1379MW)	Planned	Planned for Jan-Mar 2023

Status of Implementation of Automatic Generation Control (AGC) in Southern Region

Update in the 194th Meeting of OCC held on 12.09.2022 is as follows:

a) Central Sector implementation:

Entity	Generator	Status
NTPC	Simhadri STPS Stage-II (2 x 500MW)	Implemented on 18.11.2018. AGC is disabled in Unit IV due to high vibration issues.
	Ramagundam STPS Stage- II (4x500 MW)	Commissioned on 31.03.2021. Put under AGC.
	Simhadri STPS Stage- I (2x500 MW)	Commissioned, put under AGC.
	Ramagundam STPS Stage-I (3x200MW)	AGC implementation works would be taken after the maintenance/renovation works.
	Talcher STPS (4 x 500 MW)	Made operational on 26.07.2022.
NTECL	Vallur T PS (3x500MW)	AGC is in place from 14.06.2021.
	NTPL (2 x 500 MW)	In operation from 14.06.2021.
NLCIL	TPS II (7 x 210 MW)	NLC TS I Expn: Unit 1 Implemented on 19.06.2022 Unit II is under shut down. As and when opportunity comes AGC will be implemented. NNTPP/NLC TS II Expn: All the works are completed. In coordination with NLDC will be made operational.
	TPSI Expn (2 x 210 MW)	
	TPSII Expn (2 x 250 MW)	
	NNTPS (2 x 500 MW)	
NP-Kunta	Solar in AP AGC: 5 blocks of 50MW i.e. 5 x 50 = 250 MW	Works stopped due to some contractual issues.

b) AGC at state Level- Pilot Project identification & Implementation:

State	Generator	Status
Andhra Pradesh	Krishnapatnam(2x800 MW)	After finalization at Management level in coordination with generator M/s APPDCL and AP Discoms, the proposal will be submitted to the Hon'ble APERC.
	In addition to Krishnapatnam planning AGC at VTPS, Ry TPP, Upper Sileru & Lower Sileru APGENCO: The proposals which are submitted to Management are under consideration.	
Karnataka	Sharavathy Generating Station(1035MW) (Available MW for AGC is 10 % of liveload up to maximum of 100MW (10% of 1035 MW))	Implementation of AGC Pilot under USAID GTG Scheme completed. KPTCL&KPCL in coordination would put the units under AGC operation. Commercial implications are being examined.
	Varahi Under Ground Power House(4x115 MW) (Available MW for AGC is 20% of live load up to maximum of 80 MW as per the programme planned)	Go-live pilot completed (January 2021) KPTCL&KPCL in coordination would put the units under AGC operation..
Kerala	Kuttiady Unit No. 5(50MW)	State Regulator has been approached for putting AGC on regular basis. Permission is still awaited.
	Commission has been approached only for permission to put the units under AGC. Incentive part is not included.	
	Idukki Unit No.1(130MW)	AGC would be implemented once the Optical Fiber link from SLDC to Idukki PH is established. Expected the works completion by December 2022.
Tamil Nadu	North Chennai TPS Stage-II (two units i.e. 2x600 MW)	Tenders will be floated again since only one party had appeared.
	MTPS – II(1x600MW)	Technical bid opened and after clearing the clarification price bid would be opened and works would be awarded shortly.
Telangana	KTPS-VI(500MW) (132MW downward)	Put in to regular operation with existing SCADA. Performance is being observed. Further course of action will be taken accordingly.

Annexure-III

Overview of the status of Islanding Scheme in all Regions									
Regions	Number of Islanding Schemes			No. of Implemented/Inservice IS (Green Color)	No. of existing IS (Cat-A) which are Under Implementation/under review (Yellow Color)	No. of Newly proposed IS (Cat-B) which are under design/Under Implementaion stage (Yellow Color)	No. of Newly proposed IS (Cat-B) which are Implemented/Inservice (Red color)	No. of IS having SCADA visibility	Remarks
	Cat-A	Cat-B	Total						
SR	4	3	7	7	0	0	3	7	-
ER	7	2	9	4	3	2	0	5*	*1-under implementation IS KBUNL IS is discontinued.
NR	4	7	11	2	2	7	0	4*	*2-under implementationIS /IS in design stage
WR	7	5	12	6	1	5	0	6*	*All In service IS are made available at SLDC/WRLDC except Uran Islanding Scheme
NER	2	1	3	1	1	1	0	3*	*2-under implementationIS /IS in design stage
Total	24	18	42	20	7	15	3	25*	5-under implementationIS /IS in design stage

Category of Islanding Schemes:	
Category 'A' IS	Islanding Schemes which are existing or already planned and in implementation stage.
Category 'B' IS	Islanding Schemes which are newly proposed.
Category-'I' IS	Islanding Schemes which are designed for the major cities, sensitive generation or strategic loads.
Category-'II' IS	Islanding Schemes other than category I are Category II IS
Colour codes of Islanding Schemes:	
Green	Implemented/In service Islanding Scheme
Yellow	Under review/ Under Implementation Islanding Scheme
Red	Newly proposed Islanding Scheme which are under design/under implementation stage

<p style="text-align: center;">Central Electricity Authority National Power Committee Division</p> <p style="text-align: center;">Monthly MIS report - Islanding Scheme (IS) of Sothern Region (SR) Status updated on 17.10.2022</p>										
SN (Color Coding for Island Implementation)	Name of Islanding Scheme	Category A/B	Sub Category- (City/Major Town/ Strategic Load/Sensitive Generation)	Status (Category A -In-Service/ Under Review/ Reviewed & Under Implementation) (Category B-DPR Preparation/Study/ Design/ Approval/Procurement/Commissioning/Implementation)	Timeline for completion of Review/ Reviewed & Under Implementation for Category A Timeline for implementation for Category B (DPR Preparation/Study/ Design/ Approval/Procurement/Commissioning/Implementation)	Progress of the scheme during the last month	Healthiness of the Scheme	Timeline for SCADA Visibility in Sub SLDC/ SLDC/ RLDC	Remarks, if any (Major Change in the scheme may also be intimated)	Color Coding for SCADA Display Creation
	I	II	III	IV	V	VI	VII	VIII	IX	
Category I										
1	Hyderabad IS	A	City/Major Town/ Strategic Load	Reviewed scheme implemented w.e.f. 31.07.2021/ In service	Review completed on 05.03.2021. Reviewed scheme put into service w.e.f. 31.07.2021. In line with SOP, the scheme was last discussed in PCSC-101 held on 13.04.2022, and it was noted that in view of no change in boundary & LGB, the scheme in operation is found to be in order.	NA	Healthy	November, 2021/ Completed on 30.11.2021	—	
2	Chennai IS	A	City/Major Town/ Strategic Load	Reviewed scheme implemented	Review completed on 18.05.2021. Reviewed scheme put into service w.e.f. 31.05.2022. In line with SOP, the scheme was last discussed in PCSC-101 held on 13.04.2022, and it was noted that in view of no change in boundary & LGB, the scheme in operation is found to be in order.	NA	Healthy	November, 2021/ Completed on 28.02.2022	—	
3	Kudankulam IS	A	City/Major Town/ Strategic Load/ Sensitive Generation	Reviewed scheme implemented w.e.f. 31.12.2021/ In Service	Review completed on 18.08.2021. Reviewed scheme put into service w.e.f. 31.12.2021. In line with SOP, the scheme was last discussed in PCSC-101 held on 13.04.2022, and it was noted that in view of no change in boundary & LGB, the scheme in operation is found to be in order.	NA	Healthy	December, 2021/ Completed on 31.03.2022		
4	Bengaluru IS	B	City/Major Town/ Strategic Load	Implemented w.e.f. 31.05.2022/ In-Service	The Scheme was identified in December 2020. Design completed in July, 2021, and the scheme was put into service w.e.f. 31.05.2022.	NA	NA	December, 2021/ Completed on 31.05.2022	—	
Category II										
5	Neyveli IS	A	City/Major Town/ Strategic Load	Reviewed Scheme implemented w.e.f. 01.11.2021/ In-Service	Review completed on 04.06.2021; Reviewed scheme put into service w.e.f. 01.11.2021. In line with SOP, the scheme was last discussed in PCSC-101 held on 13.04.2022, and it was noted that in view of no change in boundary & LGB, the scheme in operation is found to be in order.	NA	Healthy	November, 2021/ Completed on 28.02.2022	—	
6	Visakhapatnam IS	B	City/Major Town/ Strategic Load	Implemented w.e.f. 31.07.2021/ In-Service	The Scheme was identified in Jan 2020, but owing to Covid-19 pandemic, the scheme was taken up for implementation in January, 2021. The scheme was put into service w.e.f. 31.07.2021.	NA	Healthy	Novemeber, 2021/ Completed on 30.11.2021	—	

7	Vijayawada IS	B	City/Major Town	Implemented w.e.f. 30.11.2021/ In-Service	<p>The Scheme was identified in April 2021. Design completed in July, 2021, and the scheme was put into service w.e.f. 30.11.2021.</p> <p>In line with SOP, the scheme was last discussed in PCSC-101 held on 13.04.2022, and it was noted that in view of no change in boundary & LGB, the scheme in operation is found to be in order.</p>	NA	Healthy	Novemeber, 2021/ Completed on 30.11.2021	—	
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<p style="text-align: center;">Central Electricity Authority National Power Committee Division MIS report - Islanding Scheme(IS) of Eastern Region (ER)</p>									
status as on 17.10.2022									
S.No. (Color code for Islanding Scheme)	Name of Islanding Scheme	Category A/B	Sub Category- (City/Major Town/ Strategic Load/Sensitive Generation)	Status (Category A -In-Service/ Under Review/ Reviewed & Under Implementation) (Category B-DPR Preparation/Study/ Design/ Approval/Procurement/Commissioning/Implementation)	Timeline for completion of Review/ Reviewed & Under Implementation for Category A Timeline for implementation for Category B (DPR Preparation/Study/ Design/ Approval/Procurement/Commissioning/Implementation)	Progress of the scheme	Healthiness of the scheme	Timeline for SCADA Visibility in Sub SLDC/ SLDC/ RLDC	Remarks, if any (Major Change in the scheme may also be intimated)
	I	II	III	IV	V	VI	VII	VIII	IX
Category I									
1	Kolkata (CESC) IS	A	City/Major Town/ Strategic Load	Implemented/ In-Service.	The scheme was last reviewed in February, 2021. No operational constraints have been reported.	NA	Healthy	Implemented on 13.11.2021	—
2	Patna IS	B	City/Major Town/ Strategic Load	Design Stage	Review of islanding study & designing of the logic: Completed Implementation of Islanding Scheme: By December' 2022	46th TCC opined that for detailed study by OEM, NTPC has to take initiatives & advised NTPC to take up the matter with OEM for carrying out detailed study of the proposed islanding scheme in a time bound manner. NTPC agreed to it. TCC advised Bihar to initiate the process of DPR preparation & advised all the concerned stakeholders to coordinate for providing relevant inputs for preparation of DPR. In 195th OCC Meeting, NTPC representative submitted that they would submit the detailed study report shortly.	NA	-	—
3	Ranchi IS	B	City/Major Town/ Strategic Load	Under Study	Feasibility study would again be done after the commissioning of PVUNL units.	Ranchi Islanding Scheme would be discussed after commissioning of PVUNL units.	NA	-	—
Category II									
4	Bakreswar TPS IS	A	Industrial and Railway load	Implemented/ In-Service.	The scheme was last reviewed in February, 2021. No operational constraints have been reported.	NA	—	Implemented in January, 2022	—
5	Haldia (Tata Power) IS	A	Industrial areas of Haldia and Port	Implemented/ In-Service.	The scheme was last reviewed in February, 2021. No operational constraints have been reported.	NA	—	Implemented in January, 2022	—
6	Howrah (Bandel) IS	A	Industrial load	Implemented/ In-Service.	The scheme was last reviewed in February, 2021. No operational constraints have been reported.	NA	—	Implemented in January, 2022	—
7	IB valley TPS IS	A	MCL Load	Under-implementation.	The scheme is under implementation and expected to be completed by Sept 2022	In the 193rd OCC meeting, OPTCL representative submitted that the installation, commissioning and testing of DTTC at both Budhipadar and OPGC end was completed. OPGC representative submitted that end to end signal testing and wiring from switchyard to relay panel had been completed. The testing would be carried out during the 2nd week of September 2022.	NA	Septemebr 2022	—
8	Farakka STPS, NTPC IS	A	Industrial & ECL Load	Under revision	—	—	NA	Implemented in December 2021	In 194th OCC Meeting, JUSNL representative submitted that requisition for sanctioning of funds from Govt. of Jharkhand is in process and is expected to be approved in the first week of September 2022.
9	Chandrapura IS of DVC System	A	Industrial load	Under revision	The scheme is under Review and scheme is expected to complete by September 2022.	In the 193rd OCC meeting, DVC representative submitted that the order had been placed to M/s Siemens on 14th July 2022. The expected timeline for completion of work is 9 months due to semi-conductor issues.	NA	September, 2022	Discussed in Special Meeting of ERPC held on 06.08.2021. Original scheme was with stage A of CTPS (3x120 MW). As stage A of CTPS has been retired, this scheme is being evolved considering the stage B of CTPS (2x250 MW).
10	KBUNL IS of Bihar	A	Industrial & Station Load	Discontinued	Scheme aborted	KBUNL Islanding scheme has been aborted as per the discussion of 188th OCC Meeting. Further, possibilities may be explored to study of Islanding scheme considering the Barauni units. The hardware procured for KBUNL Islanding scheme may be used for the same.	NA	-	—

Category of Islanding Schemes:	
Category 'A' IS	Islanding Schemes which are existing or already planned and in implementation stage.
Category 'B' IS	Islanding Schemes which are newly proposed.
Category-'I' IS	Islanding Schemes which are designed for the major cities, sensitive generation or strategic loads.
Category-'II' IS	Islanding Schemes other than category I are Category II IS
Colour codes of Islanding Schemes:	
Green	Implemented/In service Islanding Scheme
Yellow	Under review/ Under Implementation Islanding Scheme
Red	Newly proposed Islanding Scheme which are under design/under implementation stage

NA	Not Applicable
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<p style="text-align: center;">Central Electricity Authority National Power Committee Division MIS report - Islanding Scheme (IS) of Northern Region (NR)</p>									
status as on 17.10.2022									
S.No. (Color code for Islanding Scheme)	Name of Islanding Scheme	Category A/B	Sub Category- (City/Major Town/ Strategic Load/Sensitive Generation)	Status (Category A -In-Service/ Under Review/ Reviewed & Under Implementation) (Category B-DPR Preparation/Study/ Design/ Approval/Procurement/Commissioning/Im plementation)	Timeline for completion of Review/ Reviewed & Under Implementation for Category A Timeline for implementation for Category B (DPR Preparation/Study/ Design/ Approval/Procurement/Commissioning/Impl ementation)	Progress of the scheme	Healthiness of the scheme	Timeline for SCADA Visibility in Sub SLDC/ SLDC/ RLDC	Remarks, if any (Major Change in the scheme may also be intimated)
I	II	III	IV	V	VI	VII	VIII	IX	
Category I									
1	Delhi IS	A	City/Major Town/ Strategic Load	In service/ Under revision	Submission of timeline for completion of Review of Scheme is pending on part of Delhi SLDC.	—	Healthy	Visible in Delhi SLDC	—
2	NAPS IS	A	Sensitive Generation	Implemented/Inservice	The review of IS has been done with peak load of Summer and Winter 2019-20 and no operational constraints found.	NA	Healthy	Visible in UP SLDC	—
3	Lucknow (Unchahar) IS	A	City/Major Town	Under Design Stage	—	UP has submitted revised islanding scheme on 20.07.2022 which is under examination in consultation with NRLDC, UPSLDC and NTPC.	NA	Visible in UP SLDC	
4	RAPS IS	A	Sensitive Generation	Implemented/Inservice	Review of IS has been done in view of last Peak/off-peak loading and no operational constraints found.	Rajasthan SLDC has created SCADA display of Islanding scheme.	Healthy	Visible in Rajasthan SLDC	RRVPN has reviewed the Islanding Scheme and has suggested the consideration of additional transmission lines to manage load generation balance at different load scenario. Proposed scheme has been deliberated and approved in 56th NRPC meeting held on 29th July,2022.
5	Dehradun IS	B	City/Major Town/ Strategic Load	Planning / Design Stage	—	Matter is pending at Uttarakhand SLDC for finalization/rejection of scheme.	NA	Dec-22	
6	Agra IS	B	City/Major Town/ Strategic Load	Planning / Design Stage	—	UP has placed offer to CPRI for dynamic study in July, 2022. The estimated time of study is 5 months from date of acceptance.	NA	Dec-22	
7	Jodhpur-Barmer- Rajwest IS	B	City/Major Town/ Strategic Load	Planning / Design Stage	The Planning/design of the scheme is in progress.	Scheme/Study was approved in 195th OCC meeting held on 24.05.2022. The same was discussed in 56th NRPC meeting held on 29th July, 2022 and RVPN has been requested to submit revised proposal before OCC.	NA	Dec-22	
8	Nabha Power Rajpura IS	B	City/Major Town/ Strategic Load	Planning / Design Stage	Scheme design is being finalized and will be submitted to CPRI for study	Punjab has submitted islanding scheme on 12.07.2022 which has been examined. Punjab has been requested for clarification on few points. However, reply is awaited.	NA	Dec-22	—
9	Pathankot-RSD IS	B	City/Major Town/ Strategic Load	Planning / Design Stage	Scheme design is being finalized and will be submitted to CPRI for study	Punjab has submitted islanding scheme on 12.07.2022 which has been examined. Punjab has been requested for clarification on few points. However, reply is awaited.	NA	Dec-22	—
10	Suratgarh IS	B	Strategic Load	Planning / Design Stage	The Planning/design of the scheme is in progress.	Scheme/Study was approved in 195th OCC meeting held on 24.05.2022. The same was discussed in 56th NRPC meeting held on 29th July, 2022 and RVPN has been requested to submit revised proposal before OCC.	NA	Dec-22	
Category II									
11	Talwandi Sabo IS	B	City/Major Town	Planning / Design Stage	Scheme design is being finalized and will be submitted to CPRI for study	Punjab has sent the offer to CPRI for study of Islanding Schemes. CPRI has asked for PSSE file for dynamic study which is being coordinated with NRLDC. Timeline: 6 months for implementation after CPRI study.	NA	Jul-24	—

Category of Islanding Schemes:

Category 'A' IS	Islanding Schemes which are existing or already planned and in implementation stage.
Category 'B' IS	Islanding Schemes which are newly proposed.
Category-'I' IS	Islanding Schemes which are designed for the major cities, sensitive generation or strategic loads.
Category-'II' IS	Islanding Schemes other than category I are Category II IS
Colour codes of Islanding Schemes:	
Green	Implemented/In service Islanding Scheme
Yellow	Under review/ Under Implementation Islanding Scheme
Red	Newly proposed Islanding Scheme which are under design/under implementation stage

NA	Not Applicable
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**Central Electricity Authority
National Power Committee Division
MIS report - Islanding Scheme (IS) of Western Region (WR)**

status as on 17.10.2022									
S.No. (Color code for Islanding Scheme)	Name of Islanding Scheme	Category A/B	Sub Category- (City/Major Town/ Strategic Load/Sensitive Generation)	Status (Category A -In-Service/ Under Review/ Reviewed & Under Implementation) (Category B-DPR Preparation/Study/ Design/ Approval/Procurement/Commissioning/I mplementation)	Timeline for completion of Review/ Reviewed & Under Implementation for Category A Timeline for implementation for Category B (DPR Preparation/Study/ Design/ Approval/Procurement/Commissioning/Implement ation)	Progress of the scheme	Healthiness of the scheme	Timeline for SCADA Visibility in Sub SLDC/ SLDC/ RLDC	Remarks, if any (Major Change in the scheme may also be intimated)
	I	II	III	IV	V	VI	VII	VIII	IX
Category I									
1	Mumbai Islanding Scheme	A	City/ Strategic Load	Implemented/Inservice	Last reviewed on 04.04.2021 and no operational constraints found.	NA	Healthy	Visible	—
2	Uran Islanding Scheme	A	City/Major Town	Implemented/Inservice	Scheme last reviewed on 04.04.2021 and no modification required and no operational constraint found.	NA	Healthy	Oct 2022	—
3	Surat Islanding Scheme	A	City/Major Town	Implemented/Inservice	Scheme last reviewed on 04.04.2021 and no modification required and no operational constraint found.	NA	Healthy	Visible	The Scheme is healthy and visible on Gujarat SLDC and WRLDC SCADA (as informed telephonically). WRLDC recommendations about visibility are under consideration.
4	Ahmedabad City Islanding Scheme	A	City/Major Town/ Strategic Load	Implemented/Inservice	Scheme last reviewed on 04.04.2021 and no modification required and no operational constraint found.	NA	Healthy	Visible	The Scheme is healthy and visible on Gujarat SLDC and WRLDC SCADA (as informed telephonically). WRLDC recommendations about visibility are under consideration.
5	KAPS 1&2 Islanding Scheme.	A	Sensitive Generation	Implemented/Inservice	Scheme last reviewed on 04.04.2021 and no modification required and no operational constraint found.	NA	Healthy	Visible	The Scheme is healthy and visible on Gujarat SLDC and WRLDC SCADA (as informed telephonically). WRLDC recommendations about visibility are under consideration.
6	KAPS 3&4 Islanding Scheme.	A	Sensitive Generation	Under Implementation	Last reviewed on 04-07 June, 2021.	—	Healthy	Visible	The Scheme is healthy and visible on Gujarat SLDC and WRLDC SCADA (as informed telephonically). WRLDC recommendations about visibility are under consideration.
7	Nagpur Islanding Scheme	B	City/Major Town/ Strategic Load	Design/Engineering Stage.	Schematic design finalised on during discussion on 01.04.2021, 24.06.2021, 26.06.2021	DPR preparation completed.	NA	NA	—
8	Jamnagar Islanding Scheme	B	City/Major Town/ Strategic Load	Design/Engineering Stage.	Schematic design finalised on during discussion on 01.04.2021, 24.06.2021.	Detailed engineering is under progress.	NA	NA	—
9	Bhuj(Anjar-Kukma) Islanding Scheme.	B	City/Major Town/ Strategic Load	Design/Engineering Stage.	Schematic design finalised on during discussion on 01.04.2021, 24.06.2021.	Detailed engineering is under progress.	NA	NA	—
10	Jabalpur Islanding Scheme	B	City/Major Town/ Strategic Load	Design/Engineering Stage.	Schematic design finalised on during discussion on 01.04.2021, 24.06.2021.	DPR preparation completed.	NA	NA	—
11	Raipur Islanding Scheme	B	City/Major Town	Design/Engineering Stage.	Schematic design finalised on during discussion on 01.04.2021, 24.06.2021, 28.06.2021.	Detailed engineering is under progress.	NA	NA	—
Category II									
12	Vadodara/GIPCL Islanding Scheme.	A	Nandesari Industrial Load	Implemented/Inservice	Scheme last reviewed on 04.04.2021 and no modification required and no operational constraint found.	NA	Healthy	Visible	The Scheme is healthy and visible on Gujarat SLDC and WRLDC SCADA (as informed telephonically). WRLDC recommendations about visibility are under consideration.

Category of Islanding Schemes:	
Category 'A' IS	Islanding Schemes which are existing or already planned and in implementation stage.
Category 'B' IS	Islanding Schemes which are newly proposed.
Category-'I' IS	Islanding Schemes which are designed for the major cities, sensitive generation or strategic loads.
Category-'II' IS	Islanding Schemes other than category I are Category II IS
Colour codes of Islanding Schemes:	
Green	Implemented/In service Islanding Scheme
Yellow	Under review/ Under Implementation Islanding Scheme
Red	Newly proposed Islanding Scheme which are under design/under implementation stage

NA	Not Applicable
----	----------------

Central Electricity Authority
National Power Committee Division
MIS report - Islanding Scheme (IS) of North Eastern Region (NER)

status as on 17.10.2022									
S.No. (Color code for Islanding Scheme)	Name of Islanding Scheme	Catego ry A/B	Sub Category- (City/Major Town/ Strategic Load/Sensitive Generation)	Status (Category A -In-Service/ Under Review/ Reviewed & Under Implementation) (Category B-DPR Preparation/Study/ Design/ Approval/Procurement/Commissioning /Implementation)	Timeline for completion of Review/ Reviewed & Under Implementation for Category A Timeline for implementation for Category B (DPR Preparation/Study/ Design/ Approval/Procurement/Commissioning/Implementatio n)	Progress of the scheme	Healthines s of the scheme	Timeline for SCADA Visibility in Sub SLDC/ SLDC/ RLDC	Remarks, if any (Major Change in the scheme may also be intimated)
	I	II	III	IV	V	VI	VII	VIII	IX
Category I									
1	Tripura Islanding Scheme.	A	City/Major Town	Reviewed Scheme under implementation	The scheme was reviewed and revised on 29.09.2021. 7 out of 20 additional UFRs already installed. The balance UFRs would be installed by November, 2022.	—	—	Completed	—
2	Upper Assam (Assam-I) Islanding Scheme.	A	City/Major Town	Implemented/Inservice	The scheme was reviewed on 29.09.2021 and the Revised scheme implemented & recorded in 57th PCC Meeting held on 15th February, 2022.	Completed	Completed	Completed	—
3	Guwahati (Assam-II) Islanding Scheme	B	City/Major Town	Planning / Design Stage.	Design reviewed on 18.01.2022. Draft DPR already prepared, detailed DPR will be submitted after BoQ is finalized by Utilities and Budgetary offer is received from at least two vendors. The Scheme is scheduled to be implemented by December, 2022.	DPR sent to NLDC.	NA	Completed	—
Category II									
No Islanding Scheme under this Category									

Category of Islanding Schemes:

Category 'A' IS	Islanding Schemes which are existing or already planned and in implementation stage.
Category 'B' IS	Islanding Schemes which are newly proposed.
Category-'I' IS	Islanding Schemes which are designed for the major cities, sensitive generation or strategic loads.
Category-'II' IS	Islanding Schemes other than category I are Category II IS

Colour codes of Islanding Schemes:

Green	Implemented/In service Islanding Scheme
Yellow	Under review/ Under Implementation Islanding Scheme
Red	Newly proposed Islanding Scheme which are under design/under implementation stage

NA	Not Applicable
----	----------------

No. A-60016/24/2012-Adm-I
Government of India
Ministry of Power

New Delhi, Dated:

ORDER

Subject: Establishment of National Power Committee (NPC).

Keeping in view the ever growing complexity of Power System, synchronous mode of operation of the entire grid of the country and to evolve a common approach to issues related to reliability and security of the grid, it has been decided with the approval of the Competent Authority to establish National Power Committee (NPC). The composition of the Committee shall be as under:

1. Chairperson, CEA	Chairperson of NPC
2. Member (GO&D), CEA	Member
3. Chairperson of each of NRPC, WRPC, SRPC and ERPC	Member
4. Representative of Chairperson, NERPC	Member
5. TCC Chairperson of each RPC (NRPC, WRPC, SRPC, ERPC, NERPC)	Member
6. Member Secretary of each of NRPC, WRPC, SRPC, ERPC & NERPC	Member
7. ED, NLDC, POSOCO	Member
8. Chief Operating Officer, CTU	Member
9. Chief Engineer (NPC Div, CEA)	Member Secretary

2. NPC shall carry out following functions for integrated operation of the power system of the country:

- (i) To resolve issue among RPCs; and
- (ii) Discuss and resolve issues referred to NPC requiring consultation among one or more RPCs, concerning inter-alia inter-regional implication or any other issue affecting more than one region or all regions.

(iii) Preparation and issuance of National Energy Account (NEA) for inter-regional and inter-national energy transactions by NPC Secretariat.

P.T.O

DRAFT

3. Decision taken in the NPC shall be considered concurred by respective RPCs for implementation.
4. The Conduct of the Business Rule (CBR) for NPC providing for establishment of the secretariat of NPC, procedure for conduct of meetings of NPC, funding etc. is at Annex.

()
Deputy Secretary to Govt. of India
Tel No.

To:

1. Chairperson, CEA
2. Member (GO&D), CEA
3. Chairperson of NRPC/WRPC/SRPC/ERPC/NERPC
4. TCC Chairperson of each of NRPC/WRPC/SRPC/ERPC/NERPC
5. Member Secretary of NRPC/WRPC/SRPC/ERPC/NERPC
6. Chief Engineer (Grid Management Division), CEA
7. Chief Engineer (NPC Division), CEA
8. ED, NLDC, POSOCO
9. COO, CTU

Copy to

1. PS to MOS (P) (I/C)
2. PS to Secretary (Power)/ PPS to AS (DC)/ PSO to AS (AL)
3. All Joint Secretaries, Ministry of Power
4. All Directors/ Deputy Secretaries, Ministry of Power

()
Deputy Secretary to Govt. of India
Tel No.

**National Power Committee
Conduct of Business Rules**

CHAPTER I

GENERAL

1. Short title and commencement:

These rules shall come into force from the date of its formation i.e. 26-09-2011 and shall remain in force unless otherwise modified.

2. Definitions:

2.1 In these Rules unless the context otherwise requires: -

- (a) 'Agenda' means the list of business proposed to be transacted at a meeting of the Committee.
- (b) 'Committee' means the National Power Committee
- (c) 'Meeting' means a meeting of the Committee convened by Member Secretary after consultation with Chairperson, NPC.
- (d) 'Member' means the member of the NPC
- (e) 'Rule' means National Power Committee (Conduct of Business) Rules, 2011.

3. Composition of NPC:

- 1. Chairperson, CEA – Chairperson, NPC
- 2. Chairperson, NRPC
- 3. Chairperson, WRPC
- 4. Chairperson, SRPC
- 5. Chairperson, ERPC
- 6. Representative of Chairperson, NERPC
- 7. Chairperson, TCC of NRPC
- 8. Chairperson, TCC of WRPC
- 9. Chairperson, TCC of SRPC
- 10. Chairperson, TCC of ERPC
- 11. Chairperson, TCC of NERPC
- 12. Member (GO&D), CEA
- 13. Member Secretary, NRPC
- 14. Member Secretary, WRPC
- 15. Member Secretary, SRPC
- 16. Member Secretary, ERPC
- 17. Member Secretary, NERPC
- 18. ED, NLDC, POSOCO
- 19. Chief Operating Officer, CTU
- 20. Chief Engineer, NPC Div., CEA – Member Secretary, NPC

4. Functions of NPC

NPC shall carry out following functions for integrated operation of the power system of the country:

- (i) To resolve issue among RPCs
- (ii) Discuss and resolve issues referred to NPC requiring consultation among one or more RPCs, concerning inter-alia inter-regional implication or any other issue affecting more than one region or all regions
- (iii) Preparation and issuance of National Energy Account (NEA) for inter-regional and international energy transactions by NPC Secretariat.

Decisions taken in the NPC shall be considered concurred by the respective RPCs for implementation.

5. Secretariat of NPC

Secretariat of NPC will be provided by CEA and Chief Engineer (NPC Division), CEA will be Member Secretary. Secretariat shall perform the following duties namely:

- a) Keep custody of records of proceedings of the Committee meetings.
- b) Prepare agenda for the Committee meetings.
- c) Prepare minutes of Committee meetings.
- d) Take follow-up action on the decision taken in the Committee meetings.
- e) Collect from constituent members or other offices or any other party as may be directed by Committee, such information as may be considered useful for the efficient discharge of functions of the Committee and place the information before the Committee.
- f) Collection of data from NLDC on weekly basis (Interregional and International scheduled energy and actual energy data)
- g) Preparation of Weekly NDSM and Reactive Energy Account (if required)
- f) Preparation of monthly NEA

6. Sub-Committees of NPC

To deal with matters pertaining to the energy accounting and related issues there shall be a commercial sub-committee with the members drawn from representatives of each RPC Secretariat, RLDCs and NLDC. The commercial sub-committee shall be headed by the Chief Engineer (NPC Division), CEA. NPC can create other Sub-Committees to deal with matters pertaining to operation and protection issues on national basis.

CHAPTER II PROCEDURE FOR CONDUCTING NPC MEETINGS

7. Place and date of NPC Meeting

The place and date of the meeting shall be decided by Chairperson, NPC

8. Notice for the Committee Meetings and Agenda

- 8.1 Notice for the Committee meetings shall be issued by Member Secretary, NPC at least 25 days in advance in consultation with Chairperson, NPC. In case of emergency meetings required to be conducted to carry out urgent business, notice of one week is to be given.
- 8.2 The Agenda points for the meeting shall be sent to the Member Secretary by the members at least 20 days in advance of the meeting. The Member Secretary, NPC shall finalize the agenda and circulate the same to all its members at least 10 days in advance before the meeting.
- 8.3 Agenda for Committee meeting shall generally be put up after discussions in RPC.
- 8.4 Member Secretary, NPC may also put any agenda involving urgent matters/policy issue directly in consultation with Chairperson, NPC.
- 8.5 Member Secretary, NPC may convene a meeting at short notice on any urgent matter in consultation with Chairperson of the NPC.

9. Effect of Non-receipt of Notice of Meeting by a Member

The non-receipt of notice by any member of NPC shall not invalidate the proceeding of the meeting or any decision taken in the meeting.

10. Cancellation / Re-scheduling of Meeting

If a meeting is required to be cancelled or rescheduled the same shall be intimated to the members at the earliest by telephone / fax/ email.

11. Periodicity of Meetings

The Committee members shall meet at least once in six months. However, the Committee may meet any time to discuss any issue as and when required in consultation with Chairperson, NPC.

12. Quorum of NPC Meeting

- 11.1 The quorum of the meeting shall be 50% of its members.
- 11.2 NPC would take decisions based on majority/ general consensus of the strength present.
- 11.3 Members of NPC and NPC Secretariat shall participate in Committee Meetings. The Special invitees by the Committee may also attend the meeting.

13. Presiding Authority

- 13.1 The Chairperson, NPC shall preside over the meeting of NPC and conduct the meeting. The Member Secretary, NPC shall assist the Chairperson of NPC in conducting the meeting. If the Chairperson is unable to be present at the meeting for any reason, Member (GO&D) would preside over the meeting.
- 13.2 In the absence of Member Secretary, NPC, Director (NPC Div.), CEA shall function as Member Secretary to assist Chairperson, NPC.

14. Recording of the Minutes

The minutes of the meeting shall be finalized and circulated to all its members by the Member Secretary, NPC normally within 15 working days from the date of the Committee Meeting.

15. Confirmation of the Minutes

Minutes of the NPC meeting shall be placed in the next meeting for confirmation. However, in case of urgency the minutes may be confirmed by circulation.

16. Funding

Requirement of funds for hosting the meetings of NPC would be met through CEA's budgetary provisions. However, NPC may decide to create a fund for NPC in future for establishment expenses of its Secretariat.

**CHAPTER III
MISCELLANEOUS**

17. Savings of inherent Power of the NPC

17.1 Nothing in these Rules shall bar the NPC from adopting a procedure that is at variance with provisions of these Rules, if the NPC in view of the special circumstances of a matter or class of matters deem it necessary or expedient to deal with such a matter or class of matters.

17.2 Nothing in these Rules shall expressly or by implication, bar the NPC to deal with any matter or exercise any power for which no Rules have been framed and NPC may deal with such matters, and functions in a manner it thinks fit.

()
Deputy Secretary



भारतसरकार
Government of India
केंद्रीय विद्युत् प्राधिकरण
Central Electricity Authority
पश्चिम क्षेत्रीय विद्युत् समिति
Western Regional Power Committee
एफ-3, एमआईडीसी क्षेत्र, अंधेरी (पूर्व), मुंबई- 400 093
F-3, MIDC Area, Andheri (East), Mumbai -
400 093

Annexure-V

आईएसओ:
9001-2015
IS/ISO:9001-2015

दूरभाष/Phone: 022-28221681, 2820 0194, 95, 96
Website: www.wrpc.gov.in

फैक्स/Fax: 022-2837193
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संख्य पक्षविस/ वणि.-I/2022/

दिनांक: 14.10.2022

No.:WRPC/Comml-I/NPC/2022/ 10706

To,

The Member Secretary, NPC

Central Electricity Authority

New Delhi – 110066

विषय: "यूआरटीडीएसएम परियोजना के तहत पीएमयू स्थानों के समान दर्शन, नए विश्लेषण और नियंत्रण केंद्र के उन्नयन की आवश्यकताओं पर उप-समिति" की रिपोर्ट - के संबंध में।

Subject: Report of the "Sub-committee on the uniform philosophy of PMU locations, new analytics and requirements of up gradation of Control Centre under URTDSM project" - reg.

Ref: NPC Division letter no. 4/MTGS/NPC/CEA/2021/285-298 dated 20.09.2021

Please find enclosed herewith the final report of the sub-Committee on "The uniform philosophy of PMU locations, new analytics and requirements of up gradation of Control Centre under URTDSM project", constituted by NPC vide letter under reference.

Submitted for needful please.

भवदीय /Yours faithfully

Enclosed: As above.

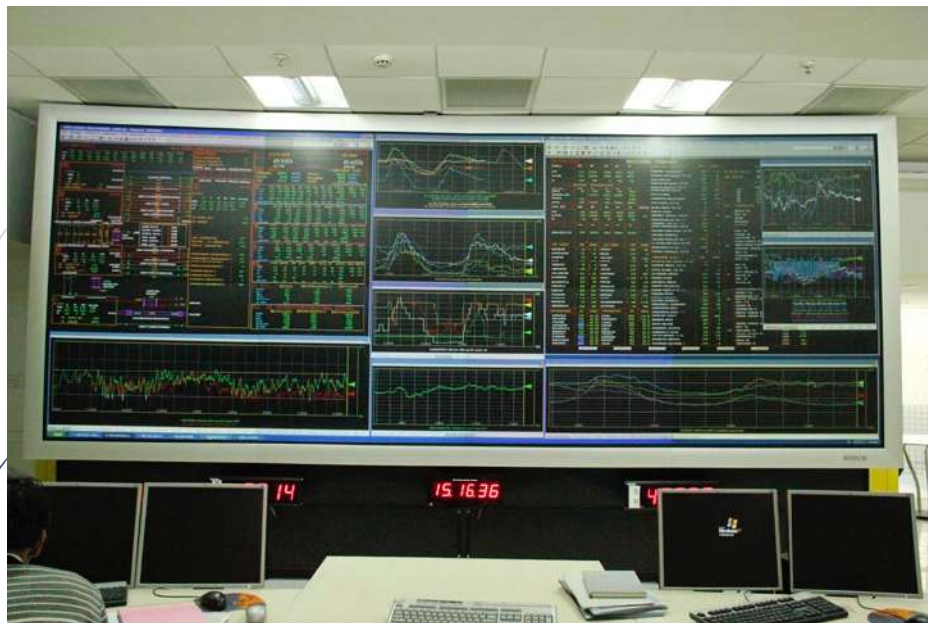
(P. D. Lone)

(सदस्य संयोजक/Member Convener)

Copy to: All members as per list.

October 2022

Report of the Sub-Committee on PMU Placement and Analytics under URTDSM Phase II.



National Power Committee
CEA

Acknowledgement

The Committee acknowledges the cooperation extended by RPCs, POSOCO, PGCIL and CTU for giving their valuable inputs to finalize the recommendations for the URTDSM Project Phase - II.

The Committee also acknowledges and extends gratitude to the sincere efforts of Shri Deepak Sharma EE WRPC and Shri Sachin Bhise EE WRPC, for their inputs and suggestions and putting all the inputs in proper perspective & giving shape to this report.

The committee would also like to thank Sh. Rahul Shukla, Chief Manager, NLDC and Sh. Aman Gautam, Manager, NLDC for the painstaking efforts taken to provide comments and help in the drafting of the report.

The committee puts on record the efforts of Dr Rajeev Gajbhiye, Sh. Prashant Navalkar and Sh. Gopal Gajjar from IIT Bombay who provided valuable inputs and feedback on the URTDSM Phase I and futuristic applications that can be developed.

The committee also acknowledges the efforts of M/s PRDC for arranging presentation of EPG USA and giving perspective of applications developed and used worldwide.



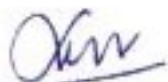
(Rishika Sharan)
Chief Engineer (NPC), CEA



(Nutan Mishra)
Sr. G. M., CTUIL



(P Suresh Babu)
S. E., TS SLDC



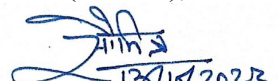
(Len J B)
E. E., SRPC



(P. D. Lone)
S. E., WRPC & Member
Convener

please refer Note-1
3/1/21

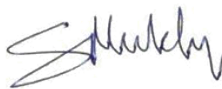
(Sunita Chohan)
CGM (GA&C), PGCIL


13/10/2022

(Saumitra Mazumdar)
Director (IT & CS), CEA


12/11/22

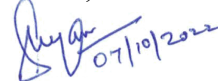
T. Sivakumar
S.E., TANTRANSO



(Srijit Mukherjee)
Deputy Director, NERPC



(Vivek Pandey)
G. M., NLDC


07/10/2022


(Shyam Kejriwal)
S. E., ERPC



(Abdullah Siddique)
Chief Manager, SRLDC



(Himanshu Lal)
Deputy Director, NPC



(Satyanarayan S.)
Member Secretary, WRPC &
Chairperson

Summary of the Report

- Initially a Pilot Project was implemented by POSOCO with 52 Phasor Measurement Units (PMUs) installed all over the Country progressively from 2008 to 2010. Based on the experience gained in Pilot Projects, a Feasibility Report was prepared for Nation-wide development of WAMS namely Unified Real Time Dynamic State Measurement (URTDSTM) Project. A Detailed Project Report (DPR) was prepared in 2012 for implementation of 1740 PMUs on Pan-India basis. The Project was agreed for implementation in a Joint Meeting of all the five Regional Standing Committees on Power System Planning held on 5th March 2012. Also, it was decided that the project of installation of the PMUs will be taken up in two stages.
- CERC granted in principle approval for the project in Sept'2013 with 70% funding from PSDF & 30% equity from POWERGRID. CERC granted in principle approval for the implementation of URTDSTM Phase-I and advised to take up Phase-2 after receiving feedback on Phase-I performance from POSOCO. POWERGRID took up the implementation of URTDSTM Project in Jan'2014 and 1409 PMUs are installed in Phase-I of the Project (the increase in quantity of PMUs was due to addition of new bays etc. at the substations). Nodal PDC at strategic substations, Master PDC at all SLDCs, super PDC at 5 RLDCs, Main & backup PDC at NLDC have been installed and are fully functional. PMUs are installed at only those 400 kV lines which had connectivity of the fibre optic network.
- Data of these PMUs is being utilized by power system operators as an analytical tool for better system operation in real time as well as for off-line analysis. Operators are also utilizing various facilities provided under the project which includes the GUI application supplied by GE and 6 analytics have been deployed by IIT-B.
- In the 10th NPC Meeting held on 9th April 2021 it was decided to form a sub-committee, *under the Chairmanship of Member Secretary, WRPC with representatives from POSOCO, CTU, POWERGRID, all RPCs/NPC. The Sub-Committee was entrusted to recommend uniform philosophy of PMU locations, new analytics and requirement of up gradation of Control Centre under URTDSTM project and submit its recommendations to the NPC.*
- The sub-committee held 3 meetings. The first meeting was held on 10.12.2021 and the second meeting was held on 31.05.2022. In both the meetings IIT Bombay gave presentation on the analytics developed in URTDSTM Phase-I, improvements in these analytics and futuristic analytics that can be undertaken under URTDSTM Phase-II.

- The EPG group presentation was arranged by PRDC in the second meeting held on 31.05.2022 and the EPG LLC, USA highlighted various application analytics which are deployed by power Utilities worldwide and are being used.
- The third meeting of the sub-committee was held on 14.09.2022 to discuss the finalised draft report of the sub-committee.
- PGCIL has expressed some reservations on the recommendations of the sub-committee. The same are attached at *Annexure – 9*.
- Based on the above discussions, the report has been broadly divided into 6 Sections
 - Section-1 briefly explains the background discussions that took place in various meeting for implementation of the PMU/WAMS project on pan India basis and the progress and hardware implementation of the Phase-I of the URTDSM project.
 - Section-2 briefly explains the OEM online and offline applications and its use.
 - Section-3 deals with the PMU placement criteria and status of Phase-I analytics.
 - Section-4 outlays various issues regarding hardware, application & analytics faced in the Phase-I of the URTDSM project and feedback of stakeholders.
 - Section-5 describes in brief discussions took place on requirement of PMUs that took place in regional levels, various new applications/analytics that can be taken up in Phase-II of the project.
 - Section-6, the recommendations of the sub-Group on improvement of Phase-I applications/analytics/hardware optimisation required to be taken up Phase-II, placement/requirement of PMUs in phase-II and new applications/analytics required to be implemented in Phase-II of the URTDSM project.

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1. Background of the URTDSM Project

1.1 Background

In the 10th NPC Meeting held on 9th April 2021 it was decided to form a sub-committee, the relevant extract of the minutes of the above meeting is reproduced below.

“After deliberations, NPC decided that a Sub-Committee would be formed under the Chairmanship of Member Secretary, WRPC with representatives from POSOCO, CTU, POWERGRID, all RPCs/NPC. The Sub-Committee shall discuss on the uniform philosophy of PMU locations, new analytics and requirement of up gradation of Control Centre under URTDSM project and submit its recommendations to the NPC.

Consequently, the sub-committee was formed vide NPC Letter NO. 4/MTGS/NPC/CEA/2021/285-298 dated 20.09.2021 (letter enclosed at *Annexure – I*) based on nominations received at NPC.

1.2 URTDSM Project Phase-I

- a) A Pilot Project was implemented with 52 Phasor Measurement Units (PMUs) installed all over the Country progressively from 2008 to 2010. Based on the experience gained in Pilot Projects, a Feasibility Report was prepared for Nation-wide development of WAMS namely Unified Real Time Dynamic State Measurement (URTDSM) Project. A Detailed Project Report (DPR) was prepared in 2012 for implementation of 1740 PMUs on Pan-India basis.
- b) The Project was agreed for implementation in a Joint Meeting of all the five Regional Standing Committees on Power System Planning held on 5th March 2012.
- c) Also, it was decided that the project of installation of the PMUs will be taken up in two stages.

Table 1: Proposed Stage- I

Region	Sub-stations		No of Transmission line		PMU		Nodal PDC	MPDC	SPDC	Main & B/U NLDC
	ISTS	STU	ISTS	STU	ISTS	STU				
NR	74	42	394	224	206	120	6	9	1	
WR	49	18	456	135	234	71	11	4	1	
ER	51	31	395	149	202	79	4	5	1	
SR	57	16	338	90	178	47	6	4	1	
NER	9	5	69	24	36	13	0	3	1	
Total	240	111	1652	622	856	330	27	25	5	
	351		2274		1186		57		2	

Stage-I: Installation of PMUs at the locations where Fibre Optic communication is available or would be made available under microwave frequency vacating program and regional strengthening program by 2014-15 along with installation of PDCs at all SLDCs, RLDCs, NLDC, NTAMC, strategic locations in State, remote consoles at RPCs, CEA, CTU and other locations.

Table 2 : Proposed Stage- II

Region	Sub-stations		No of Line		PMU	
	ISTS	STU	ISTS	STU	ISTS	STU
NR	9	55	40	211	21	111
WR	11	58	64	280	33	145
ER	-	13	-	50	-	26
SR	3	55	10	199	5	105
NER	9	17	26	45	14	23
Total	32	198	140	785	73	410
	230		925		483	

Stage-II: Installation of PMUs at balance locations along with communications links.

- d) The stage wise deployment of PMUs and PDCs is given as under
- The project was approved with the above tabulated infrastructure in stage – I & II.
 - Phase-I: 1186 PMUs at 351 substations (communication existing) - Rs. 278.89 Crs.

- iii. Phase-II: 554 PMUs at 301 substations (with installation of 11,000 Kms OPGW)
- Rs.377 Crs.
- iv. Phasor Data Concentrators with 6 Analytical Software at 32 Control centres considering requirement of both i.e., Phase-I & Phase-II.
- e) CERC granted in principle approval for the project in Sept'2013 with 70% funding from PSDF & 30% equity from POWERGRID. CERC granted in principle approval for the implementation of URTDSM Phase-I and advised to take up Phase-2 after receiving feedback on Phase-I performance from POSOCO.
- f) POWERGRID took up the implementation of URTDSM Project in Jan'2014 and 1409 PMUs are installed in Phase-I of the Project (the increase in quantity of PMUs was due to addition of new bays etc. at the substations). The list of PMUs installed is given at *Annexure – II*.
- g) In line with agreed philosophy in Joint Meeting of all the five Regional Standing Committees on Power System Planning, POWERGRID took up the requirement of URTDSM Phase – II in all Regional Power Committees. During the discussion on finalization of PMU quantity for URTDSM phase-II, requirement of additional measurements emerged. POSOCO also desired additional Analytical software using PMU data.

2. Applications under URTDSM Phase-I

2.1 PMU based real time monitoring applications:

PMU based visualization helps not only operators of affected control areas, but also in alerting neighbouring operators of a stressed grid. In the real time grid operation, PMUs data are being utilized for following purposes:

- a) Real time event and alarm processing: WAMS System provides spatio-temporal aggregation of the events, magnitude related violations in frequency, Positive Sequence Voltage Magnitude, Rate of Change Frequency (ROCOF) and Angular Difference. These are processed in real time at each second in batch processing to alert the operator.
- b) Visualization of frequency, Rate of change of frequency, Voltage, Power flows and Angle difference monitoring through trending at high resolution, helps in taking early actions by control room.
- c) Visualization of angular difference data, real-time angular separations, Real time monitoring and analysis, obtaining angular differences.
- d) Geographical network diagram provides information about the system through visual objects representing network elements, contours, rubber band zooming, panning, flyouts and pods through sub second resolution measurements and its variation in real time.
- e) Contour display allows overview of the voltage/frequency profile for the entire grid, Voltage Contour visualization, Voltage contour variation before and after generator trip allows real time monitoring of voltages across all the nodes. Frequency contour identifies the coherent group of generators during incidents of low frequency oscillations in the grid.
- f) Oscillatory Stability Management (OSM): Oscillation Stability Management (OSM) helps in monitoring the low frequency oscillations or small signal stability issues in the system, the oscillation frequency related information like, dominant mode frequency, energy and damping helps the operator in taking real time necessary actions by identifying root cause of oscillation. The OSM provides the information pertaining to negatively damped modes. OSM module extracts oscillatory stability parameters from small, random movements of the power system that are continuously occurring, mainly due to load changes in configured frequency, angle difference and active Power signals. Low frequency oscillations

and damping ratios are obtained using Auto Regressive Moving Average (ARMA) analysis of the measured signal. The dominant modes of oscillation are extracted, and key parameters identified – mode frequency, amplitude, and decay time. It also shows the mode shape (Right Eigen Vector) and mode chart for better Analysis of Oscillation in the system.

2.2 Off-line Applications/usages:

Some of the off-line usages are given as follows:

- a) Primary frequency Response assessment requires high resolution data of frequency for any event. The monitoring of pattern of frequency posts any incident involving load/generation imbalance helps in identifying the percentage of ideal response achieved in event.
- b) The oscillation detection, using UTRDSM system is used to provide necessary feedback to generators for taking corrective actions. The poorly damped oscillations indicate the review of controller settings in power system stabilizers of units.
- c) The high sampling rate of PMU data helps in validations of responses and fine tuning of various power system elements.
- d) The high-resolution data helps in validating the actions of system protection schemes and also parameter variations across the grid.
- e) The high-resolution data helps in monitoring the operation of various transmission line protection schemes which operate in sub-second time horizon with the lines having high fault clearing times can be reported to entity along with RPC for early resolution.
- f) Synchro phasor has helped to find the issues in time synchronization in event loggers, disturbance recorders details submitted by utilities also for checking of sequence of operation of the events etc.
- g) PMU also helped RLDCs in validating the Power system stabilizer tuning process with high sampled data. It has provided feedback in form of oscillation/power swing where PSS tuning is required to be carried out and based on these generators had been informed.
- h) PMU data was utilized in monitoring of power system during site testing of power transformers at National High Power Testing Laboratory (NHPTL) at Bina station.

The transient stability was monitored for the period of test shot. The PMU based data provided inputs on fault clearing time, faulty phases and short circuit MVA during tests.

- i) Post-Disturbance Analysis: It is required to assemble and study the signals from various PMUs that are dispersed throughout the grid for the analysis. The time-synchronized PMU data from different locations of grid, helps in understanding and reconstructing the event.

3. PMU Placement criteria & Analytics in Phase – I and its status

3.1 PMU locations under Phase – I

During the Joint Meeting of all the five Regional Standing Committees on Power System Planning held on 5th March 2012, following PMU placement philosophy was decided:

- a) All 400 kV stations in State and ISTS grids.
- b) All generating stations at 220 kV and above.
- c) HVDC terminals and inter-regional and inter-national tie lines.
- d) Both ends of all the transmission lines at 400kV and above: State and ISTS sector.

3.2 Status of Phase – I (Broad configuration of PMUs, PDCs and infrastructure used)

- a) The PMUs procured are having 2 set of voltage, 2 set of current measurement & some (16) digital input configuration.
- b) The utilization of measurement inputs of PMU depends on the bay configuration at substations. In cases where there is one line & ICT or reactor only, one set of current input is utilized, and other input remains unutilised.
- c) The PMUs are measuring line and bus voltages as per the configuration of installation. PMUs installed are of the Measurement class and wired up in the metering core of CVT/CT.
- d) Nodal PDC at strategic substations, Master PDC at all SLDCs, super PDC at 5 RLDCs, Main & backup PDC at NLDC have been installed and are fully functional.
- e) POSOCO's initial pilot project & States PMUs were also integrated with the URTDSM project.
- f) POSOCO has informed that the PMUs were installed at only those 400 kV lines which had connectivity of the fibre optic network.
- g) The List of PMUs installed in phase – I of the projects is attached at *Annexure – II*. A region wise map of the existing placement of PMUs (pictorial representation of PMUs installed is attached at *Annexure III*.
- h) The number of PMUs installed on 132kV lines is 5nos., 220kV lines is 179nos., 400kV Lines is 1093nos., 765kV lines is 148nos.

3.3 Present functionalities under URTDSM:

Data of these PMUs is being utilized by power system operators as an analytical tool for better system operation in real time as well as for off-line analysis. Operators are also utilizing various facilities provided under the project.

The PMU data can be used for real time monitoring of the system and taking decisions. Under para 3.4, below the potential of the WAMS project in real time system monitoring and taking decisions is highlighted.

3.4 Existing features of URTDSM

- a) Time Series Derivation Framework (TDF) TDF is the user interface of the Historian Application provided by OEM M/s GE and is being used in Control room to plot the events which occurred during last one year (at NLDC, six months at RLDCs level) to analyse details of events and its characterization. Data Storage limitations are constraints in storing historian data for longer duration.
- b) Spectral Analysis (using E-Tera Phasor Analytics) Spectral analysis of PMU data enables revealing which frequencies occur in system and how they change as a function of time. Spectral analysis provides an intuitive and visual way of representing changes in power system parameters at 8 different frequency and time instances. Mainly three types of spectral trends are provided in e-terra Phasor Analytics:
 - i. Power Spectral Density (PSD): Power Spectral Density (PSD) is very useful tool to identify oscillatory signals in time series data and their amplitude. It also tells at which frequency ranges variations are strong that might be quite useful for further analysis.
 - ii. Coherency: Coherency, is a measure of frequency domain correlation between two signals. Coherency is always greater than zero and less than one, if two signals are loosely correlated in the frequency domain, the coherency tends to be close to zero. If there is strong correlation, the coherency tends to be close to unity.
 - iii. Cross Spectral Density (CSD): Cross spectral Density as a measure of frequency domain covariance between two signals and is related to transfer function between two signals.

3.5 Analytics under Phase – I

- a) Under URTDSM phase I, following 6 Analytics were developed in association with IIT Bombay:
 - i. Line Parameter Estimation
 - ii. Vulnerability Analysis of Distance Relay (VADR)
 - iii. Linear State Estimator
 - iv. Supervised Zone-3 distance protection scheme to prevent unwanted tripping of backup distance relay
 - v. CT/CVT Calibration
 - vi. Control for improving system security
- b) Presently, first 6(six) Analytics have been deployed at control centres under URTDSM with regular updates being installed based on feedback received from constituents. Training for WR and SR constituents for all analytics has been completed.

3.6 Utilization of PMU data for taking real time decisions and offline Analysis at RLDCs and NLDC:

- a) PMU helped in synchronization of NEW-SR grid by helping control room operator in taking appropriate decisions in time through the access of high-resolution data in real time.
- b) The availability of PMU visualization helped in taking informed decisions in real time when any abnormality was observed in PMU placed on AC side of HVDC converter station
- c) The availability of PMU data at LV side of pooling station of RE based generation sources helped in monitoring the operation in real time. The various power electronic based controls in RE generation plant for low voltage ride through (LVRT), reactive support at pooling station and power park control are closely monitored using PMU data.
- d) The transmission system has also observed integration of state of art power electronic devices, these devices act in time span of milliseconds. The response can be observed at control centres with availability of PMU data. The response of FACTS devices is observed well with PMU placed at coupling transformer of STATCOM/SVC.

- e) Power-system restoration: The PMUs are well-suited for online monitoring of angles, and thus are helpful for the operator during a power restoration by monitoring of standing phase angle (SPA) difference across a breaker, which connects two adjacent stations whose excessive difference can damage equipment.

4. Feedback on applications/Analytics under Phase – I

4.1 Improvements required in the Existing PMUs data Streaming/GUI

Improvements in the various applications/functionalities available in present system, if carried out can enhance its utilization. List of such improvements are given below, which are purely based on operational experience of existing system:

a) Improvement required in the visualization /GUI

- i. Adding trends of phase voltage and current: It is only possible to plot trend of positive sequence voltage, frequency, df/dt , angle difference, MW and MVAR in real-time. It shall be possible to plot trend of phase voltages and currents also in real-time. Need to display phase voltage instead of positive sequence voltage. The phase voltages are required to identify the faulty phase and helps in real time in understanding the issue.
- ii. Capability to visualize data for larger time window: Real-time trend given to operator has the capability of plotting real-time values up to the interval of 15 minutes only at its native resolution (25 samples/sec). For the data beyond 15 10 minutes duration operator needs go to TDF application to fetch data and see the details. TDF application is not very user friendly which leads to inconvenience to Real-time operator. There should be a single user interface, through which user can visualize real-time as-well-as historical data as per their interest and interval/duration.
- iii. Trending system is having a capability to show only 8 signals and if additional signal is added in same trend window, then it results in freezing or display crash causing limited overview of the system.
- iv. PMU with high sampling rate required a few locations: General data storage/display rate of PMU is 25 samples/sec, so as per Nyquist criteria oscillation of 12.5Hz can be detected. However, the PSD display in Phasor Analytics detects modes up to 4Hz only. OSM should be able to captures oscillation up to 12.5 Hz. It is needed to extend the monitored frequencies, to also cover sub-synchronous resonance, very low frequency governor modes and control modes. Higher sampling rate is needed for these applications. In addition, PDC should have capabilities to store data of higher sample rate PMU apart from existing 25 Hz. Present system allow only storage of 25 Hz data only.

- v. Option to select reference angle: There should be an option to the selection of reference angle by the user (real-time as-well-as historical) and visualization of other data w.r.t same. Data stored in historian must be RAW data, so that visualization can be done as per the user requirement w.r.t any station. The angular difference values are in reference to a particular node and when the data is dumped in excel for analysing any past event, it is important that reference node is known. However in many cases it is not available so make it difficult to find the reference node.
- vi. Font and axis size: Formatting of PMU snapshots arrangements should be user friendly so that it could efficiently utilized for daily reporting control room shift. The auto-scaling and adequate font size need to be ensured in PMU
- vii. Portability of display: Visualization is an essential part for URTDSM system which requires better interface and flexibility for real time operation. This needs advanced development platforms for retrieval and visualisation of phasor data based on the requirement of the operator in real time. Portability of display to be used in different applications may be ensured for easy reporting
- viii. Non-generation of alarms: The real time applications sometimes fail to detect the oscillations. The Modes Applet and Analyst chart show normal state and Alarm/ Alert states are not observed even though Oscillations were present in the system. E-terra vision is having an issue of alarm processing as per user requirement, as and when alarm detects in a group of signals and returns to normal values in few sets of signals in group, then this alarm processing engine is clueless, what to report to operator.
- ix. Freezing of display: Visualization screen gets sluggish on certain occasion when trending feature and replay feature is heavily used by operators.
- x. Integration with different make of PMU: Interoperability of different PMU manufacturers has been a concern and is progressively taken up post commissioning through firmware upgrades etc. This interoperability aspect may be addressed.
- xi. Logic based analytical tools: Logic based analytical tools may be implemented for enhanced situational awareness. Further improvement in alarm-based features with the different mathematical and logical conditions can be carried out.
- xii. Modal analysis issues in URTDSM Analytics:

- Baselineing of modes from OSM engine is a separate engineering activity and is must to set limits for mode amplitude, damping and selecting mode bands for alerting operators. However, this activity was not part of the current system.
- High noise in PMU: It has been observed that higher order frequency (near to 4 Hz) shows low damping and lower order frequency (near 0.1 Hz) shows high damping. High Noise in some of the PMU's data is another issue and the same has been flagged to GE also. The severity of noise in data is quite high in some cases. Such noisy data will result in bad Analytics and poor performance and utilization and confidence in the system. Some automated tool to be developed for such type of error detection.

b) OSM related issues:

- Right Eigen Vector plot of modes not observed though it is seen that during that time Inter, Intra, Local and Intra Plant modes were present in the system as reported by existing pilot PMUs. Move upwards in oscillation section.
- Availability of statistical functions like a) Mean b) Median c) Standard Deviation d) Maximum e) Minimum and f) Average Values against each of the available parameters in PMUs. Also, the user should be able to generate Box & Whisker plots against each of the available parameters in PMU.

c) System Utilisation related issues

- Data storage is currently configured to store 1 YEAR data irrespective of the space utilization – Storage only utilized up to ~20% only. Needs review for utilization up to 70% irrespective of time.
- 16 Digital slots are currently available in each PMU where only 5 are used rest can be utilized for isolator points of line, BUS, and line reactors etc., helps to improve LSE RESULTS.
- Each PMU can monitor 2 elements, spare slot available can be used to integrate new lines / ICT from same substation (Non- SAS SUBSTATIONS)

d) Infrastructure related issues

- Voltage discrepancy in voltage measurement is observed in some PMU's, it's almost 5 to 10 kV difference in consecutive phases due to that positive sequence voltage is not accurate to take the decision by operator in real time. Some 12 logic/tool must be developed to detect such measurement errors and

generate alarms as well. Utilities need to be sensitized for managing issues related to measurement devices.

- ii. Standby communication links have not been implemented in URTDSM project. In case of any issue with communication channel, data loss has been observed on several occasions. Considering the importance of PMUs data in real time grid operation and post facto grid event analysis, it is recommended to implement main and standby philosophy in data communication between PMU & PDC and between PDC & PDC to avoid any data loss.
- iii. Frequent time synchronization issues arise in PMU's data due to the GPS issue. In few Stations GPS time synchronization source was shared among the PMUs with some intermediate converters/extenders, which use to have record of going faulty, so there is need for strengthening of GPS source and stringent daily monitoring by substation on daily basis.
- iv. Loss of PPS (Pulse per second) is a common cause in case of URTDSM PMUs, mainly due to the disturbance of PPS cable during maintenance activities. Infra issue
- v. Dead band defined in PMU data for frequency, voltage and df/dt , it sometimes led to discrepancy in values.

e) Historian

Access to historian data through autonomous software interface is a must requirement for any new WAMS infrastructure. An important API requirement is to get a snapshot of complete PMU measurements at a given timestamp. This is not supported by the present URTDSM historian. In Phase-II, it should be ensured that this kind of feature is available in new historian. The interface should follow well established industry open standards that support both Windows and Linux operating systems to avoid any shortcomings in applications due to lack of inter-connectivity between applications of different vendors.

4.2 Analytical Application Software's developed by IIT Bombay

IIT Bombay (IITB) and POWERGRID have initiated a joint project "Synchro phasors Analytics for Electrical Transmission Systems". Under the project, development of following six analytics by IITB was envisaged. All six analytics have been installed at control centres under URTDSM with regular updates being installed based on feedback

received from constituents. Further, Linear State Estimator (LSE) and Line Parameter Estimation are installed but the performance is not satisfactory. The summary and limitations of the envisaged/installed applications is given below:

- a) Line Parameter Estimation Application of total least squares (TLS) method is used to estimate line parameters moving window technique to use voltage, current, active, and reactive power measurements from PMUs and other measuring devices to estimate the positive sequence parameters of an equivalent π model.
- b) Online vulnerability analysis PMU measurements can be used to identify relays that are vulnerable to insecure tripping. In this application, each PMU on Transmission line measurements shall create a virtual relay mimic and relays are termed as vulnerable relays if the margin between their operating characteristics and the distance protection zone boundary is very low, a vulnerability index is presented where the vulnerable relays are ranked based on their risk. The errors get introduced when input relay settings are not validated.

Comment : The Zone-3 power swing blocking setting is available in all the relays and has been reported as implemented by all the utilities as per recommendation of the Committee on the blackout of 2012. Further, the Load encroachment tripping in Zone-3 can be addressed through proper setting of Zone-3 in the relay, which has also been reported to be complied by all the Utilities as per the recommendation of the Committee on the blackout of 2012. This application does not have relevance if metering cores are used.

- c) Linear State Estimation PMU has the capability to directly measure the magnitude and angle of bus voltage and current. If enough voltage and current phasors are measured to make the network observable, state estimation could become linear. The measurements are voltage phasor and current phasor, and states are voltage phasor. A state estimator, essentially, removes the errors from the measurements and converts them into states. The control centre can make use of it, to make decisions on system economy, quality, and security. So far, the application is working with some errors and further testing is under progress to identify the bugs.

Comments:

Linear State Estimator Application is not having sub second measurements from ICTs, GTs, bus couplers and bus sectionalizers, due to which most of the time LSE is creating many electrical islands, and the voltage estimates at each bus are not matching the

measurements from the same bus. Due to deviation in estimates and less user-friendly application, acceptability in real time operation is very low.

The network database is not updated constantly and the state estimation with incomplete data becomes difficult. Data base should be taken from existing EMS system. Sub seconds measurements need to be taken.

IIT-B: The issues are focused particularly on LSE, but the changes suggested will also help in improving the results of other analytics like Line Parameter Estimation and instrument transformer calibration (LPE-RMC) and vulnerability assessment of distance relays (VADR). Feedback provided by IIT Bombay based on the WRLDC WAMS Project is as follows.

- i. The network editor is used to enter static power system data that is used in LSE. The existing database was found to have missing / wrong data. kV lines. Lines have wrong values for R & X Values of 400 kV as well.
- ii. PMU Mapping Errors: Some PMUS has both voltage and current channels mapped wrongly. One current channel is mapped to line voltage
- iii. Wrong Polarity in PMU data There are lines where it is suspected that either one end PMU polarity is wrong or there is some other more serious gross error. These errors can be verified by comparing the P and Q measurements of these PMU measurements with corresponding SCADA measurements. Here it must be noted that we can identify such errors only in the transmission lines that have PMUs connected to both ends.
- iv. Apart from these, there are following lines that give unrealistic results when state estimation is performed using their measurements. The error could be in entering their transmission line data, or their PMU measurements or even the PMU channel mapping. Transmission lines that can be checked in this way, some have wrong polarity and other have some other serious measurement issue that make overall state estimation results poor.
- v. Some of the lines are parallel lines originating and terminating to the same substations. Hence it is possible that topology or transmission line data of such lines may be wrong. Many of these lines could have been tapped at some place, resulting in LILO but the database has not been modified. Hence special care must be taken on such lines to verify their data.
- vi. Reduced observability: As a result of elimination of all the bad current measurements, many substations that have PMUs installed, all current

measurements associated with that substation cannot be used. The bad measurement has a significant impact on degrading the LSE observability.

- vii. *Almost 50 percent of the PMU data comes under list of bad data. This is a very high proposition for any state estimation analytics. Hence it is suggested that each of the suspected measurements is systematically checked and eliminated in step-by-step manner. It is possible that many of the above-mentioned measurements are in fact correct, but the nature of LSE analytics which impact neighbouring measurements also, make them suspect. So, after clearing some of the obvious bad data that could be identified, the same exercise as this one must be repeated to see if some of the measurements that were identified as bad data get reclassified as valid. The errors identified in database and PMU channel mapping must be eliminated first.*

Expanded observability concept : It is required to estimate the state of the buses where PMUs have not been installed through one or more PMUs installed at remote ends of the substation. This will avoid islands formation in the system due to measurements not available at those locations. The voltage and angle measured through the PMUs at remote locations (one or more locations) can be used to estimate the voltage and angles of these buses, if the line parameters are known. This feature should be developed and deployed in the LSE enhancement.

- d) CT/CVT Calibration It is difficult to ascertain accuracy of any instrument transformer at site, once it is installed. State estimation techniques can perform “soft calibration” of these instruments to reduce errors in state estimation and identify any gross error if present in instrument transformer.

Comments: The performance of this analytic is required to be ascertained with actual on-site testing of CT/CVTs.

- e) Supervised Zone-3 Distance Protection:

Distance relays are widely used for transmission line protection. These relays also provide remote backup protection for transmission lines. However, there are a few issues with backup protection as provided by distance relays

- Zone-3 based remote backup protection schemes are dependable but not secure.
- A relay mal-operation can act as a catalyst or even trigger a system collapse situation.

- Incorrect Zone 3 relay operation may be a consequence of either
 - quasi-stationary events like load encroachment, overload, undervoltage etc., or
 - electromechanical oscillations like power swings.

To overcome the problems mentioned above, an adaptive remote backup protection scheme using output of the linear least square state estimator was envisaged under analytics of phase I.

At present metering core of CT, CVT is used as inputs to the PMUs. In the event of faults, the metering class CTs generally get saturated, therefore the measurements obtained from these CTs are erroneous. Since these inputs are provided to the PMUs, any application using the transient data during the un-cleared fault period may not give desired results. The results of these analytic needs to be corroborated with the DRs obtained from the field. If protection class CT cores would have been wired up to the PMUs, this analytic would have provided reliable results. The comments at b) above are valid for this analytic also.

- f) Control Schemes for Improving System Security: This analytic has been installed.

4.3 Issues in Phase – I analytics and observations:

The problems faced in the analytics have been detailed above. Analytics at 4.2 Sr. No. 1), 2), 4) & 5) needs further investigation and decision as to whether continue the development. If the results of these analytics are found to be consistent with the observations made through the DR analysis and PMU data of the local PMUs installed near the disturbance points of a sufficient number of disturbances, then these analytics could be put to use. Analytics at 4.2 Sr, No. 1) Line Parameter Estimation & 4) CT/CVT CALIBRATION are least useful from system point of view and therefore it is recommended that wherever opportunity exists, these analytics can be used for estimation of line parameters and CT/CVT calibrations. Additional PMUs required exclusively for these two analytics are not required to be included for future scope. Similarly, analytic at Sr.No. 2) Online vulnerability Analysis and analytic at Sr. No. 5) Supervised Zone-3 Distance Protection are of protection class analytics, however the PMUs and CT/CVTs used are of metering class and therefore these analytics are prone to give erroneous results as described above. Hence additional PMUs required exclusively for these two analytics are not required to be included for future scope and

the facility developed so far can be used, wherever possible. LSE, which is partly functioning, needs to be developed further, so that the same can be put to use and other deliverable analytics could further be taken up. For this, following needs to be taken care in the phase II.

4.4 Improvements needed to address above issues:

- a) PMUs should not only be limited to post event analysis and should be employed for state of analytics such as Dynamic State Estimation, threats forecasting and alarming systems in real time, if possible, control systems for real time control of active/reactive power etc.
- b) Several equipment's such as ICTs, Bus Couplers were not configured in the LSE. Also, PMUs were not provided on ICTs, Bus reactors, Switchable line reactors and some important substations where Fibre Optic connectivity is not available. Lack of observability & lack of communication link also led to problems in PMUs LSE.
- c) Logic based analytical tools for enhanced situational awareness, Advance development platforms for retrieval and visualization of phasor data, etc. may be added in the existing system, so that system operators' visualization can be enhanced to take appropriate decisions.
- d) POSOCO informed that the POSOCO pilot project & States PMUs were also integrated with the URTDSM project. However, the data was not complete, and it led to formation of Islands and therefore State estimation of complete system is not available with the existing installed PMUs. There are network modifications happening and the data was not regularly updated/made available in the system since the same is required to be updated in SCADA network database & PMU LSE database. The network and the network topology database need to be updated by putting extra effort and therefore the network database of PMU based LSE can be exactly aligned with the actual system
- e) Additional PMUs should be installed at substations which are critical from system point of view, by laying of the Fibre Optic under Phase – II of the URTDSM project.
- f) An engine can be developed which will enable the SCADA topology and network database to be imported in the PMU based LSE. The database should be common for both the systems (SCADA & PMU LSE).

5. Phase – II of URTDSM

5.1 PMU Placement Criteria

Inputs and views of POSOCO, IIT-B, RPCs and recommendations in various meetings on placement of PMUs under phase-II, are briefly outlined below.

- a) **CTU**: During the Standing Committee on Communication System Planning in Power Sector (SCCSPPS) held on 09.03.2021, **CTU** in its agenda item suggested that the above criteria need to be reviewed in respect of NER & Sikkim as most of the transmission lines in NER & Sikkim are at 132kV/ 220 kV level. The **CTU** proposed that following locations may also be included for PMU placement:

- i. All 132 kV and above ISTS lines in NER & Sikkim
- ii. All 132 kV and above ISGS in NER & Sikkim.
- iii. (Additional factor of “distance between such stations” for extent of Wide Area Measurement also to be accounted for Placement in NER.)

Tentative additional quantity of PMUs required in NER - 120 nos. and in Sikkim- 22 nos. Details of links for PMU placements in NER & Sikkim are attached at *Annexure IV* and *Annexure V* respectively. This requirement of PMUs in NER and Sikkim may be included in the upcoming URTDSM Phase-II project.

Matter was discussed with IIT Mumbai & POWERGRID and it being mentioned that NERLDC may validate the list enclosed as Annexure IV & V for NER Lines/ Links w.r.t. the significance of Transmission Lines for NER network in view of expected Voltage Upgrade of Lines/ Generating Station Connectivity, Ownership / Tie Lines/ etc.

- b) **NRPC**: NRPC (in 45th TCC, 48th NRPC meeting) and SRPC (in TCC & 37th SRPC meeting) proposed following additional PMU locations beyond the already agreed philosophy in standing committee:
- i. Generating Transformers (GTs) at LV side (having HV side of 220kV and above).
 - ii. FACTS devices such as STATCOM, SVC, FSC, TCSC etc.
 - iii. HVDC Converter transformers
 - iv. Phase Shifting Transformers
 - v. Renewable Energy Pooling Stations (PS).
- c) **POSOCO**: POSOCO in its feedback report on the URTDSM Project dated March 2021 has suggested following:

- i. Placement at all Inter-regional lines.
- ii. HVDC & FACTS Devices - At both ends of Interconnecting lines between HVDC side AC switchyard with connecting AC Sub Station, all convertor Transformer (HV Side), at STATCOM/SVC/ station Coupling Transformer (LV&HV Side) including STATCOM/SVC.
- iii. Renewable Energy Generation Pooling Points.
- iv. On all outgoing feeders including bus sectionalize or tie line between two stages of generating stations having different tariffs or different ownership or both
 - High Voltage (HV) side & Low Voltage side of Transformers
 - Reactive Power sources & Sinks shall be measured through Synchro phasor
 - All CB and isolators shall be wired to Synchro phasor device as digital signals
- v. Islanding, Separating & Restoration Points- At both ends of line connected black start stations or 28 restoration path lines (both ends including CB and isolators).
- vi. Points where State Estimation error chances are high
 - Substation shall have Three phase Bus voltage measurements through PMUs & Circuit breakers and isolator position shall be wired to PMU (for Linear State Estimator) for topology processing and full observability
 - Reactive Power sources & Sinks shall be measured through Synchro phasor to avoid MVAR mismatch in Linear State Estimation.
 - All 765/400 kV, 400/220 kV Interconnecting Transformers (ICT) should have PMU on both sides (LV & HV).
- vii. Power Flow Gates – High power corridors need to have PMU Placements.
- viii. Major Load Centres - PMUs should be installed at appropriate radial load feeding substations so that the load sensitivities to system frequency and voltage changes can be monitored.
- ix. Angular Difference Monitoring Locations.
- x. Major Generating Stations-
 - At 400 kV and above Generating stations (132 kV in case of NER).
 - Individual Unit of rating 200MW and above for Coal/lignite, 50MW and above for gas turbine and 25 MW and above for Hydro units shall have

PMU placed at the terminals of the generator(s) at either the HV or LV side of the Generator Transformers.

- In case of plant having multiple units, PMU can be placed on 50 percent of the units
- xi. System Protection Scheme Monitoring
- xii. Experience based locations known for small signal stability related issues.

The details of above are given at *Annexure – VI*.

d) **POWERGRID:** POWERGRID informed that the impact of additional PMUs locations and WAMS analytics, as proposed above, will be as follows:

- i. The number of PMUs initially envisaged in Phase II would increase to about 2500.
- ii. This increase in number of PMUs will also affect the performance of Phasor Data Concentrator (PDC) and other equipment at the Control Centre Location at SLDC, RLDC and NLDC, RPCs which may also need upgradation / installation.
- iii. The additional WAMS analytics shall also require additional hardware.
- iv. In view of the increase in PMU population, the existing configuration of Nodal PDC, MPDC, SPDC & Main & B/U NLDC also needs to be seen whether these additional PMUs can be accommodated in the infrastructure of Phase-I. Also, it needs to be seen whether the Nodal PDC, MPDC, SPDC & Main & B/U requires up-gradation or additional hardware is required for accommodating the additional PMUs in Phase-II.
- v. Communication related issues are also required to be considered to accommodate the additional PMUs under Phase-II.

e) **Observations:** The number of PMUs initially envisaged in Phase II would increase, if the above philosophy is taken into consideration. This increase in number of PMUs will also affect the performance of Phasor Data Concentrator (PDC) and other equipment such as Historian etc. at the Control Centre Location at SLDC, RLDC and NLDC, RPCs/NPC which may also need up gradation / installation. The additional WAMS analytics shall also require additional hardware.

5.2 New Analytics under URTDSM Project Phase - II.

The proposed analytics under Phase-II of URTDSM is outlined below.

- a) **NRPC & SRPC**: Additional WAMS analytics for URTDSM Phase – II were proposed by NRPC (in 45th TCC, 48th NRPC meeting) and SRPC (in TCC & 37th SRPC meeting) as follows:
- i. Real time Automated Event Analysis tool
 - ii. Oscillation Source location tool/engine.
 - iii. Real time Inertia Estimation Tool
 - iv. big data analytics tool/engine
- b) **POWERGRID**: POWERGRID has suggested following analytics for the Phase – II:
- i. Real time Automated Event Analysis tool (using AI, Machine learning and big data)
 - ii. Event monitoring for early warning system (using AI, Machine learning and big data)
 - iii. *WAMS based contingency analysis and static security assessment*
 - iv. Oscillation Source location
 - v. Response of Windfarm and solar PV farms for LVRT, reactive power etc.
 - vi. Control of HVDC and STATCOM for damping system oscillations

The details are given in Annexure – VII.

- c) **POSOCO**: POSOCO in its feedback report on the URTDSM Project dated March 2021 has suggested following analytics based on analytics being used in foreign power grids:
- i. Voltage Stability Monitoring: Measurement based dynamics provide voltage sensitivities; monitoring of key corridors or load pockets; scatter plots for power voltage and power-angle monitoring.
 - ii. Detection of disturbances: Recognition of short circuits by watching the currents, and indication of loss of load, or loss of generation by watching the frequencies.
 - iii. Online monitoring of Inertia.
 - iv. Identification of source of Oscillation.
 - v. Identification of stressed corridors.
 - vi. ROCOF calculation over variable window.
 - vii. Island identification/detection.
 - viii. Locating contributions to poorly damped or unstable oscillations.
 - ix. Model Validation.

- x. Higher frequency sub-synchronous oscillation analysis and early warning of resonance.
- xi. Big Data Analytics

The details are given in *Annexure – VIII*.

6. Recommendations

The recommendations of the sub-group have been grouped under following categories:

- 6.1 Improvements in applications available in URTDSM-I
- 6.2 New applications for deployment in URTDSM-II.
- 6.3 Improvements in system infrastructure
- 6.4 Minimum criteria for PMU placement under URTDSM-II.

6.1 Following improvements are recommended in applications available in URTDSM-I:

a) Graphical User Interface for visualization of system dynamics

URTDSM Phase-I has a graphical user interface for visualization of power system dynamic parameters. Following improvements are recommended in PMUs data Streaming/GUI in future applications:

- i. **Trending of phase voltage and current:** Based on the selection made by the operator in real time it shall be possible to trend phase voltages or positive sequence voltage and currents in real-time.
- ii. **Trending of all dynamic power system parameters**
- iii. **Option to select reference angle:** There should be an option to the selection of reference angle of any node by the user (real-time as-well-as historical) and visualization of other data w.r.t same.
- iv. **Capability to visualize data for larger time window:** There should be a single user interface, through which user can visualize real-time as-well-as historical data as per their interest and interval/duration.
- v. **Trending window:** Trending system should have a capability to show more than 8 signals without freezing of results or display crash causing limited overview of the system.
- vi. **Font and axis size:** Formatting of PMU snapshots arrangements should be user friendly. The auto-scaling and adequate font size need to be ensured in PMU
- vii. **Portability of display:** Advanced development platforms for retrieval and visualisation of phasor data based on the requirement of the operator in real time. Portability of display to be used in different applications may be ensured for easy reporting
- viii. **Non-generation of alarms:** Alarm processing as per user requirement.

- ix. **Freezing of display:** Visualization screen should not get sluggish when trending feature and replay feature is heavily used by operators.
- x. **Integration with different make of PMU:** The interoperability of different PMU manufacturers needs to be addressed.
- xi. **Logic based analytical tools:** Logic based analytical tools may be implemented for enhanced situational awareness. Further improvement in alarm-based features with the different mathematical and logical conditions needs to be implemented.
- xii. **Modal analysis issues in URTDSM Analytics:**
Baselining of modes to set limits for mode amplitude, damping and selecting mode bands for alerting operators needs to be implemented.
- xiii. Automated tool for detection of bad Analytics and poor performance due to errors because of High Noise in some of the PMU's data.
- xiv. Display of data for a larger time horizon (more than 5 minutes at present) shall be possible. There shall be a feature to permit the operator to select the sampling rate to display the data.
- xv. User shall have facility to update charts with primary & secondary axis assignment before viewing/downloading images.
- xvi. User shall have the facility to make customize displays for monitoring & data retrieval. Further in one screen multiple display facility shall be provided.
- xvii. Downloading of historical data should be made more user friendly
At present in Time derivation framework for downloading a signal data many other signals are getting downloaded. For example, one signal of MW is selected for one transmission line for desired period, then it is downloading time, type of signal, status, type of data, feeder name and MW values for desired period, whereas only required information was time & MW for desired duration. Time Series Derivation Framework (TDF) shall have feature to download only desired information. If multiple signals are selected, then they are being downloaded in series which is consuming a lot of the time to just re-arrange the data during analysis. For example, if MW value is selected for two feeders for desired duration, then when data is downloaded, it is coming in series one below to other. Then we need to first filter for feeder-1, copy it and again filter for feeder-2 and then plot. However, downloaded data should have been downloaded in three columns one time, feeder-1_MW, feeder-2_MW only for desired period.

TDF shall have facility to provide only required multiple feeder data for same time period in columns instead of in rows for desired period.

b) Oscillation Detection, monitoring and analytics

The application shall have following capabilities:

- i. Capability to detect power system oscillations from dynamic measurements - active power, reactive power, system frequency, voltage phase angle difference and others
- ii. Capability to monitor, classify oscillation modes in real time – Intra Plant modes (0.01 to 0.15 Hz), Inter area (0.15 to 1.0 Hz), Local (1 to 5 Hz) and HVDC/FACTS Controller (5 Hz and higher)
- iii. Real-time display for oscillation monitoring: Capability to provide simultaneous visualization of the multiple modes (mode frequency, mode damping, mode phase, energy, amplitude etc.) to the operator on a dashboard.
- iv. Detecting the dominant and poorly damped modes from the selected power system signals
- v. Alarms – Provide a tool to generator alarm if pre-defined mode amplitude and damping limits, set for the safe operation of the power system, are exceeded.
- vi. Alarm Settings – Ability for user to define alarm persistence settings (seconds) for mode alarm thresholds
- vii. Map Displays – Location and Severity of Oscillation Modes
- viii. Oscillation Severity- Show energy of oscillations by locations contributing to a specific oscillatory mode
- ix. Oscillation location –Identify the source of the oscillation and display root causes such as: Generator PSS, AVR, controller issues Wind/ Solar controller issues System resonant conditions HVDC/FACTS device controller issues.
 - Pinpoint the oscillation source to a generating plant/unit
 - Area-wise identification of source location
 - Help in identifying event root cause
 - Event severity in terms of oscillation energy and affected areas
 - Provide oscillation frequency
 - List of locations with highest oscillation energies
 - Plots of key metrics relevant to the event
- x. Statistical functions- Mean, Median, Standard Deviation, Maximum, Minimum and Average Values against each of the available parameters in PMUs. The user should

be able to generate Box & Whisker plots against each of the available parameters in PMU.

- xi. Logic based analytical tools for enhanced situational awareness, Advance development platforms for retrieval and visualization of phasor data, etc. needs to be added in the existing system.

c) Linear State Estimator

The Linear State Estimation analytics is the most important application which forms base for all the analytics like Contingency analysis, Vulnerability analysis, System Security analysis, Control Schemes for Improving System Security etc. The LSE analytics provided in the URTDSM Phase-I requires significant improvement in the following aspects for gainful utilization by the operators in real-time.

- i. **Database Integration:** An engine shall be provided to enable the SCADA topology and network database to be imported in the PMU based Linear State Estimation. The database should be common for both the systems (SCADA & PMU LSE) so ease database management.
- ii. **Bad data detection and conditioning:** Substation Level State Estimation could be considered for conditioning bad measurement within substation. A multi-layer system that is both model-less and model-based to deal with bad data detection and conditioning. In the model, raw PMU Measurements should be compared to LSE's model-based estimations in real-time for determination of the quality and usability. The LSE should also include the ability to condition bad data with estimated results. The application should be capable of bad data detection through plausibility checks, validation and conditioning. It should provide features to checking and correcting PMU channel mapping. Polarity of PMUs connected to both ends should be corrected by utilities.
- iii. **Observability analysis:** It should include the capability to quantify the full extent of the observable nodes in the system based on PMU placement and measurement availability relative to the power system network model. This analysis, which occurs in near real-time, can include "islanded" or disconnected portions of the system. It should be capable of providing real-time estimations for multiple islands or disconnected systems. As the topology of the system changes in real-time, a real-time observability analysis is required to correlate the PMU measurements with the topology, so that the LSE can identify observable areas of

the system. It is suggested that each of the suspected measurements is systematically checked and eliminated in step-by-step manner.

- iv. **Topology detection:** Topology processor should be capable of operating independently across multiple islands in the system. Changes to topology are detected in real-time for each observable island, and new connectivity matrices are constructed to correctly estimate the new state of the system. The network topology processor determines the present topology of the network from the telemetered status of circuit breakers.
- v. **Sampling rate:** Three-phase linear state estimation at sampling rate (25 or 50 s/s for 50 Hz system): It should operate at the PMU sampling rate. Visualization of higher frequency sub-synchronous oscillation and resonance
- vi. **Single-Line diagrams:** It should include a robust real-time visualization with the capability of displaying one-line diagrams with PMU and LSE data overlaid and updated in real-time. The visualization tools should the capability to create new one-line diagrams and import existing ones.
- vii. **Scalability:** It should be highly scalable to accommodate the increase of PMUs and end users to the system.
- viii. **Expanded observability:** The PMUs are not required to be placed at all the ends of the elements in the system, since it will result in large data handling by PDCs and super PDCs. Also, it will introduce the large latencies. The concept of expanded observability where the locations at which PMUs are not installed can be made observable through the PMU measurements at other ends. Through this the Islands formed in the system can be bridged and the complete system becomes observable.

6.2 Following new applications are recommended for deployment in URTDSM-II

a) Real time automated event detection and notification dashboard

The application should use high resolution and time synchronized data for:

- i. Event Detection - line trips, generation trips, load trips, load loss, islanding, complete loss of supply at a station and other events
- ii. Event characteristics - LG fault, LL fault, auto-reclosure and others
- iii. Automated report generation and email

The application should be capable of indicating probably event location. The dashboard should provide link to geographical display to reach to the nearest PMU location on the grid map. A library of events shall be maintained. The application should have the capability of automated event mining to scan through large amounts of data (weeks, months, years) to assess grid performance by identifying and classifying events. Data and event mining include identification of the type of event, location, severity and duration. and it should provide prompt the operator with quick information about similar event (s) in the past. (The application may use AI, machine learning, big data analytics to deliver such a solution).

b) Early warning system

The application should detect contingencies and slow trends in PMU measurements (such as angular separation, voltage, power flows etc).and generate alarms to draw the attention of the operator. The application should assist system operators in

- i. Identifying stress levels in both apparatus and system by detecting dynamic events linked to phase angle separations and other dynamic metrics
- ii. By providing guidance towards meaningful real time contingency selection and analysis
- iii. Early indicators of potential equipment failure (CTs, PTs, CCVTs etc.,) and device malfunctions
- iv. Provide easy summary reports for case study preparation, post event analysis and archival purposes.

(The application may use AI, machine learning, big data analytics to deliver such a solution).

c) Voltage Stability analytics (VSA)

Synchro phasor data enables high-resolution monitoring of actual system voltages, which can be used for advanced real-time visualization of current operating conditions and voltage stability limits to assess the power system's proximity to system collapse. The application shall use LSE based power flow case to perform VSA and identify active and reactive power margins and limiting contingencies in real time operation.

d) WAMS based contingency analysis and security assessment

Static security assessment tool improves operator assist feature of grid monitoring and makes it adaptive and interactive. This tool is meant to provide and perform what-if simulations and integrate power of data mining with intuition and insights of

operators. Application shall This will help in improving grid operation efficacy. The output of the LSE should be available for static and dynamic security assessment applications.

e) Islanding detection

The application should be capable of automatically detect islanding events in the grid and identify locations (PMUs) that are in the islanded region. The islanding detection algorithm could use a combination of frequency and phase angle difference signals to detect islands and shows key metrics to the operators. The heatmap/contouring feature should allow users to visualize the islanding event on the geographic map. Islanding Detection Methods should include:

- i. Frequency based island detection: If the difference in frequencies is getting larger than a certain limit, then an island state is detected.
- ii. ROCOF based island detection: If the rate of change of frequency (ROCOF) between at least two neighbouring values is getting larger than a certain limit, then an island state is possibly present or is in the process of arising.
- iii. Phase angle-based island detection: Phase Angle differences between voltage phasors from different PMU locations are used to detect out-of-step/islanding conditions.

f) Real time Inertia Estimation and monitoring

This application should be capable of providing an estimate of system inertia. The application shall provide features for monitoring and trending system MVA/MW capacity on bar/off-bar and the real-time kinetic energy of the system.

g) Post-mortem analytics

This application should provide offline data meta tools to facilitate post-mortem event/disturbance analysis to answer commonly asked questions related to event – When, Where, What and Why?. The application shall have following facilities

- i. Disturbance analysis and root cause assessment - Quick and detailed analysis of power system events like generation trips, line trips, generation-load imbalances, and other dynamic events.
- ii. Baseline daily performance and establish safe operating ranges - Examine Daily System Performance and establish reliable ranges for voltage, frequency, and other system metrics for real time monitoring systems.

- iii. Establish alarm limits for use in operations - Calculate key alarm event detection parameter for different real-time applications and establish after investigating multiple events of same type
- iv. Rate of Change of Frequency calculation over variable window.
- v. Generator Frequency Response Analysis – Calculation of Primary/Inertial Frequency Response, frequency response characteristics of a system following a generation loss.
- vi. Measurement Validation - Verify & Validate SCADA & State Estimation results with phasor data to identify differences & deviations.
- vii. Stability Assessment - Identify & Locate substations approaching instability issues and quantify sensitivity limits for real time monitoring

h) Generator Model Validation

The application should have the capability to validate generator models and provide validation reports in real-time to provide the most relevant event information:

- i. Automated system to perform model validation after significant events
- ii. Validates multiple events
- iii. Validates multiple generators
- iv. Identifies good vs questionable model parameters (programmatically not visually)

i) Wide Area Control Systems

- i. **WAMS based automatic load shedding (AUFLS and df/dt):** The AUFLS and df/dt based automatic load shedding schemes could be effective, if the measurements and control is based on the logic at a central location. This would identify the area/locations where load shedding, if carried out, could be effective in relieving the stress in the system and taking a calibrated decision. e.g. Load shedding will be effective in the States/regions who are importing power if the trigger frequency of the Stages in AUFLS is reached and disabling the Load shedding relays of the States/regions who are exporting power to other States/regions in real time.
- ii. **Control of HVDC, PSS and STATCOM for damping system oscillations:** This is the usage of WAMS measurements for actual automatic control applications. This was one of the original thoughts behind going for WAMS installation. The power system oscillations that originate in a post fault event or spontaneous oscillations can be damped quickly using controllers of HVDC and FACTS (like

STATCON) devices. It improves the overall transfer capacity of a power corridor. Lot of actual projects are now under operation in the USA and China. India must take up such projects for capacity building for the future.

The above applications may have to be developed in consultation with the utilities and other stakeholders. Pilots may be taken up for gaining experience on these applications before deployment.

6.3 Following improvements in system infrastructure are recommended

Recommended improvement in the system utilization and its performance

- i. 16 digital slots are currently available in each PMU where only 5 are used rest can be utilized for isolator points of line, bus, and line reactors etc.
- ii. Each PMU can monitor 2 elements, spare slot available can be used to integrate new lines / ICT from same substation (Non- SAS SUBSTATIONS)
- iii. Logic/tool must be developed to detect Voltage discrepancy in phase measurement errors and generate alarms. Utilities need to test/check PMUs during the routine calibration of VTs/SEMs.
- iv. Adopting main and standby philosophy in data communication between PMU & PDC and between PDC & PDC to avoid any data loss.
- v. Strengthening of time reference / GPS source and stringent daily monitoring by substation on daily basis for time synchronization.
- vi. It needs to be ensured that loss of PPS (Pulse per second) should not occur due to the disturbance of PPS cable during maintenance activities.
- vii. Dead band defined in PMU data for frequency, voltage and df/dt , should not cause discrepancy in values.
- viii. Data storage and Historian: Data storage should be configured to store and retain data at least up to one year. Since the population of PMUs is expected to increase manifold in the coming years, the standards / best practices need to be established for Indian power system. A separate sub-committee may be constituted to formulate a criteria for data archival and retention. For the time being data beyond one year shall be stored and made easily accessible for real-time and off-line applications depending upon the space utilization. Access to historian data through a separate software interface is required to be included. The interface should follow well established industry open standards that support both Windows and Linux operating systems to avoid any shortcomings in applications

due to lack of inter-connectivity between applications of different vendors. API shall be provided to enable development of user defined applications.

- ix. **PMU Testing:** PMU standards conformance tests shall be performed to verify whether the PMU meets the requirements of IEC/IEEE 60255-118-1 under steady-state, transient, and dynamic power system conditions, and the associated data transfer requirements as given in IEEE Std C37.118.2 or communication requirements given in IEC 61850. PMU field commissioning tests shall include routine visual inspection, insulation test, wiring check, basic functionality check, etc., as required by the relevant standards. In addition, a PMU field commissioning test shall verify correct phase sequence verification. Correct phasor magnitude measurement verification, Correct CT polarity, Correct indication of time, Data and control frames sending/receiving verification. System integration tests shall verify the following: expected phase angles relative to the phase angles from other locations, proper sending/receiving data/control frames to/from PDCs, Proper logging of PMU activities, such as on-line/off-line time, setting changes, etc., PMU status monitoring and trouble reporting, communications channel speed (packets per second)
- x. **PDC Latency in multiple streams:** A PDC can thus create a time-aligned, system-wide measurement set. In the hierarchy mode of operation, a local PDC aggregates, time-aligns data from multiple PMUs and feeds it to local applications, and to a control center PDC. The control center PDC collects data from multiple local PDCs, may conduct data quality checks, and feed the data to a regional PDC. A regional PDC may operate in a similar manner, exchanging data with several control center PDCs. PDC latency can be affected by the number of phasors and number of input data streams. If a PDC belongs to a system with multiple PDCs then the latency of the entire network must be considered. PDC must be able to handle off nominal conditions such as high rates of incoming data, incorrect timestamps, and unsupported protocols. PDC must be able to achieve the availability and reliability target levels consistent with the application.
- xi. **Sampling rate:** Installation of PMU with high sampling rate is recommended at a few locations to monitor sub-synchronous resonance, very low frequency governor modes and control modes. PDC should have capabilities to store data of higher sample rate PMU apart from existing 25 Hz.

- xii. Redundant and reliable high speed communication system is vital for PMU based Wide Area monitoring system. Fiber Optic connectivity between the substation identified for placement of PMU and control center is strongly recommended.

6.4 PMU placement strategy:

- a) Placement of PMUs Criterion:

The PMU placement should be based on the analytics/application being developed and put into use.

- b) Limiting constraints for Placement of PMUs.

The limiting constraints in installation of additional PMUs include

- i. The hardware requirement of the PDCs & Master PDCs as the current PDCs may not have enough memory to process the additional data from the PMUs.
- ii. Hardware and communication requirements will also be required to be changed and upgraded.

Communication link issues cannot be entirely eliminated, but suitable measures may be taken for mitigating them. The failure modes are often related to the quality of equipment and installation. Effective measures like planning to reduce failures by employing redundancy techniques shall be taken. As more PMUs are connected to a PDC, the possibility for more latency become more frequent. PDC requirements shall be matching with PMU data requirements and appropriate matching capabilities shall be ensured in advance.

- c) Type of PMUs

There are two different type of PMUs defined in IEEE standard C37.118-1. M type (Measurements) PMU is slower i.e., have higher PMU reporting and measurement latency and it is immune to errors caused by out of band frequency oscillations. P type (Protection) PMU is comparatively faster, but it does not filter out out-of-band frequency component, hence it is slightly inaccurate (only when such oscillations are present which is the case when saturation of the core).

Further, the connection of CT and CVTs to PMU input channels is a permanent choice that cannot be changed, or it takes lots of effort and time and money to change. Hence it is important to decide in the beginning of the project whether to connect PMUs to metering cores of CT and CVTs or to protection cores.

Since the PMUs in Phase-I are M type PMUs and are connected to metering core of CT/CVTs, the committee recommends that under Phase-II, M-type PMUs are to be procured and connected to the metering core. The placement of PMUs where it is expected that high fault current would be observed shall take the measurement from protection core. Using measurement core of the CT can lead to issues like saturation while measuring high fault current. Therefore, it is recommended that **few P-type PMUs shall be deployed on pilot basis (say 5 to 10 PMUs in each region).**

d) Minimum criteria of PMU locations:

Based on the above limiting constraints and proposed applications, the following locations should have PMUs (Minimum Criteria)

- i. **At one end of all 400 kV and above transmission lines**
- ii. **At the HV side of all ICTs connected to 220 kV and above**
- iii. **On HV side of coupling transformer of SVC/STATCOM for measurement of HV Bus voltage and current of coupling transformer**
- iv. **At one end of line wherever FSC/ TCSC are installed.**
- v. **On HV side of converter transformers for measuring HVAC bus voltage and current of converter transformer on each converter station.**
- vi. **On both ends of Inter-regional and trans-national tie lines and on boundary buses for such lines.**
- vii. **At the Generating Transformers (GTs) at LV side (having HV side of 220kV and above) of the Generating units with capacity above 200 MW for Thermal units, 50 MW for Hydro units and 100 MW for Gas units.**
- viii. **On all 220kV substations for measuring voltage of 220 kV bus and current of two lines/transformer catering to load centers.**
- ix. **All 132 kV and above ISTS lines in NER & Sikkim and important load centers.**
- x. **At RE developer end of the evacuating line connecting the Renewable Energy Pooling Stations (PS) to point of interconnection with the grid of 50MW and above.**
- xi. **Islanding, Separating & Restoration Points- At one end of line which is connected to black start stations along with circuit breaker status via synchro phasors.**

xii. Fiber Optic should be covered under Phase – II for all the above locations of the URTDSM project.

xiii. At all ICTs, Bus reactors, Switchable line reactors of critical substations.

e) Future Considerations & integration of State PMUs

Following locations may also be considered for installation of PMUs under Phase-II, for future projects:

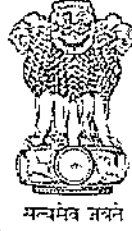
- i. Requirement of PMUs under Phase-II, as per above philosophy, be framed for the planned system up to 2024. Thereafter CTUIL may include the provisioning of PMUs in the scope of planned projects as per the above philosophy.**
- ii. The placement of PMUs for special cases such as Islanding, Separating & Restoration Points and ICTs, Bus reactors, Switchable line reactors of critical substations, load centres of NER shall be suggested by POSOCO in consultation with RPCs & CTU.**
- iii. Existing PMUs & PMUs planned in future by States should be integrated with the URTDSM Project.**
- iv. PMUs in the future projects should be made part of the system with improvements in the PDCs capabilities incorporated in the new Project.**
- v. PMU & PDC consoles at CTUIL, RPCs and CEA- Since CTUIL is entrusted with planning ISTS system, it is recommended that PMU & PDC consoles along with redundant, dedicated & secure communication link up to CTUIL premises be provided for CTUIL.**

The Power flow, Voltage, Angle data of PMU shall be integrated with CTUIL Planning system software for System studies, System planning of ISTS system, in consumable form, through standard protocols along with visualization.

Similar facilities should be made available at all RPCs and CEA if the same is not covered under Phase I. The console for CEA is supplied but could not be installed due to non-availability of dedicated secure communication link.

- vi. The up gradation of PDCs and control centre equipments be reviewed once in two (2) years, so that they can handle the data due to incremental PMU population in the system.**

- vii. PGCIL was of the view that 5 out of 6 analytics developed in Phase-I would not work, due to adoption of the above PMU placement philosophy (in all these 5 analytics PMU is required at both ends). The analytics viz Line parameter estimation, CT/CVT calibration are complementary to each other, where, in one analytic the CT/CVTs are assumed to be accurate and in the other the line parameters are assumed to be accurate (the reference used for one analytic is dependent on the other) and therefore the result of this analytics are not found to be much of use. The Online Vulnerability analysis and Supervised Zone-3 distance protection are protection class analytics as explained in the previous chapters and the results needs validation through DRs. The Zone-3 power swing blocking setting is available in all the relays and has been reported to be implemented by all the utilities as per recommendation of the Committee on the blackout of 2012. Further, the Load encroachment tripping in Zone-3 can be addressed through proper setting of Zone-3 in the relay, which has also been reported to be complied by all the Utilities as per the recommendation of the Committee on the blackout of 2012. Control System for improving system security analytic and the above four analytics, however, shall to be used wherever PMUs are available at both ends and the results be validated.**
- viii. The relevant orders of Ministry of Power, Government of India and CEA/CERC regulations for cyber security compliance should be followed. The directives of CERT-In for time synchronisation of PMUs should be followed in view of cyber security.**
- ix. Training module should be incorporated in Phase-II of URTDSM project for the State Utilities, CTU, POSOCO, CEA and RPCs.**



भारत सरकार/Government of India

विद्युत मंत्रालय/ Ministry of Power

केन्द्रीय विद्युत प्राधिकरण/Central Electricity Authority

राष्ट्रीय विद्युत समिति प्रभाग/National Power Committee Division

1st Floor, Wing-5, West Block-II, R.K. Puram, New Delhi-66

No. 4/MTGS/NPC/CEA/2021/ 285 - 298

दिनांक: 20.09.2021

To

(As per distribution list)

विषय : "यूआरटीडीएसएम (URTDSM) परियोजना के तहत पीएमयू (PMU) स्थानों के समान दर्शन, नए विश्लेषण और नियंत्रण केंद्र के उन्नयन की आवश्यकता पर उप-समिति" का गठन-के सम्बन्ध में।

Subject: Constitution of "Sub-Committee on the uniform philosophy of PMU locations, new analytics and requirement of up gradation of Control Centre under URTDSM project"-reg.

Madam/Sir.

In the 10th meeting of NPC held on 09th April 2021, it was decided that a Sub-Committee would be formed under the Chairmanship of Member Secretary, WRPC with representatives from POSOCO, CTU, POWERGRID and all RPCs/NPC. The Sub-Committee shall discuss on the uniform philosophy of PMU locations, new analytics and requirement of up gradation of Control Centre under URTDSM project and submit its recommendations to the NPC.

Accordingly, the nominations has been sought from RPCs, POSOCO, CTU and POWERGRID via email dated 01st Sept 2021. Based on the nominations received, the Constitution of "Sub-Committee on the uniform philosophy of PMU locations, new analytics and requirement of up gradation of Control Centre under URTDSM project" is as follows:

1	Member Secretary, WRPC	Shri Satyanarayan S.	Chairperson
2	Chief Engineer, NPC	Smt Rishika Sharan	Member
3	Superintending Engineer, NRPC	Shri Saumitra Mazumdar	Member
4	Superintending Engineer, ERPC	Shri Shyam Kejriwal	Member
5	Superintending Engineer, WRPC	Shri P. D. Lone	Member Convener

EECS
27/09/21.

6	Superintending Engineer, TS SLDC Executive Engineer, (P&C II) TANTRANSCO Executive Engineer, SRPC	Shri P Suresh Babu Shri T Sivakumar Shri Len J.B.	Member
7	Deputy Director, NERPC	Shri Srijit Mukherjee	Member
8	Deputy Director, NPC	Shri Himanshu Lal	Member
9	Sr. GM(LD&C),PGCIL	Dr. Sunita Chohan	Member
10	General Manager, NLDC Chief Manager, SRLDC	Shri Vivek Pandey Shri Abdulla Siddique	Member
11	General Manager, CTUIL	Ms Nutan Mishra	Member

(कृषिका शरण/Rishika Sharan)

मुख्य अभियन्ता एवं सदस्य सचिव, रा.वि.स /
Chief Engineer & Member Secretary, NPC

Distribution list:

1. Member Secretary, WRPC
- ✓ 2. Shri P. D. Lone, SE, WRPC
3. Shri Saumitra Mazumdar, SE, NRPC
4. Shri Shyam Kejriwal, SE, ERPC
5. Shri P Suresh Babu, Superintending Engineer, TS SLDC, TSTRANSCO, Vidhuth Soudha, Khairthabad, Hyderabad, Telangana
6. Shri T Sivakumar, Executive Engineer, (P&C II) TANTRANSCO, Chennai, TN
7. Shri Len J.B., Executive Engineer, SRPC, 29, Race Course Cross Road, Bengaluru
8. Shri Srijit Mukherjee, Deputy Director, NERPC
9. Shri Abdulla Siddique, Chief Manager, SRLDC
10. Shri Vivek Pandey, General Manager, NLDC, B-9 (1st Floor), Qutab Institutional Area, Katwaria Sarai, New Delhi
11. Dr. Sunita Chohan, Sr. GM(LD&C),PGCIL, Plot No.2, Near, IFFCO Chowk, Sector 29, Saudamini, Haryana 122001
12. Ms Nutan Mishra, General Manager, CTUIL, PGCIL, Plot No.2, Near, IFFCO Chowk, Sector 29, Saudamini, Haryana 122001

Copy to:

1. Chairperson, CEA
2. Member (GO&D), CEA

Annexure II

S.No	Region	Sub-Region	State	Sub-Station	Owner/ Utility	kV level-1 DETAILS	Feeder name As per Contract	Feeder name As per Site Survey	As per Discussion	Additional / Deficit Feeder name as per Site	Deviation in feeder Qty.	Deviation in feeder Name as per contact vs Site	PMU
													1409
1	NER	NER	Assam	220kVMariani (New)	Powergrid	220	200kv Kathalguri , 220KV Misa , 220kv Mockochung 1 & 2	Kathalguri, Misa Mockochung 1 & 2	-	0	0	NA	3
2	ER	ER-I	Jharkhand	765/400kv Ranchi (N)	Powergrid	765	765KV Dharamjaygarh 400kv Ranchi-1,2,3,4 400kv NKSTPP-1,2 400kv J pool-1,2	765KV Dharamjaygarh-1 400kv Ranchi-1,2,3,4 400kv NKSTPP-1,2 400kv J pool-1,2 765KV Dharamjaygarh-2		1	1	765kvDharamjaygarh- >765kvDharamjaygarh-1 Not in contract->765KV Dharamjaygarh-2	8
3	ER	ER-I	BIHAR	765kv Gaya	Powergrid	765	765kv varanasi-2, 765kv varanasi-1, 765kv sasaram, 400kv kodarma-1 400kv kodarma-2 400kv maithon-1 400kv maithon-2 400kv NKSTPP-1 400kv NKSTPP-2 400kv Nabinagar-1 400kv Nabinagar-2 400kv j'pool-1 400kv j'pool-2	765kv varanasi-2, 765kv Balia, 765kv gaya-fatehpur, 400kv koderma-1 400kv koderma-2 400kv maithon-1 400kv maithon-2 400kv NKSTPP-1 400kv NKSTPP-2 400kv Nabinagar-1 400kv Nabinagar-2 400kv chadna 2 400kv j'pool-2		3	0	765kv varanasi-1->765kv Balia 765kv sasaram->765kv gaya- fatehpur, 400kv j'pool-1->400kv chadna 2	11
4	NR	NR-II	Haryana	Abdullapur	Powergrid	400	Bawana-1, Sonapat(HVPNL), Sonepat-1&2, Panchkula-1&2, Karcham Wangtoo-1&2, dehradun-1&2	Bawana-1, Dipalpur, Sonepat-1&2, Panchkula-1&2, Karcham Wangtoo-1&2, dehradun-1&2	-	0	0	Sonapat(HVPNL) > Dipalpur	5
5	NER	NER	Assam	Agia	AEGCL	220	BTPS-1 BTPS-2 AZRA BOKO	220kv feeder 3 control panel 220kv BTPS- Agia FDR-2 220kv Agia-SoniSajai FDR-2 220kv Feeder 4 control panel		0	0	BTPS-1->220kv feeder 3 control panel BTPS-2->220kv BTPS-Agia FDR-2 AZRA->220kv Agia- SoniSajai FDR-2 BOKO->220kv Feeder 4 control panel	2
6	NR	NR-I	Uttar pradesh	Agra	Powergrid	400	Agra-1(UP) Agra-2(UP), Auraiya-1 Auraiya-2 bassi-1, bassi-2 bassi-3, Kanpur, Ballabgarh, Bhiwadi, Gwalior-1 Sikar-1&2, Gwalior-2	UPPCL-1 UPPCL-2 Auraiya-1 Auraiya-2 Jaipur-1 Jaipur-2 Jaipur-3 Kanpur Ballabgarh Bhiwadi-I Bhiwadi-II Sikar-1&2, Not identified	As per Site Survey	1	-1	Agra-1>UPPCL-1 Agra-2>UPPCL-2 Bassi-1>Jaipur-1 Bassi-2>Jaipur-2 Bassi-3>Jaipur-3 Bhiwadi> Bhiwadi-I Gwalior-I> Bhiwadi-II Gwalior-II> Not identified	7
7	NR	NR-I	Uttar pradesh	Agra 765	Powergrid	765	Fatehpur-2, Gwalior-2, Meerut-1, Jatikara-1, Not identified, Not identified	Fatehpur-II, Gwalior-II, Meerut, Mundka Fatehpur-I, Gwalior-I,	As per site survey	0	0	Meerut-I > Meerut Jatikara-I > Mundka Not identified > Fatehpur-I Not identified > Gwalior-I	6

8	ER	ER-II	West Bengal	Alipurduar	Powergrid		400kV Bongigaon 1&2, 400kV Tala 1&2, 400kV Siliguri 1,2,3&4, B'Charyali HVDC 1&2, Agra HVDC 1&2, Punatsanghu 1&2						6
9	NR	NR-I	Uttar pradesh	Allahabad	Powergrid	400	Kanpur - 2 , Kanpur - 1 , Biharsharif , Sarnath , Singrauli - 1 , Singrauli - 2 , Rihand - 1 , Mainpuri - 2 , Rihand - 2 , Mainpuri - 1	Kanpur - 2 , Fatehpur -3 , Sasaram , Sarnath , Singrauli - 1 , Singrauli - 2 , Rihand - 1 , Fatehpur -2 , Rihand - 2 , Fatehpur -1	As per Site Survey	0	0	Kanpur - 1 > Fatehpur -3 Biharsharif > Sasaram Mainpuri - 2 > Fatehpur - 2 Mainpuri - 1 > Fatehpur - 1	5
10	NR	NR-II	Punjab	Amritsar	Powergrid	400	Jalandhar	Jalandhar	Jalandhar Banala- 1&2 Makhu- 1&2.	0	0	NIL	3
11	ER	ORISSA	Orissa	ANGUL	Powergrid	765	765kV Jharsuguda 1 ,2 400kV jindal1 &2, 400kV mannet 1 &2, 400kV GMR-1,&2 400kV Navbarath-1&2 400kV Lanco-1,2,3&4, 765kV Jharsuguda 3,4 765kV srikakulam 1 & 2, .	765kV Jharsuguda 1 ,2, 400kV jindal1 &2, 400kV mannet 1 &2, 400kV GMR-1,&2 400kV Navbarath-1&2 400kV Balangir, 400kV Talcher, Meramaundali-1&2 .		1	1	Nil->400kv Balangir, Nil->400kv Talcher, Nil->400kvMeramaundali-1&2 400kv Lanco-1,2,3&4-> Not available 765kV Jharsuguda 3,4->Not available 765kV srikakulam 1 & 2-> Not available.	10
12	NR	NR-I	Uttar Pradesh	Anpara	Uttar Pradesh	400	Sarnath-1, Sarnath-2, Mau, Singarauli, Obra-1, Obra-2, Unnao	Sarnath-1, Sarnath-2, Mau, Singarauli, Obra, Anpara-D, Anpara-D	As per site survey	0	0	Obra-1 > Obra, Obra-2 > Anpara-D, Unnao > Anpara-D	4
13	ER	ER-II	West Bengal	Arambagh	WBSETCL	400	pssp-i pssp-ii baekeshwar kolaghat bidhinagar	pssp-i pssp-ii baekeshwar kolaghat durgapur		0	0	bidhinagar->durgapur	3
14	NR	NR-I	Uttar Pradesh	Azamgarh	Uttar Pradesh	400	Gorakhpur(up),Sarnath,Mau, Sultanpur	Gorakhpur(up),Sarnath,Mau,Sultanpur	As per Site Survey	0	0	NIL	2
15	NR	NR-II	Haryana	Bahadurgarh	Powergrid	400	Bawana,Bhiwani, sonapat-1,2	Bawana,Bhiwani, sonapat-1,2	Bawana,Bhiwani (POWERGRID) sonapat-1,2	0	0	NIL	2
16	ER	ER-II	West Bengal	Baharampur	Powergrid	400	400kV Farakka, 400kV Jeerat, Bheramara (Bangladesh) 1&2	Farakka, Jeerat, Bheramara 1&2	-	0	0	Bheramara (Bangladesh) 1&2-> Bheramara 1&2	2

17	ER	ER-II	West Bengal	BAKRESHWAR	WBSETCL	400	400kv arambag jeerat 220kv bidhan nagar-i bidhan nagar-ii satgachia-i satgachia-ii gokarna-i gokarna-ii	400kv arambag jeerat 220kv bidhan nagar-i bidhan nagar-ii satgachia-i satgachia-ii gokarna-i gokarna-ii		0	0	nill	4
18	NR	NR-I	Uttar pradesh	Balia	Powergrid	400	Patna-1, Patna-2, Bargh-1, Bargh-2, Biharsharif-1, Biharsharif-2, Lko(PG)-1, Lko(PG)-2, Mau-1, Mau-2	Patna-1, Patna-2, Patna-3, Patna-4, Biharsharif-1, Biharsharif-2, Sohowal-1, Sohowal-2, Mau-1, Mau-2	As per site survey	0	0	Bargh-1 > Patna-3, Bargh-2 > Patna-4, Lko(PG)-1 > Sohowal-1, Lko(PG)-2 > Sohowal-2	7
19	NR	NR-I	Uttar pradesh	Balia-765	Powergrid	765	Gaya, Lucknow	Gaya, Lucknow, Future Line-1, Future Line-2	Gaya, Lucknow	2	2	Not identified > Future Line-1, Not identified > Future Line-2.	2
20	ER	ORISSA	Orissa	BALIMELA(H)	OPTCL	220	Jayangar-1, Jayangar-2, Jayangar-3, Upper-sileru	Jayangar-1, Jayangar-2, Jayangar-3, Upper-sileru, OPTCL-balimela	-	1	1	Nill->OPTCL-Balimela	3
21	NER	NER	Assam	BALIPARA PG	Powergrid	400	Misa PG-I Misa PG-II B'Charyali-I B'Charyali-II B'Charyali-III B'Charyali-IV Bongaigaon-I Bongaigaon-II Bongaigaon-III Bongaigaon-IV Kameng-I Kameng-II	Misa-I Misa-II Ranganadi-I Ranganadi-II B'Charyali-III B'Charyali-IV Bongaigaon-I Bongaigaon-II Bongaigaon-III Bongaigaon-IV Kameng-I Kameng-II		0	0	Misa PG-I->Misa-I Misa PG-II->Misa-II B'Charyali-I->Ranganadi-I B'Charyali-II->Ranganadi-II	6
22	NR	NR-I	Haryana	Ballabgarh	Powergrid	400	Bamnauli -1&2, Maharanibagh,Kanpur1,2, Agra, GNoida Mainpuri-1,2 Bhiwadi Gurgaon	Bamnauli -1&2, Maharanibagh,Kanpur1,2, Agra Nawada, Mainpuri-1,2 Gurgaon, Kanpur-III,	As per Site Survey	0	0	Bhiwadi > gurgaon G.Noida > Nawada Gurgaon > Kanpur-III	6
23	NR	NR-I	Delhi	Bamnauli	DTL	400	Jattikalan-1, Jattikalan-2, Ballabhgarh-1, Ballabhgarh-2	Jattikalan-1, Jattikalan-2, Ballabhgarh-1, Ballabhgarh-2	As per site survey	0	0	NIL	2
24	ER	ER-I	BIHAR	BANKA	Powergrid	400	Biharshariff-1,2 Kahalgaon-1,2	Biharshariff-1,2 Kahalgaon-1,2		0	0	NA	4
25	NR	NR-I	Uttar Pradesh	Bareilly	Uttar Pradesh	400	Barelli-1&2(PG),Unnao-1,2	Barelli-1&2(PG),Unnao-1,2	As per Site Survey	0	0	NIL	2
26	NR	NR-I	Uttar Pradesh	Bareilly-PG	Powergrid		Muradabad-1&2,Muradnagar- 1&2,Barelli- 1&2(UPPCL),Lucknow- 1&2,Lucknow(UP)						6
27	ER	ER-I	BIHAR	BARH	NTPC	400	Patna 1,2, Gorakhpur 1&2 Patna 3 Patna 4, KHSTPP 1&2,	Patna 1,2, Gorakhpur 1&2 Balua 1, Balua-2 Kahalgaon 1&2	-	0	0	Patna 3-> Balua-1 Patna 4-> Balua-2 KHSTPP 1&2->Kahalgaon 1&2	4

28	ER	ORISSA	Orissa	Baripada	Powergrid	400	Jamshedpur , Jamshedpur (DVC), Keonjhar, Chanditala, KVK, Duburi,	Jamshedpur 1 Jamshedpur 2, Keonjhar, Khoragpur, Mendajhul 1, Mendajhul 2	-	0	0	Jamshedpur > Jamshedpur 1 Jamshedpur (DVC) > Jamshedpur 2, Chanditala> Khoragpur, KVK > Mendajhul 1, Duburi > Mendajhul 2	3
29	NR	NR-I	Rajasthan	Bassi	Powergrid	400	Agra-1, Agra-2, Agra-3, Jaipur-1, Jaipur-2, Bhiwadi-1, Bhiwadi-2, Sikar-1, Sikar-2	Agra, Jaipur South-1, Jaipur South-2, Phagi-1, Phagi-2, Bhiwadi, Kotputli, Sikar-1, Sikar-2	As per site survey	0	0	Agra-1 > Agra Agra-2 > Jaipur South-1 Agra-3 > Jaipur South-2 Jaipur-1 > Phagi-1 Jaipur-2 > Phagi-2 Bhiwadi-1 > Bhiwadi Bhiwadi-2 > Kotputli	5
30	NR	NR-I	Delhi	Bawana	DTL	400	Abdullapur-1,2, Bamnauli-1,2, Mandaula-1,2 Hisar, Bhadurgarh	Abdullapur-1,Dipalpur Mundka-1,2, Mandaula-1,2 Not Available Not Available	As per Site Survey	2	-2	Bamnauli-I > Munduka-I Bamnauli-II > Munduka-II Abdullapur-II > Dipalpur Hisar,Bhadurgarh are disconnected from site.	3
31	NR	NR-II	Himachal Pradesh	Bhakra(L&R)	BBMB	220	Ganguwal-1, Ganguwal-2, Ganguwal-3, Ganguwal-4, Ganguwal-5, Mahilpur-1, Mahilpur-2, Jamalpur-1, Jamalpur-2	Ganguwal-1, Ganguwal-2, Ganguwal-3, Ganguwal-4, Ganguwal-5, Mahilpur-1, Mahilpur-2, Jamalpur-1, Jamalpur-2		0	0	NIL	5
32	NR	NR-II	Punjab	Bhatinda GND TPS	Punjab	220	Muktsat-1, Muktsat-2, Lehra-1, Lehra-2	Katore wala, Muktsat-2, Lehra-1, Lehra-2	Katore wala, Muktsat-2, Lehra-1, Lehra-2	0	0	Muktsat-1 > Katore wala,	2
33	NR	NR-I	Rajasthan	Bhilwara	Rajasthan	400	Chhabra	Chhabra	As per site survey	0	0	NIL	1
34	NR	NR-I	Rajasthan	Bhinmal	Powergrid	400	Zerda, Kankorili	Zerda, Kankorili	As per site survey	0	0	NIL	2
35	NR	NR-I	Rajasthan	Bhiwadi	Powergrid	400	Bassi-1, Bassi-2, Hissar, Ballabhgarh, Agra, Moga-1, Moga-2	Bassi-1, Kotputli, Hissar, Gurgaon, Agra-1, Moga-1, Moga-2	As per site survey	0	0	Bassi-2 > Kotputli, Ballabhgarh > Gurgaon, Agra > Agra-1	5
36	NR	NR-II	Haryana	Bhiwani	BBMB	400	Hisar, Bhadurgarh, Rajpura	Hisar, PGCIL Bhiwani, Dehar	Hisar, PGCIL Bhiwani, Dehar	0	0	Bhadurgarh > PGCIL Bhiwani, Rajpura > Dehar	2

37	NR	NR-II	Haryana	Bhiwani-PG	Powergrid	400	Bhiwani(BBMB), Bahduragarh, Hissar, Bawana, Mahendergarh-1, Mahendergarh-2, Jind-1, Jind-2	Bhiwani(BBMB), Bahduragarh, Hissar, Bawana, Mahendergarh-1, Mahendergarh-2, Jind-1, Jind-2, Rothak HVPNL-1, Rothak HVPNL-2	Bhiwani(BBMB), Bahduragarh, Hissar, Bawana, Mahendergarh-1, Mahendergarh-2, Jind-1, Jind-2, Mahendergarh-3, Mahendergarh-4, Hisar 1&2 Bhiwani 765kV Jhatikara, MOGA, Jaipur 1&2	0	0	Rothak HVPNL-1, Rothak HVPNL-2 Rothak -1 & 2 feeders are captured additionally as a part of Survey	15
38	ER	ER-II	West Bengal	Bidhannagar	WBSETCL	400	ppsp-i ppsp-ii arambag durgapur-i durgapur-ii dpl-i dpl-ii	ppsp-i ppsp-ii arambag pgcil-I pgcil-ii Available in 220kV Available in 220kV		0	0	durgapur-i->pgcil-i durgapur-ii->pgcil-ii	3
39	ER	ER-I	Bihar	Biharshariff	Powergrid								9
40	ER	ER-II	West Bengal	Binaguri	Powergrid	400	Bongigaon 1,2, TALA1,2 , Bongaigaon 3&4, Rangpo 1&2, Malbase Karandeghi 1, Karandeghi 2, Karandeghi 3, Karandeghi 4. Allipurduar 1,2,3&4,	Bongigaon 1,2, TALA1,2 , Bongaigaon 3&4, Teesta 1&2, Tala-3, Purnea 1, Purnea 2, Purnea 3, Purnea 4. Tala-4	-	3	-3	Rangpo 1&2 > Teesta 1&2, Malbase > Tala-3, Karandeghi 1 > Purnea 1, Karandeghi 2 > Purnea 2, Karandeghi 3 > Purnea 3, Karandeghi 4 > Purnea 4, Not Identified > Tala-4 Allipurduar 1,2,3&4-> Future bays	7
41	ER	ER-II	West Bengal	Birpara	Powergrid	220	chukha-i chukha-ii bongaigaon-i bongaigaon-ii malbase binaguri-i binaguri-ii	chukha-i chukha-ii bongaigaon-i bongaigaon-ii malbase binaguri-i binaguri-ii		0	0	nill	4
42	NER	NER	Assam	Birpara (salakati)	Powergrid	220	Birpara-I Birpara-II BTPS-I BTPS-II Gelaphu	Birpara-I Birpara-II BTPS-I BTPS-II Gelaphu		0	1	Gelaphu-> Not identified	3
43	NER	NER	Assam	Biswanath	Powergrid		Subansiri 1,2,3&4,Alipurduar HVDC 1&2,Balipara 1,2,3&4, Ranganadi 1&2						4
44	ER	ER-II	Jharkhand	Bokaro	DVC	220	Jamshedpur-1&2, CTPS-1&2	Jamshedpur-1&2, CTPS-1&2	-	0	0	NIL	2
45	ER	ER-II	Jharkhand	Bokaro TPS	DVC								1
46	ER	ORISSA	Orissa	Bolangir	Powergrid	400	Meramundali Jeypore	Angul, Jeypore		0	0	Meramundali->Angul	2

47	NER	NER	Assam	BONGAIGAON	Powergrid	400	BTPS-1 BTPS-2 Balipara-1 Balipara-2 Balipara-3 Balipara-4 N.Siliguri-1 N.Siliguri-2 N.Siliguri-3 N.Siliguri-4 400kv Azara-1 400kv Azara-2	BTPS-1 BTPS-2 Balipara-1 Balipara-2 Balipara-3 Balipara-4 N.Siliguri-1 N.Siliguri-3 N.Siliguri-4 Silchar-1 Silchar-2		0	0	400kv Azara-1->Silchar-1 400kv Azara-2->Silchar-2	6
48	ER	ORISSA	Orissa	Budhipadar	OPTCL	220	ib vally-i ib vally-ii ib vally-iii ib vally-iv tarkera-i tarkera-ii vedenta-i vedenta-ii korba-i korba-ii korba-iii sps bhusan msp katapally-i katapally-ii bargarh-i bargarh-ii	ib tps-i ib tps-ii ib tps-iii ib tps-iv tarkera-i tarkera-ii val-i val-ii raigarh korba-ii korba-iii sps-i bhusan-i msp burla-i burla-ii bhusan-ii sps-ii aditya aluminium-i aditya aluminium-ii busandara-ii		2	2	ib vally-i->ib tps-i ib vally-ii->ib tps-ii ib vally-iii->ib tps-iii ib vally-iv->ib tps-iv vedenta-i->val-i vedenta-ii->val-ii korba-i->raigarh sps->sps-i bhusan->bhusan-i katapally-i->burla-i katapally-ii->burla-ii nill->bhusan-ii nill->sps-ii nill->aditya aluminium-i nill->aditya aluminium-ii nill->busandara-ii bargah-i->Not available at site bargah-ii->Not available at site	10
49	ER	ER-I	Jharkhand	Chaibasa	Powergrid	400	Jamshedpur 1&2, Rourkela 1&2	Jamshedpur 1&2, Rourkela 1&2	-	0	0	-	4
50	NR	NR-II	Himachal Pradesh	Chamba	Powergrid								2
51	NR	NR-II	Himachal Pradesh	Chamera 1	NHPC		Chamera-II ,Jalandhar-1&2						2
52	NR	NR-II	Himachal pradesh	Chamera 2	NHPC	400	Kishenpur, chamera-I	Kishenpur, chamera-I		0	0	NIL	1
53	NR	NR-II	Himachal pradesh	Chamera III 220kV	NHPC	220	Pooling Point-2, Budhil-1	Line-1, Line-2	220kV Chamba PG-1, 220kV Chamba PG-2	0	0	Pooling Point-2 > Line-1, Budhil-1 > Line-2	1
54	ER	ER-II	Jharkhand	CTPS B (Chanderpur)	DVC	220	Not in contract	Dhanbad 1 Dhanbad 2 Bokaro 1 Bokaro 2 CTPS Old 1 CTPS Old 2	-	NA	NA	Not in contract -> Dhanbad 1 Not in contract ->Dhanbad 2 Not in contract ->Bokaro 1 Not in contract ->Bokaro 2 Not in contract ->CTPS Old 1 Not in contract ->CTPS Old 2	3

55	ER	ER-II	Jharkhand	CTPS(Chanderpur)	DVC	220	Kalyaneshwar 1, Kalyaneshwar 2, Maithan(PG)-1&2, Bokaro1&2, Kalyaneshwar 3, Kalyaneshwar 4, Santhldi	Kalyaneshwari 1, Kalyaneshwari 2, CTPS New-1, CTPS New-2	-	5	-5	Kalyaneshwar 1-> Kalyaneshwari 1, 'Kalyaneshwar 2-> Kalyaneshwari 2, Not in contract -> CTPS New-1, Not in contract -> CTPS New-2	2	
56	NR	NR-I	Uttar Pradesh	DADRI	NTPC		Panipath-1&2,mandola- 1&2,Maharanibagh,GreaterNoi da,Muradnagar,Malerkotla							5
57	NR	NR-I	Uttar Pradesh	DADRI HVDC	Powergrid		Dadri-Thermal							1
58	ER	ER-I	Jharkhand	Daltonganj	Powergrid		Sasaram 1&2							2
59	NR	NR-II	Himachal Pradesh	Dehar	BBMB	400	Panchkula, Rajpura	Dehar-Bhiwani, Dehar-Panipat	Dehar-Bhiwani, Dehar-Panipat	0	0	Panchkula > Dehar- Bhiwani, Rajpura > Dehar-Panipat	1	
60	NR	NR-I	Uttarakhand	Dehradun-400	Powergrid		Abdullapur-2, Saharanpur-2							4
61	NR	NR-I	Uttarakhand	Dhauli Ganga	NHPC	220	Pithoragarh, Bareilly	Dhauli Ganga - Pithoragarh, Dhauli Ganga - Bareilly	As per site survey	0	0	Pithoragarh > Dhauli Ganga - Pithoragarh, Bareilly > Dhauli Ganga - Bareilly	1	
62	NER	NER	Nagaland	Dimapur	Powergrid	220	Doyang 1 & 2, Imphal 1 & 2. Misa, N.Kohima,	Doyang 1 & 2, Imphal 1 & 2, Misa-1, Kohima, Misa-2, Dimapur-1, Dimapur-2	-	3	3	Misa >Misa-1, N.Kohima> Kohima, Not in contract->Misa-2, Not in contract->Dimapur- 1, Not in contract->Dimapur- 2	5	
63	ER	ER-II	West Bengal	DSTPS	DVC	400	Mejia, Maithon	Raghunathpur-1 Raghunathpur-2 Jamshedpur-1 Jamshedpur-2	-	2	2	Mejia >Raghunathpur-1, Maithon > Raghunathpur- 1, Not identified > Jamshedpur-1, Not identified > Jamshedpur-2.	2	
64	NR	NR-II	Jammu & Kashmir	Dulhasti	NHPC	400	Kishenpur-1, Kishenpur-2	Kishenpur-1, Kishenpur-2		0	0	NIL	1	
65	ER	ER-II	West Bengal	Durgapur	Powergrid	400	Jamshedpur, Farakka 1&2, Sagardighi 1&2, Maithon 1&2	Jamshedpur, Farakka 1&2, Sagardighi 1&2, Maithon 1&2, Bidhannagar 1&2.	-	2	2	Not in contract > Bidhannagar -1 Not in contract > Bidhannagar -2	5	
66	ER	ER-II	West Bengal	Durgapur TPS	DVC									3
67	NR	NR-I	Haryana	Faridabad	NTPC	220	Palla-1, Palla-2, Samaypur-1, Samaypur-2	Palla-1, Palla-2, Samaypur-1, Samaypur-2	As per site survey	0	0	NIL	2	
68	ER	ER-II	West Bengal	FARRAKA	NTPC	400	malda-i sagardighi baharampur durgapur-i durgapur-ii kahalgaon-i kahalgaon-ii purnea kahalgaon-iii kahalgaon-iv rajarhat malda-ii	malda-i sagardighi baharampur durgapur-i durgapur-ii kahalgaon-i kahalgaon-ii future-i kahalgaon-iii kahalgaon-iv future-ii malda-ii		2		purnea->future-i rajarhat->future-ii	5	

69	NR	NR-II	Haryana	Fatehabad	Powergrid	400	Moga,Hissar, Khedar-1 Khedar-2	Moga,Hissar, Nuhawali, Khedar.	As per site survey	0	0	Khedar-1 > Nuhawavi Khedar-2 > Khedar	4
70	NR	NR-I	Haryana	Fatehpur PG- 765	Powergrid	765	765kV Varnasi-1, Sasaram-1 Agra-2	765kV Gaya Sasaram Agra-II Agra-I 400kV Allahabad-I Allahabad-II Mainpuri-I Mainpuri-II Singrauli Kanpur-I Kanpur-II Allahabad-III	-	8	8	Varanasi-1->Gaya Sasaram-1-> Sasaram Agra-2->Agra-II Not in contract->Allahabad-I Not in contract->Allahabad-II Not in contract->Mainpuri-I Not in contract->Mainpuri-II Not in contract->Singrauli Not in contract->Kanpur-I Not in contract->Kanpur-II Not in contract->Allahabad-III	11
71	NR	NR-II	Punjab	Ganguwal	BBMB	220	Bhakra-1, Bhakra-2, Bhakra-3, Bhakra(R)-1, Bhakra(R)-2, Dhar-1, Dhar-2, Jamalpur-1, Jamalpur-2, Govingarh-1, Govingarh-2, Jagdhari-1, Mohali-1, Not Identified, Daulkote-1, Not Identified	Bhakra-1, Bhakra-2, Bhakra-3, Bhakra(R)-1, Bhakra(R)-2, Dhar-1, Dhar-2, Jamalpur-1, Jamalpur-2, Govingarh-1, Govingarh-2, Jagdhari-1, Mohali-1, Mohali-2, Daulkote-1, Daulkote-2	-	2	2	Not identified > Mohali-2, Not identified > Daulkote-2	8
72	ER	ORISSA	Orissa	GMR	GMR	400	400kv Angul-1 400kv Angul-2	GMR-1(GMR-Phulpada) GMR-2(GMR-Phulpada) OPTCL-Miramundali		1	1	400kv Angul-1->GMR-1(GMR-Phulpada) 400kv Angul-2->GMR-2(GMR-Phulpada) Not in contract->OPTCL-Miramundali	3
73	NR	NR-I	Haryana	Gurgaon	Powergrid	400	Daulatabad-1,2, Maneser-1,2	Daulatabad-1,2, Maneser-1,2	As per site survey	0	0	NIL	3
74	NR	NR-II	Himachal Pradesh	Hamirpur PG- 400	Powergrid	400	Parbati pooling, Amritsar	Banala powergrid Amritsar	Banala(POWERGRID) Amritsar	0	0	Parbati pooling > Banala powergrid,	1
75	NR	NR-I	Uttar pradesh	Harduaganj	Uttar pradesh	220	Khurja-1&2, Atrauli, Hathras, Mainpuri-PG, UPPCL	Khurja-1&2, Atrauli, Metai Etah Mainpuri	As per site survey	0	0	Hathras> Metai Mainpuri- PG> Etah UPPTCL> Mainpuri	3
76	NR	NR-I	Rajasthan	Heera pura	Rajasthan	400	Bassi-1, Bassi-2, Merta, Hindaun, Dahra-1, Dahra-2	Bassi-1, Bassi-2, Merta city, Hindaun, Not identified, Not identified	As per site survey	2	-2	Merta > Merta city, Dahra-1 > Not identified, Dahra-2 > Not identified,	2

77	NR	NR-II	Haryana	Hisar	Powergrid	400	Patiala, Kaithal, Bawana, Bhiwani, Bassi, Moga-1, Moga-2, Kheddar-1, Kheddar-2	Kaithal-2, Kaithal-1, PG Bhwani, BBMB Bhiwani, Bhiwadi, Moga, Fathehabad. Bhiwani-1, Bhiwani-2, Moga- Bhiwadi (4 feeders).	1	-1	Patiala > Kaithal-2, Kaithal > Kaithal-1, Bawana > PG Bhwani, Bhiwani > BBMB Bhiwani, Bassi > Bhiwadi, Moga-1 > Moga, Moga-2 > Fathabad Kheddar-> Not identified	7	
78	NR	NR-I	Delhi	I.P.Gas turbine / Pragati Power (New Substation)	DTL	220	Rajghat-1, Rajghat-2, Patparganj-1, Patparganj-2, Pragatigas turbin-1, Pragatigas turbin-2	Rajghat-1, Rajghat-2, Patparganj-1, Patparganj-2, Pragatigas turbin-1, Pragatigas turbin-2	As per site survey	0	0	NIL	3
79	ER	ORISSA	Orissa	Ind barath	Ind barath		400kV Jharsuguda 1&2						1
80	ER	ORISSA	Orissa	Indrawati	Powergrid	400	Rengali, Jeypore,	Rengali, Jeypore, Upper Indravati	0	0	-		2
81	ER	ORISSA	Orissa	Indrawati HPS	OPTCL	400	Upper Indravati, Rengali, Jeypore	Indravati PG	-	2	-2	Upper Indravati -> Indravati PG Rengali-> Not available Jeypore-> Not available	1
82	NR	NR-I	Rajasthan	Jaipur (S)-400	Powergrid	400	Agra-2, Jaipur-2 Not identified Not identified	Agra-2, Bassi-2, Agra-1, Bassi-1	As per site survey	0	0	Jaipur-2 > Bassi-2, Not identified > Bassi-1, Not identified > Agra-1	4
83	NR	NR-II	Punjab	Jalandhar	Powergrid	400	Chamera-1, Chamera-2, Amritsar, Moga-1, Moga-2, Ludhiana	Chamera-1, Chamera-2, Amritsar, Moga-1, Moga-2, Ludhiana	Chamera-1, Chamera-2, Amritsar, Moga-1, Moga-2, Ludhiana Chamba-1&2	0	0	NIL	4
84	ER	ER-I	Jharkhand	JAMSHEDPUR	Powergrid	400	Mejia-B, Maithon, Durgapur, Baripada, Chaibasa-1, Chiabasa-2 Durgapur TPS-1,2 Adhunik-1,2 Jamshedpur-(DVC)	Mejia, Maithon, Durgapur-1, Baripada, Chaibasa-1, Rourkela Andal-1,2 Adhunik-1,2 Jamshedpur-(TATA)	0	0	Mejia-B->Mejia, Durgapur->Durgapur-1, Chaibasa-2->Rourkela Durgapur TPS-1,2->Andal- 1,2 Jamshedpur-(DVC)- >Jamshedpur-(TATA)	6	
85	ER	ER-II	West Bengal	JEERAT	WBSETCL	400	400kV Bahrapur Bakreshwar Kolaghat RAJARHAT	400kV Bahrapur Bakreshwar Kolaghat Bubhasgram 220kV Newtown-i(rajarhat-i) Newtown-ii(rajarhat-ii) Rishra-i Rishra-ii Satgachia-i Satgachia-ii Kasba-i Kasba-ii	1	8	400kV rajarhat->bubhasgram	2	

86	ER	ORISSA	Orissa	JEYPORE	Powergrid	400	Gazuwaka-1, Gazuwaka-2, Indrawathi-1, Meramandali	Gazuwaka-1, Gazuwaka-2, Indrawathi-1, Meramandali	-	0	0	nill	2
87	ER	ER-I	Jharkhand	Jharkhand Pool (Chandwa)	Powergrid		Ranchi New 1&2, Gaya 1&2, Essar 1&2, Corporate 1&2						4
88	ER	ORISSA	Orissa	Jharsuguda	Powergrid	765	765kv Angul-1, 765kv Angul-2, 765kv Dharamjaygarh-1 765kv Dharamjaygarh-2 Rourekela-1 Rourekela-2 Raigarh-1, Raigarh-2 Sterlite-1 Sterlite-2 Sterlite-3 Sterlite-4 Barath-1 Barath-2. 765kv Angul-3, 765kv Angul-4, 765kv Dharamjaygarh-3 765kv Dharamjaygarh-4	765kv Angul-1 765kv Angul-2 765kv Dharamjaygarh-1 765kv Dharamjaygarh-2 Rourekela-1 Rourekela-2 Raigarh-1 Raigarh-2 Sterlite-1(F) Sterlite-2(F) Sterlite-3(F) Sterlite-4(F) Barath-1(F) Barath-2(F) Not Existing Not Existing Not Existing Not Existing		0	10	765kv Angul-3-> Not Existing 765kv Angul-4-> Not Existing 765kv Dharamjaygarh-3-> Not Existing 765kv Dharamjaygarh-4-> Not Existing Sterlite-1-> Sterlite-1(F) Sterlite-2->Sterlite-2(F) Sterlite-3->Sterlite-3(F) Sterlite-4->Sterlite-4(F) Barath-1->Barath-1(F) Barath-2->Barath-2(F)	8
89	NR	NR-I	Delhi	Jhatikara-765	Powergrid	765	Bhiwani, Agra	Bhiwani, Agra	As per site survey	0	0	NIL	2
90	NR	NR-II	Haryana	Jind-400	Powergrid	400	Bhiwani-2, HVPNL-2 Not identified Not identified	Bhiwani-2 Hisar-2, Hisar-1, Bhiwani-1,		0	0	HVPNL-2 > Hisar-2, Not identified > Hisar-1, Not identified > Bhiwani-1	4
91	ER	ORISSA	Orissa	Jindal	JITPL		400kV Angul 1&2						2
92	NR	NR-I	Rajasthan	Jodhpur	Rajasthan	400	Merta, Jaiselmer, Kankroli, Rajwest-1, Rajwest-2	Merta-1, Jaiselmer(Akal), Kankroli, Rajwest-1, Rajwest-2	As per site survey	0	0	Merta > Merta-1, Jaiselmer > Jaiselmer(Akal)	3
93	ER	ER-I	BIHAR	Kahalgaoon(KHSTPP)	NTPC	400	Lakhisarai-1,2 Banka-1,2 Farakka-1,2,3,4 Maithon-1,2 Barh-1,2	Lakhisarai-1,2 Banka-1,2 Farakka-1,2,3,4 Maithon-1,2 Barh-1,2		0	0	NA	6
94	NR	NR-II	Haryana	Kaithal	Powergrid		Patiala 1,2,hissar 1,2,meerut-1&2						3
95	ER	ER-II	West Bengal	KALYANESWARI	DVC	220	NA	CTPS line-1,2 Mejia line Burnpur line, MTPS line-1,2, Pithakiariline-1,2		NA	NA	Not in contract->CTPS line-1,2 Not in contract->Mejia line Not in contract->Burnpur line, Not in contract->MTPS line-1,2, Not in contract->Pithakiariline-1,2	4
96	NR	NR-I	Rajasthan	Kankroli	Powergrid	400	Zerda-1, Zerda-2, RAPP-C-1, RAPP-C-2, Jodhpur, Bhinmal	Zerda, Not identified, RAPP-1, RAPP-2, Jodhpur, Bhinmal	As per site survey	1	-1	Zerda-1 > Zerda, Zerda-2 > Not identified, RAPP-C-1 > RAPP-1, RAPP-C-2 > RAPP-2	5

97	NR	NR-I	Uttar pradesh	Kanpur	Powergrid	400	Panki-1&2, Agra, Auria-1&2, Ballabhgarh1,2,3, Allahabad-1, Allahabad-2 Singarauli	Panki-1&2, Agra, Auria-1&2, Ballabhgarh1,2,3, Fatehpur-II Allahabad Fatehpur-I	As per site survey	0	0	Allahabad-1>Fatehpur-II Allahabad-2>Allahabad Singrauli> Fatehpur-I	6
98	NR	NR-I	Uttar Pradesh	Kanpur-765	Powergrid								3
99	ER	ER-II	West Bengal	KASBA	WBSETCL	220	Jeerat-1, Jeerat-2, New town, Budge-Budge-1, Budge-Budge-2,	Jeerat-1, Jeerat-2, CESC, Subhasgram-1, Subhasgram-2,	-	0	0	New town->CESC, Budge-Budge-1-> Subhasgram-1, Budge-Budge-1-> Subhasgram-2,	3
100	ER	ORISSA	Orissa	Keonjhar	Powergrid	400	Rengali Baripada	Rengali Baripada	-	0	0	0	2
101	NR	NR-I	Uttar pradesh	Khara	Uttar pradesh	220	Samli, Shaharanpur	Samli, Shaharanpur	As per site survey	0	0	NIL	1
102	ER	ER-I	Bihar	Kishanganj (karandeghi)	Powergrid		Siliguri 1,2,3&4, Purnea 1,2,3 &4, 400kV Teesta III 1&2, Patna 1&2, Mangan 1&2						4
103	NR	NR-II	Jammu & Kashmir	Kishenpur	Powergrid	400	Wagoora-1, Wagoora-2, Baglihar-1, Baglihar-2, Dulhasti-1, Dulhasti-2, Chamer-II, Moga-1, Moga-2	Wanpoh-1, Wanpoh-2, Baglihar-1, Baglihar-2, Dulhasti-1, Dulhasti-2 (Not Commision), Chamer-II, Moga-1, Moga-2	Wanpoh-1, Wanpoh-2, Baglihar-1, Baglihar-2, Dulhasti-1, Dulhasti-2 (Not Commision), Chamer-II, Moga-1, Moga-2 Wnaph 3&4 Samba 1&2	0	0	Wagoora-1 > Wanpoh-1, Wagoora-2 > Wanpoh-2, Dulhasti-2 > Dulhasti-2 (Not Commisioned)	7
104	ER	ER-II	Jharkhand	Kodarma TPS	DVC	400	Biharshariff-1,2, Gaya 1,2	Biharshariff-1,2, Gaya 1,2, Bokaro-1, Bokaro-2.	-	2	2	Not identified >Bokaro-1 Not identified >Bokaro-2	3
105	ER	ER-II	West Bengal	Kolaghat	WBSETCL	400	400kV jeerat arambag baripada 220kv haldia-i haldia-ii howrah-i howrah-ii	400kV jeerat arambag Kharagpur-2 Kharagpur-1 220kv haldia-i haldia-ii howrah-i howrah-ii		1	1	400kV baripada->kharagpur-2 nill->kharagpur-1	4
106	NR	NR-II	Himachal Pradesh	Koldam	NTPC	400	Not Identified, Ludhiana-2, Parbati pooling, Nalagarh	Ludhiana-1, Ludhiana-2, Parvati, Nalagarh	Ludhiana-1, Ludhiana-2, Banala PG Nalagarh	0	0	Not Identified > Ludhiana-1, Parbati pooling > Parvati	2
107	NER	NER	Assam	KOPILI	NEEPCO	220	Misa-I Misa-II Misa-III	Misa-I Misa-II Misa-III		0	0	NILL	2
108	NR	NR-I	Rajasthan	Kota	Powergrid	400	Merta-1, Merta-2, RAPP-C-1, RAPP-C-2	Merta, Beawar, RAPP-1, RAPP-2	As per site survey	0	0	Merta-1 > Merta, Merta-2 > Beawar, RAPP-C-1 > RAPP-1, RAPP-C-2 > RAPP-2	4

109	NR	NR-I	Rajasthan	Kota TPS	Rajasthan	220	Kota-1, Kota-2, Kota-3, Kota-4, Beawar-1, Beawar-2, Sanganer, Jaipur, m nagar	Sakatpura-1, Sakatpura-2, Sakatpura-3, Sakatpura-4, Bundi, Beawar, Sanganer, Heerapura, Morak	As per SLD	0	0	Kota-1 > Sakatpura-1, Kota-2 > Sakatpura-2, Kota-3 > Sakatpura-3, Kota-4 > Sakatpura-4, Beawar-1 > Bundi, Beawar-2 > Beawar, Jaipur > Heerapura, m nagar > Morak	6
110	NR	NR-I	Uttarakhand	Koteshwar	Powergrid	400	Meerut-1, Meerut-2, Tehri-1, Tehri-2, Koteshwar-1, Koteshwar-2	Meerut-1, Meerut-2, Tehri-1, Tehri-2, Koteshwar-1, Koteshwar-2	As per site survey	0	0	NIL	3
111	NR	NR-I	Rajasthan	Kotputli-400	Powergrid	400	Bhiwadi-1, Jaipur-1	Bhiwadi, Bassi , Future Line	Bhiwadi, Bassi	1	1	Bhiwadi-1 > Bhiwadi-1, Jaipur-1 > Bassi, Not identified > Future Line.	3
112	ER	ER-I	BIHAR	LakhiSarai	Powergrid	400	Biharshariff-1,2 Kahalgaoon-1,2	Biharshariff-1,2 Kahalgaoon-1,2	-	0	0	NA	4
113	NR	NR-II	Punjab	Lehara	Punjab	220	Mansa-1, Mansa-2, Batinda-1, Batinda-2, Bazakhana-1, Bazakhana-2, Barnala-BBMB, PSEB	Talwandi Sabo, Dhanaula, Batinda-1, Batinda-2, Bazakhana-1, Bazakhana-2, Barnala-1, Barnala-2		0	0	Mansa-1 > Talwandi Sabo, Mansa-2 > Dhanaula, Barnala-BBMB > Barnala-1, PSEB > Barnala-2	5
114	NR	NR-I	Uttar pradesh	Lucknow	Powergrid	400	Gorakhpur-1,2,3,4, Unnao-1&2, Bareilly-2, Balua-1, Balua-2, Bareilly-1, Lucknow(UP), Sultanpur	Gorakhpur-1,2,3,4, Unnao-1&2, Bareilly-2, Sohawal-1, Sohawal-2, Roja, Sultanpur, Sarojini nagar	As per site survey	0	0	Lucknow(UP)> Sultanpur Sultanpur> Sarojini Nagar Bareilly-1> Roja Balua-1> Sohawal-1 Balua-2> Sohawal-2	6
115	NR	NR-I	Uttar Pradesh	Lucknow UPPTCL	Uttar pradesh	400	Bareilly(PG), Lucknow(UP), Unnao, Singarauli	Bareilly, Kursiroad, Unnao, Singarauli	As per site survey	0	0	Lucknow(UP) > Kursiroad	2
116	NR	NR-I	Uttar pradesh	Lucknow-765	Powergrid	765	Balia-1	Balia-1, Future Line, Bareilly-1	-	2	2	Not identified > Bareilly Not identified > Future Line	3
117	NR	NR-II	Punjab	Ludhiana	Powergrid	400	Malerkotla, Jalandhar, Patiala-1, Patiala-2, Koldam-1, Koldam-2	Malerkotla, Jalandhar, Patiala-1, Patiala-2, Koldam-1, Koldam-2	-	0	0	NIL	5
118	NR	NR-I	Delhi	Maharanibagh	Powergrid	400	Dadri,ballabhgarh	Dadri,ballabhgarh	As per site survey	0	0	NIL	1
119	NR	NR-I	Uttar Pradesh	Mainpuri	Powergrid		Allahabad-1&2,Ballabhgarh- 1&2						3

120	ER	ER-II	West Bengal	MAITHON	Powergrid	400	durgapur ranchi maithon rb-i maithon rb-ii kahalgaon-i raghunathpur mejia b-iii jamshedpur mejia b-i kahalgaon-ii gaya-i gaya-ii mejia b-ii	durgapur-2 ranchi right bank-i right bank-ii kahalgaon-i raghunathpur mejia b-iii jamshedpur mejia b-i kahalgaon-ii gaya-i gaya-ii mejia b-ii durgapur-1		7	1	durgapur->durgapur-ii nill->durgapur-i maithon rb-i->right bank-i maithon rb-ii->right bank-ii raghunathpur->rtps mejia b3->mejia-iii mejia b1->mejia-i mejia b2->mejia-ii	7
121	ER	ER-II	Jharkhand	Maithon RB TPS	DVC	400	Ranchi (PG) 1&2, Maithon 1&2	Ranchi (PG) 1&2, Maithon 1&2	-	0	0	NIL	2
122	ER	ER-II	West Bengal	MALDA	Powergrid	400	Farakka-1, Farakka-2, Purnea-1, Purnea-2,	Farakka-1, Farakka-2, Purnea-1, Purnea-2,	-	0	0	Nill	2
123	NR	NR-II	Punjab	Malerkotla	Powergrid	400	Patiala, Dadri, Ludhiana	Patiala, Dadri, Ludhiana	-	0	0	NIL	2
124	NR	NR-I	Uttar pradesh	Mandola	Powergrid	400	Meerut-1&2, Bawana-1&2, Dadri-1&2, Bareli-1 Bareli-2 Not identified, Not identified, Not identified	Meerut-1&2, Bawana-1&2, Dadri-1&2, Meerut-III, Meerut- IV Not identified, Not identified, Not identified	As per site survey	3	-3	Barelli-1 > Meerut-III Barelli-2 > Meerut-IV	4
125	NR	NR-I	Haryana	Manesar-400	Powergrid	400	Gurgaon-2 Neemrana-2 Not identifird Not identified	Gurgaon-2 Neemrana-2 Gurgaon-1 Neemrana-1	As per site survey	0	0	Not identified > Gurgaon-1 Not identified > Neemrana-1	2
126	NER	NER	Assam	Mariani	AEGCL	220	Kaithalguri , Misa, Samaguri 1 &2	Kaithalguri , Misa, Samaguri 1 &2	-	0	0	NA	2
127	NR	NR-I	Uttar pradesh	Meerut	Powergrid	400	Mandola-1&2, Koteshwar1&2, Muzaffarnagar, Kaithal-1,2, Moga	Mandola-1&2, Koteshwar1&2, Muzaffpur, Kaithal-1,2, Not identified	As per site survey	1	-1	Moga> Not identified	4
128	ER	ER-II	West Bengal	MEJIA	DVC	220	Kalswari-1, Klaswari-2, Waria-1, Waria-2, Chandrapur-1, Chandrapur-2.	Kalyanawshri, Bunpur, DTPS-1, DTPS-2, Kalyanaswari-1, Kalyanaswari-2, Durgapur(muchipuna-1), Durgapur(muchipuna-2) Borjora-1, Borjorar-2,	-	4	4	Kalswari-1->Kalyanawshri, Klaswari-2->Bunpur Waria-1->DTPS-1, Waria-2->DTPS-2, Chandrapur-1->Kalyanaswari-1, Chandrapur-2->Kalyanaswari-2, Nill->Durgapur(muchipuna-1), Nill->Durgapur(muchipuna-1), Nill->Borjora-1, nill->Borjora-2,	5

129	ER	ER-II	West Bengal	MEJIA-B	DVC	400	Maithon-1, Maithon-2, Maithon-3, Jamshedpur	Maithon-1, Maithon-2, Maithon-3, Jamshedpur		0	0	-	2
130	ER	ORISSA	Orissa	MENDHASAL	OPTCL	400	Meramundali-1,2 Uttara-1,2 KVK Duburi	Meramundali-1,2 Baripada-1,2		2	2	Uttara-1,2->Not available KVK->Not available Duburi->Not available Not in contract->Baripada-1 Not in contract->Baripada-2	2
131	ER	ORISSA	Orissa	MERAMANDALI	OPTCL	400	Bolangir Mendhasal-1,2 TSTPP-1 TSTPP-2 Duburi-1,2	Angul-1, Mendhasala-1,2 Kaniha, Angul-2, Duburi-1,2, IBTPS-1,2(Sterlite-1,2) JSPL-1,2, GMR		5	5	Bolangir->Angul-1, Mendhasal-1,2-> Mendhasala-1,2 TSTPP-1->Kaniha, TSTPP-2->Angul-2, Not in contract->IBTPS-1,2(Sterlite-1,2) Not in contract->JSPL-1,2, Not in contract->GMR,	6
132	NR	NR-I	Rajasthan	Merta City	Rajasthan	400	Kota-1, Kota-2, Heerapur, Ratangarh, Jodhpur	Kota, SCL-Beawar, Heerapur, Ratangarh, Jodhpur	As per site survey	0	0	Kota-1 > Kota, Kota-2 > SCL-Beawar	3
133	NER	NER	Assam	Misa	Powergrid	400	Balipara PG 1 & 2 220kV Dimapur 1 & 2 220kV KOPIII 1, 2, & 3 220kV Byrnihat 1 & 2 Samaguri 1 & 2 220kV Mariani, 220kV Mariani (N)	Balipara 1 & 2 220kV Dimapur 1 & 2 220kV KOPIII 1, 2, & 3 220kV Byrnihat 1 & 2 220kV Samaguri 1 & 2 220kV Mariani, 220kV Kaithalguri	-	0	0	Balipara PG 1 & 2 > Balipara 1 & 2 Samaguri 1 & 2 > 220KV Samaguri 1 & 2 220kV Mariani (N) > 220kV Kaithalguri,	7
134	NR	NR-II	Punjab	Moga	Powergrid	400	Mandaula-1,, Mandaula-2, Mandaula-3, Mandaula-4, Bareilly-1, Bareilly-2, Tehri pooling-1, Tehri pooling-2, Muzaffarnagar, Baghpat-1, Baghpat-2	Jalandhar-1, Jalandhar-2, Kishenpur-1, Kishenpur-2, Bhiwadi-1, Bhiwadi-2, Fatehabad, Nakedar, Hissar, Talwandi Sabo	Jalandhar-1, Jalandhar-2, Kishenpur-1, Kishenpur-2, Bhiwadi-1, Bhiwadi-2, Fatehabad, Nakedar, Hissar, Talwandi Sabo	1	-1	As per Site survey all feeder names are not matching with contract.	5
135	NR	NR-II	Punjab	Moga 765	Powergrid	765	Bhiwani	Bhiwani	Bhiwani Meerut	0	0	NIL	2
136	ER	ORISSA	Orissa	Monnet	Monnet		400kV Angul 1&2						1
137	NR	NR-I	Uttar pradesh	Moradabad	Uttar pradesh	400	Bareli-1&2, Kashipur, Muradnagar	Bareli-1&2, Kashipur, Muradnagar	As per site survey	0	0	NIL	2
138	NR	NR-I	Uttar pradesh	Muradnagar	Uttar pradesh	400	Muzaffarnagar,Dadri, Agra(UPPPCL),Muradabad, Panki	Muzaffarnagar,Dadri, Agra(UPPPCL),Muradabad, Panki	As per site survey	0	0	NIL	3
139	ER	ER-I	Bihar	MUZAFFAPUR	Powergrid		Gorakhpur 1&2, Purnea 1&2, B'Shariff 1&2						5
140	NR	NR-I	Uttar pradesh	Muzaffarnagar	Uttar pradesh	400	Vishnu Prayag-1&2, Meerut,Muradnagar, Rishkesh	Vishnu Prayag-1&2, Meerut,Muradnagar, Roorkee	As per site survey	0	0	Rishkesh--> Roorkee	3

141	NR	NR-II	Himachal pradesh	Nallagarh	Powergrid	400	N Jhakri-1&2, Patiala-1&2, Koldam-1,2	N Jhakri-1&2, Patiala-1&2, Koldam-1,2	Rampur-1&2, Patiala-1&2, Koldam-1,2	0	0	NIL	3
142	NR	NR-II	Himachal pradesh	Naptha Jhakri	SJVNL	400	Baspa-1&2, Rampur-1 Rampur-2, Abdullapur-1 Abdullapur-2	Baspa-1&2, Nalagarh-1, Nalagarh-2, Panchkula-1, Panchkula-2	Baspa-1&2, Rampur-1, Rampur-2, Panchkula-1, Panchkula-2	0	0	Rampur-1>Nalagarh-1 Rampur-2>Nalagarh-2 Abdullapur-1>Panchkula-1 Abdullapur-2>Panchkula-2	3
143	NR	NR-I	Rajasthan	Neemrana-400	Powergrid	400	Manesar-2, Bhiwadi-1, Sikar-2, Jhunjhunu-2 Not Identified Not Identified Not Identified Not Identified	Manesar-2, Bhiwadi-1, Sikar-2, Manesar-1, Bhiwadi-2, Sikar-1 Not Identified Not Identified	As per site survey	2	-2	Jhunjhunu-2 >Manesar-1, Not identified > Bhiwadi-2, Not identified >Sikar-1	6
145	NR	NR-I	Uttar pradesh	Obra-ATPS	Uttar Pradesh	400	Anpra-1, Sultanpur, Anpra-2, Unnao	Anpra-1, Sultanpur, Kanpur, Not identified	As per site survey	1	-1	Anpara-2 > Kanpur Unnao> Not identified	3
146	NR	NR-I	Uttar Pradesh	Obra-BTPS	Uttar pradesh	220	RewaRoad-1, RewaRoad-2, RewaRoad-3, Shahupuri	RewaRoad-1, RewaRoad-2, RewaRoad-3, Mughal sari 1 Mughal sari 2	As per site survey	0	0	RewaRoad-1 > Allahabad-1, RewaRoad-2 > Allahabad-2, RewaRoad-3 > Allahabad-3, Shahupuri > Mughalsari-1, Not Identified > Mughalsari-2	2
147	NR	NR-II	Haryana	Panchkula-400	Powergrid	400	Not Identified, Nathpa Jhakri-2, Not Identified, Abdullapur-2	Nathpa Jhakri-1, Nathpa Jhakri-2, Abdullapur-1, Abdullapur-2		0	0	Not Identified > Nathpa Jhakri-1, Not Identified > Abdullapur-1	4
148	NR	NR-II	Haryana	Panipat	BBMB	400	Dadri-1, Dadri-2, Panchkula-1	Dadri-1, Dadri-2, Dehar	-	0	0	Panchkula-1 > Dehar	2
149	NR	NR-II	Haryana	Panipat-ST1 / Yamuna Nagar (New Substation)	HPGCL	220	panipath-BBMB-1, panipath-BBMB-2, panipath-BBMB-3, panipath-BBMB-4, Sonipath-1, Sonipath-2.	Sewah Ckt-I, Sewah Ckt-II, Sewah Ckt-III, Sewah Ckt-IV, PTPS-Sonipat Ckt-I, PTPS-Sonipat Ckt-II		0	0	Panipat-BBMB-I >PTPS-Sewah Ckt-I Panipat-BBMB-II > PTPS-Sewah Ckt-II. Panipat-BBMB-III > PTPS-Sewah Ckt-III . Panipat-BBMB-IV > PTPS-Sewah Ckt-IV Sonipat-I > PTPS-Sonipat Ckt-I Sonipat-II > PTPS Sonipat Ckt-II	3
150	NR	NR-II	Haryana	Panipat-ST2	HPGCL	220	Safidon-1, Safidon-2, Safidon-3, Jind-1&2, Nissing-1&2, Rohtak-1&2, Kernal, Safidon-4.	Safidon-1, Safidon-2, Safidon-3, Jind-1&2, Nissing-1&2, Rohtak-1&2, Kernal, Bastara		0	0	Safidon-4> Bastara	6

151	NR	NR-I	Uttar pradesh	Panki	Uttar pradesh	400	Kanpur-1 Kanpur-2, Obra, Muradnagar, Unnao1, Unnao 2.	Kanpur-1 Kanpur-2, Obra, Muradnagar, Unnao, Not identified	As per site survey	1	-1	Unnao-1 > Unnao Unnao-2 > Not identified	3
153	NR	NR-II	Himachal Pradesh	Parbati III	NHPC		Parbati-II & parbati pooling						1
154	NR	NR-II	Himachal Pradesh	Parbati P.S. (Banala)	Powergrid	400	Parbati-II, Parbati-III, Koldam, Nallagarh, Amritsar, Hamirpur	Parbati-II, Parbati-III, Koldam, Nallagarh, Amritsar, Hamirpur	Parbati-II, Parbati-III, Koldam, Nallagarh, Amritsar, Hamirpur	0	0	NIL	3
155	ER	ER-II	West Bengal	PARULIA	DVC	220	NA	DTPS line-1,2 PGCIL line-1,2 DSP line-1,2,3 Durgapur line-1,2		NA	NA	Not in contract->DTPS line-1,2 Not in contract->PGCIL line-1,2 Not in contract->DSP line-1,2,3 Not in contract->Durgapur line-1,2	5
156	NR	NR-II	Punjab	Patiala	Powergrid	400	Kaithal-1, Kaithal-2, Nalagarh-1, Nalagarh-2, Malerkotala, Ludhiana-1, Ludhiana-2	Kaithal-1, Kaithal-2, Nalagarh-1, Nalagarh-2, Malerkotala, Ludhiana-1, Ludhiana-2	Kaithal-1, Kaithal-2, Nalagarh-1, Nalagarh-2, Malerkotala, Ludhiana-1, Ludhiana-2	0	0	NIL	4
157	ER	ER-I	BIHAR	PATNA	Powergrid	400	Ballia-1,2,3,4 Barh-1.2.3.4 Karandeghi-1,2 Nabinagar-1,2	Ballia-1,2,3,4 Barh-1.2.3.4 Kishanganj-1,2		2	2	Karandeghi-1,2->not available Nabinagar-1,2->not available Not in contract->Kishanganj-1,2	6
158	ER	ER-I	Jharkhand	Patratu	Jharkhand	220	Bodhgaya-1, Bodhgaya-2 Bodhgaya-3, Hatia	gaya-1, Hatia-1 TVNL, Hatia-2	-	0	0	Bodhgaya-1->gaya-1, Bodhgaya-2->Hatia-1 Bodhgaya-3->TVNL, Hatia->Hatia-2	3
159	NR	NR-I	Uttarakhand	Pithoragarh-220kV	Powergrid	220	-	Dhauliganga, Bareilly		2	2	Feeder name not in contract-> Dhauliganga Feeder name not in contract-> Bareilly	1
160	NR	NR-II	Himachal Pradesh	Pong	BBMB	220	Dasuya-1, Dasuya-2, Jallandaher-1, Jallandaher-2, Bairasul, Jassor	Dasuya-1, Dasuya-2, Jallandaher-1, Jallandaher-2, Bairasul, Jassor		0	0	NIL	3
161	ER	ER-I	BIHAR	Purnea	Powergrid	400	Karandeghi-1,2,3,4 Muzaffarpur-1,2 Malda-1,2 Biharshariff-1,2 Farakka, Gokarana	Siliguri-1,2,3,4, Muzaffarpur-1,2, Malda-1,2, Biharshariff-1,2, Future-1 Future-2		6	0	Karandeghi-1,2,3,4->Siliguri-1,2,3,4, Farakka->Future-1 Gokarana->Future-2	6
162	ER	ER-II	West Bengal	Purulia PSP	WBSETCL								2
163	ER	ER-II	West Bengal	Raghunathpur TPS	DVC	400	maithon ranchi-i ranchi-ii ranchi-iii dtps-i dtps-ii	maithon ranchi-i ranchi-ii ranchi-iii dtps-i dtps-ii		0	0	nill	3

164	ER	ER-II	West Bengal	Rajarhat	Powergrid		Gokarna, Farakka, Subhashgram, jeerat, Chanditala 1&2						2
165	ER	ER-I	Jharkhand	RANCHI	Powergrid	400	Rourkela-1, Rourkela-2, Sipat-1, Sipat-2, Maithon RB1, Maithon RB2, Ragunathpur 1, Ragunathpur 2, Ragunathpur 3, Corporate-1, Corporate-2, Maithon	Rourkela-1, Rourkela-2, Sipat-1, Sipat-2, Maithon RB1, Maithon RB2, Ragunathpur 1, Ragunathpur 2, Ragunathpur 3, Chitarpur-1, Chitarpur-2, Maithon-1 Ranchi NRNC-1, Ranchi NRNC-2, Ranchi NRNC-3, Ranchi NRNC-4,		3	5	Corporate-1->Chitarpur-1, Corporate-2->Chitarpur-2, Maithon->Maithon-1 Not in contract->Ranchi NRNC-1, Not in contract->Ranchi NRNC-2, Not in contract->Ranchi NRNC-3, Not in contract->Ranchi NRNC-4,	12
166	NER	NER	Assam	RANGANADI	Powergrid	400							1
167	ER	ER-II	Sikkim	RANGPO	Powergrid	400	mangan-i karandeghi-i mangan-ii karandeghi-ii siliguri-ii teesta-v- line-i teesta-v-line-ii siliguri-I 220kV New Melli 1,2,3&4, 220kV Teesta VI 1&2, 220kV Rongnichu 1&2	teesta-iii-line-i kishanganj Line-i teesta-iii-line-ii kishanganj Line-i siliguri-ii teesta-v- line-i teesta-v-line-ii siliguri-i. 220kV- Not available.		2		mangan-i->teesta-iii-line-i mangan-ii->teesta-iii-line-ii Karandeghi - i,ii->Kishanganj-i,ii	4
168	NR	NR-I	Rajasthan	RAPP_C	NPCIL	400	Kota-1, Kankroli-1, Kankroli-2, Nagda-1, Nagda-2	Kota-1, Kankroli-1, Kankroli-2, Future bay, Future bay	Kota-1, Kankroli-1, Kankroli-2, Future bay, Future bay	0	0	Nagda-1 > Future bay Nagda-2 > Future bay	3
169	NR	NR-I	Rajasthan	Ratangarh	Rajasthan	400	STPS-1 (Suratgarh), STPS-2 (Suratgarh), Sikar-1, Sikar-2, Merta	STPS-1, STPS-2, Sikar-1, Sikar-2, Merta	As per site survey	0	0	Suratgarh-1 > STPS-1, Suratgarh-2 > STPS-2	3
170	ER	ORISSA	Orissa	RENGALI	OPTCL	220	Rengali(0)-1,2 Nalco, TSTPP	Rengali swyd-1,2 TTPS, Kaniha		4	0	Rengali(0)-1,2->Rengali swyd-1,2 Nalco->TTPS, TSTPP->Kaniha	2
171	ER	ORISSA	Orissa	Rengali	Powergrid	400	TSTPP1, TSTPP2, Upper Indravathi, Keonjor	Talcher-1, Talcher-2, Baripada.	-	0	0	TSTPP1->Talcher-1, TSTPP2->Talcher-2, Upper Indravathi->Indravathi Keonjor->Baripada.	2
172	NR	NR-I	Uttar pradesh	Rihand HVDC	Powergrid	400	Rihand-N-1, Rihand-N-2	HVDC Pole-1 HVDC Pole-2	As per site survey	0	0	Rihand-N-1 > HVDC Pole-1 Rihand-N-2 > HVDC Pole-2	1
173	NR	NR-I	Uttar pradesh	Rihand-NT	NTPC	400	Singrauli-1, Singrauli-2, Allahabad-1, Allahabad-2, Rihand-HVDC-1, Rihand-HVDC-2	Singrauli-1, Singrauli-2, Allahabad-1, Allahabad-2, Rihand-HVDC-1, Rihand-HVDC-2	As per site survey	0	0	NIL	3

174	NR	NR-I	Uttarakhand	Rishikesh	Uttarakhand	400	Kishenpur, Muzaffarnagar	Kashipur, Puhana(Roorkee)	As per site survey	0	0	Kishenpur > Kashipur, Muzaffarnagar > Puhana(Roorkee)	1
175	NR	NR-I	Uttarakhand	Roorkee	Powergrid	400	Muzaffarnagar, Rishikesh	Muzaffarnagar, Rishikesh	As per site survey	0	0	NIL	2
176	NR	NR-II	Punjab	Ropar GGS TPS	Punjab	220	Govindnagar-1, Govindnagar-2, Govindnagar-3, Govindnagar-4, Jamsher-1, Jamsher-2, Sanehwal-1, Sanehwal-2, Mohali-1, Mohali-2	Govindnagar-1, Govindnagar-2, Govindnagar-3, Bassi Pathana, Jamsher, Goraya, Gonsgarh, Ghulal, Kharar, Mohali		0	0	Govindnagar-4 > Bassi Pathana, Jamsher-1 > Jamsher, Jamsher-2 > Goraya, Sanehwal-1 > Gonsgarh, Sanehwal-2 > Ghulal, Mohali-1 > Kharar, Mohali-2 > Mohali	5
177	ER	ORISSA	Orissa	ROURKELA	Powergrid	400	Raigarh-1, Raigarh-2, Ranchi-1, Ranchi-2, Chaibasa-1, Chaibasa-2, TSTPP1-1, TSTPP1-2, TSTPP1-3, TSTPP1-4, Jharsuguda-1 Jharsuguda-2	Sundergarh-1, Raigarh-2 Ranchi-1, Ranchi-2, Jamshedpur-1, Jamshedpur-2, TSTPP-1, TSTPP-2 N/A N/A Sundergarh SEL-2		2	-2	Raigarh-1->Sundergarh-1, Chaibasa-1->Jamshedpur- 1, Chaibasa-2->Jamshedpur- 2, Jharsuguda-1->sundergarh Jharsuguda-2->SEL-2	5
178	NR	NR-I	Uttar Pradesh	Saharanpur-400	Powergrid								2
179	NR	NR-I	Uttar pradesh	Sahupuri	Uttar pradesh	220	Pusauli, Karmasa, obra-1&2, Ajamgarh-1, Ajamgarh-2 Not identified, Not identified.	Pusauli, Sarnath obra-1&2, Bhelupur-1, Bhelupur--2	As per site survey	2	2	Ajamgarh-1-> Bhelupur-1 Ajamgarh-2-> Bhelupur-2 Karmasa->132kv Not considered Not in contract-> Sarnath	3
180	NER	NER	Assam	Samaguri	AEGCL	220	sarusajai misa pg-I misa pg-II Balipara-I Balipara-II Mariani-I Mariani-II J.Nagar	sarusajai-I misa pg-I misa pg-II Balipara-I Mariani sarusajai-I Balipara-II Mariani-II		0	2	sarusajai-> sarusajai-I Balipara-II->Mariani Mariani-I->sarusajai-I Mariani-II-> Not available J.Nagar > Not available	4
181	NR	NR-II	Jammu & Kashmir	Samba	Powergrid								3
182	NR	NR-I	Uttar Pradesh	Sarnath	Uttar pradesh		Allahabad,Azamgarh,Anpara- 1&2,Biharsharif						3
183	ER	ER-I	BIHAR	SASARAM(Pusauli)	Powergrid	765	765kv Fatehpur, 400kv Dalthongung-1,2 400kv Saranath-1 400kv Saranath-2 400kv Biharshariff-1,2 400kv Nabinagar-1,2 765kv Gaya, 765kv Varanasi,	765Kv Fatehpur, 400kv Dalthongung-1,2 400kv Saranath 400kv Allahabad 400kv Biharshariff-1,2 400kv Nabinagar-1,2 400Kv Biharshariff-3,4		2	0	400kv Saranath-1->400kv Saranath-1 400kv Saranath-2->400kv Allahabad Not in contract->400kv Biharshariff-3 Not in contract->400kv Biharshariff-4 765kv Gaya-> Future 765kv Varanasi-> Future	9

184	NR	NR-I	Rajasthan	Sikar	Powergrid	400	Ratangarh-1, Ratangarh-2, Agra-1, Agra-2, Bassi-1, Bassi-2	Ratangarh-1, Ratangarh-2, Agra-1, Agra-2, Bassi-1, Bassi-2	As per site survey	0	0	NIL	6
185	NER	NER	Assam	Silchar	Powergrid	400	Azara, 400kV Byrnihat, Pallatana 1 Pallatana 2,	Bongaigaon-1, Bongaigaon-2, Pallatana 1 Pallatana 2,.		0	0	Azara > Bongaigaon-1, 400kV Byrnihat > Bongaigaon-2	4
186	NR	NR-I	Uttar Pradesh	Singrauli	NTPC		Vindhyachal-1,2,Rihand- 1,2,Alahabad- 1,2,Anapara,Luknow,Kanpur						5
187	NR	NR-I	Uttar Pradesh	Sohawal-400	Powergrid	400	Balia-2 , Lucknow-2	Balia-2, Lucknow-2, Balia-1, Lucknow-1. Future Line,	Balia-2, Lucknow-2, Balia-1, Lucknow-1.	0	0	Not identified > Balia-1, Not identified > Lucknow-1 Not identified > Future Line	4
188	NR	NR-II	Haryana	Sonipat	Powergrid	400	Bhadurgarh-1,2, Abdullapur-1,2	Bhadurgarh-1,2, Abdullapur-1,2	-	0	0	NIL	4
189	ER	ORISSA	Orissa	Strelite	Strelite		400kV Jharsuguda 1,2,3&4						3
190	ER	ER-II	West Bengal	SUBHASHGRAM	Powergrid	400	rajarhat sagardighi haldia-i haldia-2	rajarhat sagardighi haldia-i haldia-2		1	0	rajarhat->jeerat	2
191	NR	NR-I	Uttar pradesh	Sultanpur	Uttar pradesh	400	Obra, Azamgarh, lko(pg)	Obra, Azamgarh, Lucknow	As per site survey	0	0	NIL	2
192	ER	ORISSA	Orissa	TALCHER	NTPC		Kolar 1&2, Rengali 1&2, Meeramandali 1&2, Rourkela 1,2,3&4, Behrampur 1&2,						5
193	ER	ER-II	Sikkim	TEESTA	Powergrid		Rangpo 1&2						1
194	NR	NR-I	Uttarakhand	Tehri	THDC	400	Koteswar-1, Koteswar-2	Line-1, Line-2	As per site survey	0	0	Koteswar-1 > Line-1, Koteswar-2 > Line-2	1
196	ER	ER-I	Jharkhand	Tenughat	Jharkhand		Biharshariff(BSEB),parratu						2
197	NER	NER	Assam	Tinsukia	AEGCL	220	Behiting 1 Behiting 2 Makum	Kaithalguri-1, Kaithalguri-2, Namrup-1, Namrup-2	-	1	1	Behiting 1 ->Kaithalguri-1, Behiting 2 ->Kaithalguri-2, Makum ->Namrup-1, Not identified->Namrup-2	2
199	ER	ORISSA	Orissa	TTPS(Talcher)	OPTCL								3
200	ER	ORISSA	Orissa	U.KOLAB	OPTCL	220	Jayangar-1, Jayangar-2, Therubali,	Jayangar-1, Jayangar-2, Therubali,	Jayangar-1, Jayangar-2, Therubali,	0	0	nill	2
201	NR	NR-I	Uttar Pradesh	Unchahar (Newly Added)	NTPC								5
202	NR	NR-I	Uttar pradesh	Unnao	Uttar pradesh	220	Barelli(UP)-1&2, Lko(PG)-1&2, Lko(UP), Agra(UP), Panki, Anpara.	Barelli(UP)-1&2, Lko(PG)-1&2, Lko(UP), Agra(UP), Panki, Not identified.	As per site survey	1	-1	Anpara > Not identified	4

203	NR	NR-II	Jammu & Kashmir	Uri	NHPC	400	Wagoora-1, Wagoora-2, Urill	Wagoora-1, Wagoora-2, Urill		0	0	NIL	2
204	ER	ER-II	Orissa	Uttara	Powergrid		Mehandsal 1&2, Khargpur1&2						2
205	NR	NR-I	Uttar Pradesh	Varanasi-765	Powergrid		Gaya-2, Fatehpur-1, Kanpur-2,						6
206	NR	NR-II	Jammu & Kashmir	Wagoora	Powergrid	400	Uri-I-1, Uri-I-2, Uri-II-1, New Wanpoh-1, New Wanpoh-2	Uri-I-1, Uri-I-2, Uri-II-1, Wanpoh-1, Wanpoh-2		0	0	New Wanpoh-1 > Wanpoh-1, New Wanpoh-2 > Wanpoh-2,	3
207	NR	NR-II	Jammu & Kashmir	Wanpoh	Powergrid	400	Wagoora-1, Wagoora-2, Kishenpur -1, Kishenpur -2, Kishenpur -3, Kishenpur -4	Wagoora-1, Wagoora-2, Kishenpur -1, Kishenpur -2, Kishenpur -3, Kishenpur -4	As per site survey	0	0	NIL	6
208	SR	SR - I	Andhra Pradesh	Chittur	APTRANSCO	400	Chinkampally, Sriperumbudur	Cudappah, Madras	Cudappah, Madras, TVLM1, TVLM2, KPATNAM1, KPATNAM2.	0	0	Chinkampally > Cudappah, Sriperambudur > Madras	5
209	SR	SR - I	Andhra Pradesh	Srikakulam (Palasa)	APTRANSCO								4
210	SR	SR - II	Tamil Nadu	Kalivanthapattu	Powergrid	400	Kolar, Sriperumbudur	Vallur-1, Vallur-2	As per site survey	0	0	Kolar > Vallur-1, Sriperumbudur > Vallur-2	6
211	SR	SR - II	Tamil Nadu	Karaikudi New	Powergrid	400	Madurai, Trichy	Madurai, Trichy	As per site survey	0	0	NIL	4
212	SR	SR - II	Karnataka	Narendra	Powergrid	400	Kaiga-1, Kaiga-2, Guttur-1, Guttur-2, Nareandra765-1, Nareandra765-2	Kaiga-1, Kaiga-2, Dawangree-1, Dawangree-2, Not identified, Not identified	As per site survey	2	-2	Guttur-1 > Dawangree-1, Guttur-2 > Dawangree-2, Nareandra765-1 > Not identified, Nareandra765-2 > Not identified	3
213	SR	SR - II	Tamil Nadu	Pugalur	Powergrid	400	Neyveli TS-2, Neyveli TS-2 Exp, Madurai -1, Madurai -2	Neyveli TS-2, Neyveli TS-2 Exp, Madurai -1, Madurai -2	-	0	0	NIL	6
214	SR	SR - I	Telangana	Mamidipally	TSTRANSCO	400	Ghanapur, Khamam 1&2, SLBPH 1&2	Ghanapur, Khamam 1&2, Srisailem 1&2		0	0	SLBPH 1 > Srisailem 1 SLBPH 2 > Srisailem 2	3
215	SR	SR - II	Tamil Nadu	Tirunelveli	Powergrid	400	Madurai-1, Madurai-2, Udumalpet-1, Udumalpet-2, Koodankulam-1, Koodankulam-2, Koodankulam-3, Koodankulam-4, Trivendram-1, Trivendram-2, Edamom-1, Edamom-2, Edamom-1(m/c), Edamom-2(m/c), Edamom-3(m/c), Edamom-4(m/c)	Madurai-1, Madurai-2, Udumalpet-1, Udumalpet-2, Koodankulam-1, Koodankulam-2, Koodankulam-3, Koodankulam-4, Trivendram-1, Trivendram-2, Edamom-1, Edamom-2, Not identified, Not identified, Not identified, Not identified	Madurai-1, Madurai-2, Udumalpet-1, Udumalpet-2, Koodankulam-1, Koodankulam-2, Koodankulam-3, Koodankulam-4, Trivendram-1, Trivendram-2	4	-4	Edamom-1(m/c) > Not identified, Edamom-2(m/c) > Not identified, Edamom-3(m/c) > Not identified, Edamom-4(m/c) > Not identified	7

216	SR	SR - I	Andhra Pradesh	Warangal	Powergrid	400	Ramagundam, Bhopalpally -1, Bhopalpally -2, Khammam	Ramagundam, Bhopalpally -1, Bhopalpally -2, Khammam	As per site survey	0	0	NIL	4
217	SR	SR - I	Andhra Pradesh	Kurnool 765	Powergrid	400	Raichur-1, Nagarjunasagar-1, Gooty-1, Kurnool(AP)-1, Kurnool(AP)-2, Nellore-1, Nellore-2, Thiruvalem-1, Thiruvalem-2	Raichur-2, Nagarjunasagar-1, Gooty, Kurnool-1, Kurnool-2, Nellore-1 (Not Erected), Nellore-2 (Not Erected), Thiruvalem-1 (Not Erected), Thiruvalem-2 (Not Erected)	Raichur(N)-2, Nagarjunasagar-1, Gooty, Kurnool-1, Kurnool-2, Nellore-1 (Not Erected), Nellore-2 (Not Erected), Thiruvalem-1 (Not Erected), Thiruvalem-2 (Not Erected) Raichur(N)-1,	0	0	Raichur-1 > Raichur-2, Gooty-1 > Gooty, Kurnool(AP)-1 > Kurnool-1, Kurnool(AP)-2 > Kurnool-2	8
218	SR	SR - I	Karnataka	Raichur 765	Powergrid	400	Kurnool-1, Kurnool-2, Raichur-1, Raichur-2, Gooty-1, Gooty-2, Sholapur-1	Kurnool-1 (Not Commision), Kurnool-2, Raichur-1, Raichur-2, Gooty-1, Gooty-2, Sholapur-1	As per site survey	0	0	Kurnool-1 > Not Commision	5
219	SR	SR - II	Karnataka	Madhugiri 765	Powergrid	400	Gooty-1&2, Yelahanka 1 &2, New Salem-1, Narendra-1,2	Gooty-1&2, Yelahanka 1 &2, Under Construction, Under Construction	-	3	-3	New Salem-1 > Under Construction, Narendra-1,2 > Under Construction,	5
220	SR	SR - II	Karnataka	Hassan	Powergrid	400	Mysore-1, Mysore-2, Neelmangalam	Mysore-1, Mysore-2, Neelmangalam	Mysore-1, Mysore-2, Neelmangalam Talaguppa Udipi-1 Udupi-2	0	0	NIL	6
221	SR	SR - I	Andhra Pradesh	Cuddappah PG	Powergrid	400	Nagarjunsagar-1, Nagarjunsagar-2, Chittoor	Nagarjunsagar-1, Nagarjunsagar-2, Chittoor	As per site survey	0	0	NIL	2
222	SR	SR - II	Tamil Nadu	Salem PS	Powergrid	400	Somanahalli-1&2, Nagapattanam PS-1, Nagapattanam PS-2, Madugiri-1	Somanahalli-1&2, Salem-1, Salem-2, Madugiri-1	-	0	0	Nagapattanam PS-1> Salem-1 Nagapattanam PS-2> Salem-2	3
223	SR	SR - II	Kerala	Cochin	Powergrid	400	Edamom-1(DC), Edamom-2(DC), North Trichur-1, North Trichur-2	Thirunelveli-1, Thirunelveli-2, North Trichur-1, North Trichur-2	As per site survey	0	0	Edamom-1(DC) > Thirunelveli-1, Edamom-2(DC) > Thirunelveli-2	4
224	SR	SR - II	Puducherry	Puducherry	Powergrid	400	Neyveli TS2, Sriparembadur	Neyveli TS2, SV Chatram	As per site survey	0	0	Sriparembadur > SV Chatram	2
225	SR	SR - II	Kerala	Kozhikode	Powergrid	400	Mysore-1, Mysore-2	Mysore-1, Mysore-2	As per site survey	0	0	NIL	2
226	SR	SR - II	Tamil Nadu	Tiruvalam	Powergrid	400	Chittoor-1, Chittoor-2, Nellore-1, Nellore-2, Sholinganallur-1, Sholinganallur-2, Kolar-1, Sriperumbudur-1, Kurnool-1, Kurnool-2	Chittoor-1, Chittoor-2, Nellore-1, Nellore-2, Kalivandhapattu-1(NC) Kalivandhapattu-2(NC) Kolar-1, Sriperumbudur-1, Kurnool-1 (Under Cont), Kurnool-2 (Under Cont)	As per site survey	0	0	Sholinganallur-1 > Kalivandhapattu-1, Sholinganallur-2 > Kalivandhapattu-2	7

227	SR	SR - I	Andhra Pradesh	765 kV Nellore	Powergrid	765	Simhapuri-1, Simhapuri-2, Nellore-1, Nellore-2, Kurnool-1, Kurnool-2, Gooty-1, Gooty-2	Simhapuri (MEPL)-1, Simhapuri, Nellore-1, Nellore-2, Kurnool-1, Kurnool-2, Gooty-1, Gooty-2	MEPL, SEPL, Nellore-1, Nellore-2, Kurnool(N)-1, Kurnool(N)-2, Gooty-1, Gooty-2	0	0	Simhapuri-1 > Simhapuri (MEPL)-1, Simhapuri-2 > Simhapuri,	6
228	SR	SR - I	Andhra Pradesh	Gajuwaka	Powergrid	400	Kalpaka-1, Kalpaka-2, Nunna, Vemagiri-1, Vemagiri-2 Jeypore-1, Jeypore-2,	Kalpaka-1, Kalpaka-2, Vijayawada, Simhadri-2, Simhadri-1, Jeypore-1, Jeypore-2,	As per site survey	0	0	Nunna > Vijayawada, Vemagiri-1 > Simhadri-2, Vemagiri-2 > Simhadri-1	4
229	SR	SR - I	Andhra Pradesh	Ghanapur	Powergrid	400	Ramagundam-1, Ramagundam-2, Gajwel, Malkaram, Mamidapally, N'sagar, Kurnool, Hyderabad-1, Hyderabad-2	Ramagundam-3, Ramagundam-4, Gajwel, Malkaram, Mamidapally, N'sagar, Kurnool, Not identified, Not identified	Ramagundam-3, Ramagundam-4, Gajwel, Malkaram, Mamidapally, N'sagar, Kurnool	2	-2	Ramagundam-1 > Ramagundam-3, Ramagundam-2 > Ramagundam-4, Hyderabad-1 > Not identified, Hyderabad-2 > Not identified	4
230	SR	SR - I	Andhra Pradesh	Gooty	Powergrid	400	Raichur -1, Raichur -2, Kurnool, N'sagar, Hoody, Nelamangala, Madhugiri-1, Madhugiri-2, Nellore PS-1, Nellore PS-2	Raichur -1, Raichur -2, Kurnool, Kurnool PG, Bangalore, Nelamangala, Madhugiri-1, Madhugiri-2, Nellore PS-1, Nellore PS-2	Raichur(N) -1, Raichur(N) -2, Kurnool, Kurnool PG, Somanahalli, Nelamangala, Madhugiri-1, Madhugiri-2, Nellore PS-1, Nellore PS-2	0	0	N'sagar > Kurnool PG, Hoody > Bangalore	5
231	SR	SR - I	Andhra Pradesh	Khammam	Powergrid	400	Maimadapally-1, Maimadapally-2, Warangal, Kalpaka-1, Kalpaka-2, Nunna, N'sagar, Khammam-1, Khammam-2	Maimadapally-1, Maimadapally-2, Warangal, Kalpaka-1, Kalpaka-2, Vijayawada, N'sagar, Kothagudem-1, Kothagudem-2	As per site survey	0	0	Nunna > Vijayawada, Khammam-1 > Kothagudem-1, Khammam-2 > Kothagudem-2	5
232	SR	SR - I	Andhra Pradesh	Nagarjunsagar	Powergrid	400	Ramagundam -1, Ramagundam -2, Khammam, Mehaboobnagar, Cuddapah -1, Cuddapah -2. Gooty,	Ramagundam -1, Ramagundam -2, Khammam, Mehaboobnagar, Cuddapah -1, Cuddapah -2, Kurnool, Hyderabad	As per site survey	1	1	Gooty > Kurnool, Hyderabad feeder is captured additionally as a part of site survey.	4
233	SR	SR - II	Karnataka	Hiriyur	Powergrid	400	Guttur -1, Guttur -2, Nelamangla -1, Nelamangla -2	Guttur -1, Guttur -2, Nelamangla -1, Nelamangla -2	As per site survey	0	0	NIL	2

234	SR	SR - II	Tamil Nadu	Hosur	Powergrid	400	Kolar-1, Kolar-2, Salem-1, Salem-2, Bangalore, Electronic City-1, Electronic City-2	Kolar-1, Kolar-2, Salem-1, Salem-2, Somanahalli, Not identified, Not identified	As per site survey	2	-2	Bangalore > Somanahalli, Electronic City-1 > Not identified, Electronic City-2 > Not identified	3
235	SR	SR - II	Karnataka	Kolar	Powergrid	400	Hoody -1, Hoody -2, Somanahally, Hosur -1, Hosur -2, Kalvindapattu, Chinkampally, Talchar HVDC -1, Talchar HVDC -2	Hoody -1, Hoody -2, Somanahally, Hosur -1, Hosur -2, Tiruvallam, Cudappah, HVDC Pole-1, HVDC Pole-2	As per site survey	0	0	Kalivandhapattu > Tiruvallam, Chinkampally > Cudappah, Talchar HVDC-1 > HVDC Pole-1, Talchar HVDC-1 > HVDC Pole-2	4
236	SR	SR - II	Tamil Nadu	Madurai	Powergrid	400	Pugalur-1, Pugalur-2, Trichy, Karaikudi New, Udumalpet, Thirunelveli-1, Thirunelveli-2, Tuticorin-1, Tuticorin-2	Pugalur-1, Pugalur-2, Trichy, Karaikudi, Udumalpet, Thirunelveli, Kudankulam, Tuticorin-1, Tuticorin-2	As per site survey	0	0	Karaikudi New > Karaikudi, Thirunelveli-1 > Thirunelveli, Thirunelveli-2 > Kudankulam	5
237	SR	SR - I	Karnataka	Munirabad	Powergrid	400	Raichur, Guttur	Raichur, Davangere	As per site survey	0	0	Guttur > Davangere	1
238	SR	SR - II	Karnataka	Mysore	Powergrid	400	Neelamangla-1, Neelamangla-2, Kozhikode -1, Kozhikode -2, Hassan -1, Hassan -2	Neelamangla-1, Neelamangla-2, Kozhikode -1, Kozhikode -2, Hassan -1, Hassan -2	As per site survey	0	0	NIL	3
239	SR	SR - II	Karnataka	Neelamangala	KPTCL	400	Talaguppa, Hassan, Hiriyur PG -1, Hiriyur PG -2, Gooty, Mysore -1, Mysore -2, Hoody, Somanhally -1, Somanhally -2, Yelehanka	Talaguppa, Hassan, Hiriyur PG -1, Hiriyur PG -2, Gooty, Mysore -1, Mysore -2, Hoody-1, Bidadi -1, Bidadi -2, Hoody-2	As per site survey	0	0	Hoody > Hoody-1, Somanhally -1 > Bidadi-1, Somanhally -2 > Bidadi-2, Yelehanka > Hoody-2	6
240	SR	SR - I	Andhra Pradesh	Nunna/Vijaywada	Powergrid	400	Vemagiri-1, Vemagiri-2, Vemagiri-3, Vemagiri-4, Gazuwaka, Lanco-1, Lanco-2, VTS stg 4-1, VTS stg 4-2, Nellore-1, Nellore-2, Khammam	Vemagiri-1, Vemagiri-2, Vemagiri-3, Vemagiri-4, Gazuwaka, Lanco-1, Lanco-2, VTPS-1, VTPS-2, Nellore-1, Nellore-2, Khammam	Vemagiri-1, Vemagiri-2, Vemagiri-3, Vemagiri-4, Gazuwaka, Lanco-1, Lanco-2, VTPS-1, VTPS-2, Nellore-1, Nellore-2, Khammam Nellore(AP)-3, Nellore(AP)-4	0	0	VTS stg 4-1 > VTPS-1, VTS stg 4-2 > VTPS-2	7
241	SR	SR - II	Tamil Nadu	Salem	Powergrid	400	Hosur, Somanhally, Udumalpet-1, Udumalpet-2, Neyveli TS2-1, Neyveli TS2-2	Hosur-1, Hosur-2, Udumalpet-1, Udumalpet-2, Neyveli TS2-1, Neyveli TS2-2	As per site survey	0	0	Hosur > Hosur-1, Somanhally > Hosur-2	4

242	SR	SR - II	Karnataka	Somanhalli	Powergrid	400	Kolar, Salem, Nelamangala -1, Nelamangala -2, Salem new-1, Salem new-2 Nelamangala -3	Kolar, Hosur, Bidadi -1, Bidadi -2, Gooty	As per site survey	0	0	Salem > Hosur, Nelamangala -1 > Bidadi -1, Nelamangala -2 > Bidadi -2, Salem new-1 > Gooty,	4
243	SR	SR - II	Tamil Nadu	Udumalpet	Powergrid	400	Arasur-1, Arasur-2, Madurai, Thirunelveli-1, Thirunelveli-2, Trichur-1, Trichur-2, Not Identified, Not Identified	Arasur-1, Arasur-2, Madurai, Thirunelveli-1, Thirunelveli-2, Palakad-1, Palakad-2, Salem-1, Salem-2	-	0	0	Trichur-1 > Palakad-1, Trichur-2 > Palakad-2, Not identified > Salem-1, Not identified > Salem-2	5
244	SR	SR - II	Kerala	N.Trichur	Powergrid	400	Udumalpet-1, Udumalpet-2, Cochin-1, Cochin-2, Kozhikode-1, Kozhikode-2	Palakad-1, Palakad-2, Cochin-1, Cochin-2, Not Identified, Not Identified	As per site survey	2	-2	Udumalpet-1 > Palakad-1, Udumalpet-2 > Palakad-2, Kozhikode-1 > Not Identified, Kozhikode-2 > Not Identified	2
245	SR	SR - II	Tamil Nadu	Trichy	Powergrid	400	Karaikudi, Madurai, Neyveli TS-1 Exp, Neyveli TS-2	Karaikudi, Madurai, Neyveli TS-1 Exp, Neyveli TS-2	As per site survey	0	0	NIL	2
246	SR	SR - II	Kerala	Trivendrum	Powergrid	400	Thirunelveli -1, Thirunelveli -2	Thirunelveli -1, Thirunelveli -2	As per site survey	0	0	NIL	1
247	SR	SR - I	Andhra Pradesh	Simhadri Power	NTPC	400	Kalpaka -1, Kalpaka -2, Kalpaka -3, Kalpaka -4	Kalpaka -1, Kalpaka -2, Kalpaka -3, Kalpaka -4	Kalpaka -1, Kalpaka -2, Kalpaka -3, Kalpaka -4 Vemagiri-2 Gajuwaka-1 Gajuwaka-2	0	0	NIL	4
248	SR	SR - I	Andhra Pradesh	Nellore	Powergrid	400	Sriperumbudur-1, Sriperumbudur-2, Vijayawada-1, Vijayawada-2, Krishnapatnam UMPP-1, Krishnapatnam UMPP-2, Thiruvalem-1, Thiruvalem-2	Sriperumbudur-1, Alamathy, Vijayawada-1, Vijayawada-2, NPS-1, NPS-2, Thiruvalem-1, Thiruvalem-2	As per site survey	0	0	Sriperumbudur-2 > Alamathy, Krishnapatnam UMPP-1 > NPS-1, Krishnapatnam UMPP-1 > NPS-2	4
249	SR	SR - II	Tamil Nadu	Neyveli TS1 Ext.	NLC	400	Neyveli TS-2, Trichy	Neyveli TS-2, Trichy	As per site survey	0	0	NIL	1
250	SR	SR - II	Tamil Nadu	Neyveli TS2	NLC	400	Salem -1, Salem -2, Trichy, Neyveli TS-1 Exp, Neyveli TS-2 Exp, Puducherry, Bahrar	Salem -1, Salem -2, Trichy, Neyveli TS-1 Exp, Neyveli TS-2 Exp, Puducherry, Pugalur	As per site survey	0	0	Bahrar > Pugalur	4
251	SR	SR - II	Tamil Nadu	Neyveli TS2 Exp	NLC	400	Pugalur, Neyveli TS-1	Pugalur-2, Neyveli TS-2	As per site survey	0	0	Pugalur > Pugalur-2, Neyveli TS-1 > Neyveli TS-2	1

252	SR	SR - I	Andhra Pradesh	Ramagundam STPS	NTPC	400	Chandrapur-1, Chandrapur-2, Warangal, Nagarjuna Sagar-1, Nagarjuna Sagar-2, Ghanapur-1, Ghanapur-2, Gajwel, Malkaram, Dichipally	Chandrapur-1, Chandrapur-2, Warangal, Nagarjuna Sagar-1, Nagarjuna Sagar-2, Hyderabad-3, Hyderabad-4, Gajwel, Malkaram, Dichipally	As per site survey	0	0	Ghanapur-1 > Hyderabad-3, Ghanapur-2 > Hyderabad-4	5
253	SR	SR - II	Karnataka	Yelahanka	Powergrid	400	Neelamangla-1, Hoody-1, Madhugiri-1, Madhugiri-2 Somanhally-1, Hoody-2	Neelamangla, Hoody, Madhugiri-1, Madhugiri-2 Not available Not available	As per site survey	2	-2	Neelamangla-1 > Neelamangla, Hoody-1 > Hoody, Somanhally-1 > Not available Hoody-2 > Not available	2
254	SR	SR - II	Karnataka	Bidadi	Powergrid	400	Neelamangla -1, Neelamangla -2, Somnahlalli -1, Somnahlalli -2	Neelamangla -1, Neelamangla -2, Somnahlalli -1, Somnahlalli -2	As per site survey	0	0	NIL	2
255	SR	SR - II	Tamil Nadu	KudaNkulam	Powergrid	400	Tiruneveli-1, Tiruneveli-2, Tiruneveli-3, Tiruneveli-4	Madurai, Tiruneveli-2, Tiruneveli-3, Tiruneveli-4	As per site survey	0	0	Tiruneveli-1 > Madurai	2
256	SR	SR - II	Kerala	Kayamkulam PG	NTPC	220	Not Identified, Not Identified, Not Identified, Not Identified, Not Identified, Not Identified,	New Palom-1, New Palom-2, Edappon, Kundara, Not Identified, Not Identified,	New Palom-1, New Palom-2, Edappon, Kundara,	2	-2	Not Identified > New Palom-1, Not Identified > New Palom-2, Not Identified > Edappon, Not Identified > Kundara,	2
257	SR	SR - I	Andhra Pradesh	Kurnool	APTRANSCO	400	Gooty, SLBPH, Ghanapur	Gooty, Srisaillam, Ghanapur	Gooty, Srisaillam, Ghanapur, Kurnool(N) 1, Kurnool(N) 2	0	0	SLBPH > Srisaillam	3
258	SR	SR - I	Andhra Pradesh	Mahaboobnagar	APTRANSCO	400	Nagarjunsagar, Raichur	Thallapalli, Raichur	Nagarjunsagar, Raichur	0	0	Nagarjunsagar > Thallapalli	1
259	SR	SR - I	Telangana	Srisillem LPH	TSTRANSCO	400	Kurnool, Maimadapally -1, Maimadapally -2, VTS stg 4 -1, VTS stg 4 -2	Kurnool, Hyderabad-1, Hyderabad-2, Sattenapalli-1, Sattenapalli-2	-	0	0	Maimadapally -1 > Hyderabad-1, Maimadapally -2 > Hyderabad-2, VTS stg 4 -1 > Sattenapalli-1, VTS stg 4 -2 > Sattenapalli-2	3
260	SR	SR - I	Andhra Pradesh	VEMAGIRI PGL (GMR)	GMR	400	Vemagiri -1, Vemagiri -2	Vemagiri -1, Vemagiri -2	-	0	0	NIL	1
261	SR	SR - I	Andhra Pradesh	VTS STAGE IV	APTRANSCO	400	Nunna 1&2, SLBPH 1&2	Nunna 1&2, Sattenapalli 1&2, Malkaram 1&2	-	2	2	SLBPH 1&2 > Sattenapalli 1&2, Not in contract > Malkaram 1&2	3
262	SR	SR - I	Telangana	KTPS	TSTRANSCO	220	Manuguru, L Sileru-1, L Sileru-2, KTPS V-1, KTPS V-2, Mirayalguda, K V Kota, Shapurnagar	Manuguru-1, L Sileru-1, Manuguru-2, Tie Line-1, Tie Line-2, Mirayalguda, Nunna, Shapurnagar	-	0	0	Manuguru > Manuguru-1, L Sileru-2 > Manuguru-2, KTPS V-1 > Tie Line-1, KTPS V-2 > Tie Line-2, K V Kota > Nunna	4

263	SR	SR - I	Andhra Pradesh	VTS	APTRANSCO	220	Kondapalli-1, Kondapalli-2, Chillkallu-1, Chillkallu-2, Podili-1, Podili-2, K V Kotal, Bhimadole, Nunna, Tadikonda-1, Tadikonda-2, N sagar-1, N sagar-2, Gunadala	Kondapalli-1, Kondapalli-2, Chillkallu-1, Chillkallu-2, Podili, NR Peta, K-Kota, Not Identified, Nunna, Tadikonda-1, Tadikonda-2, Rentachintala, Tallapalli, Gunadala	As per site survey	1	-1	Podili-1 > Podili, Podili-2 > NR Peta, K V Kotal > K-Kota, Bhimadole > Not identified, N sagar-1 > Rentachintala, N sagar-2 > Tallapalli	7	
264	SR	SR - II	Karnataka	Guttur	KPTCL	400	Jindal, Munirabad, Narendra-1, Narendra-2, Kaiga-1, Kaiga-2, Hiriyur PG-1, Hiriyur PG-2	Jindal (JSWEL), Guddadahalli, Narendra-1, Narendra-2, Kaiga-1, Kaiga-2, Berenahalli-1, Berenahalli-2		0	0	Jindal > Jindal (JSWEL), Munirabad > Guddadahalli, Hiriyur PG-1 > Berenahalli- 1, Hiriyur PG-2 > Berenahalli- 2	4	
265	SR	SR - II	Tamil Nadu	Arasur	Powergrid	400	Udumalpet -1, Udumalpet -2	Udumalpet -1, Udumalpet -2		0	0	NIL	2	
266	SR	SR - II	Tamil Nadu	Alamathy	TANTRANSCO	400	Sriperumbudur -1, Sriperumbudur -2, Nellore -1, Nellore -2, North Chennai 6th Fdr Details Not Available	Vallur- 1, Vallur-2, Sriperambudur, Nellore, North chennai-1, North chennai-2	Vallur- 1, Vallur-2, Sriperambudur, Nellore, North chennai-1, North chennai-2 Sunguarchatram-1 Sunguarchatram-2		0	0	Sriperambudur-1 > Vallur- 1, Sriperambudur-2 > Vallur- 2, Nellore-1 > Sriperambudur, Nellore-2 > Nellore, North chennai > North chennai-1 6th Fdr > North chennai-2	4
267	SR	SR - II	Tamil Nadu	Sriperumbudur	Powergrid	400	Kalvindapattu, Chittoor, AlAmathy -1, AlAmathy -2, PudUcherry, Bahroor	Tiruvallam, Chittoor, AlAmathy-1, Nellore, Sunguvarchatram Not identified	As per site survey	1	-1	Kalvindapattu> Tiruvallam, Almathy -2> Nellore, Pudyucherry > Sunguvarchatram, Bahroor > Not identified	3	
268	SR	SR - I	Karnataka	Raichur TPS	KPTCL	400	Gooty-1, Gooty-2, Munirabad	Gooty-1, Gooty-2, Munirabad, Mahaboobnagar, BTPS	As per site survey	2	2	Not identified > Mahaboobnagar, Not identified > BTPS	3	
269	SR	SR - II	Kerala	Kalamassery	KSEB	220	Idukki-1, Idukki-2, Bramhapuram-1, Bramhapuram-2	220KV IDKL-1, 220KV IDKL-2, 220KV COKL-1, 220KV COKL-2	-	0	0	Idukki-1 > 220KV IDKL-1, Idukki-2 > 220KV IDKL-2, Bramhapuram-1 > 220KV COKL-1, Bramhapuram-2 > 220KV COKL-2	2	

270	WR	WR-I	Maharastra	Chandrapur	MSETCL	400	Parali-1, Parali-2, Parali-3, Bhadrawathi-1, Bhadrawathi-3, Bhadrawathi-4, Bhadrawathi-2, Khaparkheda, HVDC-1, HVDC-2, Padhge.	Chandrapur-1, Chandrapur-2, Parali-3, PGCIL-1, PGCIL-2, PGCIL-3, PGCIL-4, Khaparkheda, HVDC-1, HVDC-2, Not identified	-	1	1	Parali-1->Chandrapur-1 Parali-2->Chandrapur-2 Bhadrawathi-1->PGCIL-1, Bhadrawathi-2->PGCIL-2 Bhadrawathi-3->PGCIL-3 Bhadrawathi-4->PGCIL-4 Padhge->Not identified	5
271	WR	WR-I	Maharastra	KALWA	MSETCL	400	Padhage-1, Padhage-2, Pune PG, Khargar	Padhage-1, Padhage-2, Talegaon, Khargar	-	0	0	Pune PG->Talegaon	2
272	WR	WR-I	Maharastra	Lonikand	MSETCL	400	Pardi-1, Parali-2, Karad, Koyna IV, Jeurji, Pune PG, Chakan	LonikandII ckt-1, LonikandII ckt-2, Karad, Koyna IV, Jeurji, Pune PG, Chakan	-	0	0	Parali-1->LonikandII ckt-1 Parali-2->LonikandII ckt-2	4
273	WR	WR-I	Maharastra	PADGHE	MSETCL	400	Chandrapur-1, Chandrapur-2, Bableswhar-1, Bableswhar-2, Chakan Kalwa-1, Kalwa-2, Boiser, Tarapur, Khargar Neagothane-1 Neagothane-2	HVDC-1 HVDC-2 Bableswhar-1, Bableswhar-2, Talegaoh Kalwa-1, Kalwa-2 Boiser, Tarapur-1, Khargar, Neagothane-1 Neagothane-2 Tharapur-2,		1	1	Chandrapur-1->HVDC-1 Chandrapur-2->HVDC-2 Chakan->Talegaoh Tharapur->Tharapur-1 Not in Contract->Tharapur-2	7
274	WR	WR-II	Madhya Pradesh	BHOPAL	MPPTCL	400	DAMOH-1, DAMOH-2, ITARSI-2, BINA-2, BINA-1, ITARSI-1, BHOPAL-1, BHOPAL-2	DAMOH-1, DAMOH-2, ITARSI-2, BINA-2, BINA-1, ITARSI-1, BHOPAL-1, BHOPAL-2		0	0	-	4
275	WR	WR-II	Madhya Pradesh	BINA	MPPTCL	400	Bina PGCIL-1, Bina PGCIL-2, Bina PGCIL-3, Bina PGCIL-4, Bina Power, Bhopal-1, Bhopal-2,	Bina PGCIL-1, Bina PGCIL-2, Bina PGCIL-3, Bina PGCIL-4, JP BPSCl, Bhopal-1, Bhopal-2,	Bina PGCIL-1, Bina PGCIL-2, Bina PGCIL-3, Bina PGCIL-4, JP BPSCl, Bhopal-1, Bhopal-2,	0	0	Bina power->JP BPSCl	4
276	WR	WR-II	Madhya Pradesh	Indore	MPPTCL	400	Itarsi-1, Itarsi-2, Asoj-1, Asoj-2, Nagda, Indira sagar-1, Indira sagar-2, Indore(PG)-1, Indore(PG)-2	Itarsi-1, Itarsi-2, Asoj-1, Asoj-2, Nagda, Indira sagar-1, Indira sagar-2, Hatunia-1, Hatunia-2	Itarsi-1, Itarsi-2, Asoj-1, Asoj-2, Asoj-3 Nagda, Indira sagar-1, Indira sagar-2, Indore(PG)-1, Indore(PG)-2	0	0	Indore(PG)-1 > Hatunia-1, Indore(PG)-2 > Hatunia-2	5

277	WR	WR-II	Madhya Pradesh	765/400kv Indore	Powergrid	765	765kv Bina(PG), 765kv Vadodara, 765kv Bhopal, 400kv Indore (MP)1 & 2, 400kv Pithampur 1&2	765kv Bina(PG)- Indore, 765kv Vadodara, 765kv Bhopal, 400kv Indore (MP)1 & 2, 400kv Pithampur 1&2	765kv Bina(PG)- Indore, 765kv Vadodara, 765kv Bhopal, 400kv Indore (MP)1 & 2, 400kv Pithampur 1&2	0	0	765kv Bina(PG) >765kv Bina(PG)- Indore	7
278	WR	WR-II	Madhya Pradesh	NAGDA	MPPTCL	400	Dehgam-1 &2, Shujalpur-1&2, Rajgarh-1&2 Indira sagar, Indore	Dehgam-1 &2, Shujalpur-1&2, Rajgarh-1&2 Indira sagar, Indore	-	0	0	-	4
279	WR	WR-II	Madhya Pradesh	RAJ GARH	Powergrid	400	SSP 1&2, Nagda 1&2, Kasor 1&2, Khandawa 1,2, Khandawa 3,4	SSP 1&2, Nagda 1&2, Kasor 1&2, Khandawa 1,2, Not identified.	SSP 1&2, Nagda 1&2, Kasor 1&2, Khandawa 1,2.	2	-2	Khandawa 3,4 > Not identified	6
280	WR	WR-II	Madhya Pradesh	KATNI	MPPTCL	400	Birsinghpur, Damoh	Birsinghpur-1, Birsinghpur-2 Damoh	-	1	1	Not in contract - >Birsinghpur-2	2
281	WR	WR-II	Madhya Pradesh	Sasan	Reliance Power Ltd.	765	Satna765 1&2, 765kv Vpool, Vindhyachal 1 Vindhyachal 2 400kV Jabalpur 1 400kV Jabalpur 2 Satna 1&2, 400kV Vpool 1&2,	Satna765 1&2, 765kv Vpool, Vindhyachal 1 Vindhyachal 2 Vindhyachal 3 Jabalpur 3 Not identified. Not identified.	Satna765 1&2, 765kv Vpool	4	-4	400kV Jabalpur 1 > Vindhyachal 3 400kV Jabalpur 2 > Jabalpur 3 Satna 1 > Not identified Satna 2 > Not identified 400kV Vpool 1 > Not identified 400kV Vpool 2 > Not identified	2
282	WR	WR-I	Chattisgarh	BHILAI	CSPGCL	400	KSTPS-1, KSTPS-2, KSTPS-3, Raipur-1, Seoni, Koradi, Bhadrawati Raipur-2,	NTPC Korba-1, NTPC Korba-2, Raita-1, Raipur-1, seoni, Koradi, Bhadrawati, Raita-2, Raita-3, Korba EXT-1, Korba EXT-2, Bhatapara		4	4	KSTPS-1->NTPC Korba-1, KSTPS-2->NTPC Korba-2, KSTPS-3->Raita-1, Raipur-2->Not available. Nill->Raita-2, Nill->Raita-3, Nill->Korba EXT-1, Nill->Korba EXT-2, Nill->Bhatapara	6
283	WR	WR-I	Chattisgarh	KORBA WEST	CSPGCL	400	KSTPS, Bhilai	KSTPS (NTPC), Raita	KSTPS (NTPC), Raita. Bhilai 1, Bhilai 2.	0	0	KSTPS > KSTPS (NTPC), Bhilai > Raita	2
284	WR	WR-I	Chattisgarh	Korba(E)	CSPGCL	220	Korba East Extn-1, Korba East Extn-2, Korba West, Balco-1, Balco-2, Budhipadar-1, Budhipadar-2, Raigarh, Bhilai, Bhatapar-1, Bhatapar-2	Korba East West-1, Korba East West-2, Korba DSPM, Balco-1, Balco-2, Budhipadar-1, Budhipadar-2, Raigarh, Siltara, Not Identified, Not Identified	Korba East West-1, Korba East West-2, Korba DSPM, Balco-1, Balco-2, Budhipadar-1, Budhipadar-2, Raigarh, Siltara	2	-2	Korba East Extn-1 > Korba East West-1, Korba East Extn-2 > Korba East West-2, Korba West > Korba DSPM, Bhilai > Siltara, Bhatapar-1 > Not Identified, Bhatapar-2 > Not Identified	5

285	WR	WR-II	Gujrat	SARDARSAROVAR(SSP)	SSP	400	Rajgarh-1, Rajgarh-2, Asoj, Kasor, Limdi, Dhule-1, Dhule-2,	Nagda-1, Nagda-2 Asoj, Limdi, Dhule-1, Dhule-2,		0	0	Rajgarh-1->Nagda-1, Rajgarh-2->Nagda-2 Kasor->Limdi,	3
286	WR	WR-I	Maharastra	AURANGABAD PG	Powergrid								4
287	WR	WR-I	Maharastra	Bhadrawati	Powergrid	400	Raipur 1,2&3, Ramagundam 1&2, Parli , Chandrapur 1,2,3&4, Bhilai , EMCO 1&2, Dhariwal TPS.	Raipur 1,2&3, Ramagundam 1&2, Parli , Chandrapur 1,2,3&4, Bhilai , EMCO 1&2, Dhariwal (Parli-2), HVDC-1, HVDC-2	Raipur 1,2&3, Ramagundam 1&2, Parli , Chandrapur 1,2,3&4, Bhilai , EMCO 1&2, Dhariwal TPS, HVDC-1, HVDC-2	2	2	Dhariwal TPS > Dhariwal (Parli-2), Not identified > HVDC-1, Not identified > HVDC-2	8
288	WR	WR-II	Madhya Pradesh	Bina	Powergrid	765	765kV JabalpurPS-1, 2 & 3, 765kV Indore, 765kV Satna-1 & 2, 765kV Gwalior-1, 2 & 3, 765KV Seoni 400kV Sujalpur-1 & 2, 400kV Bina-1, 2, 3 & 4, 400kV Bina Power, 400kV Satna-1, 2, 3 & 4,	765kV Jabalpur-1, 2 & 3, 765kV Indore, 765kV Satna-1 & 2, 765kV Gwalior-1, 2 & 3, 765KV Seoni 400kV Sujalpur-1 & 2, 400kV Bina-1, 2, 3 & 4, 400kV BPSCl, 400kV Satna-1, 2, 3 & 4,	765kV Jabalpur-1, 2 & 3, 765kV Indore, 765kV Satna-1 & 2, 765kV Gwalior-1, 2 & 3, 765KV Seoni 400kV Sujalpur-1 & 2, 400kV Bina-1, 2, 3 & 4, 400kV BPSCl, 400kV Satna-1, 2, 3 & 4,	0	0	765kV Jabalpur PS-1 > 765kV Jabalpur-1 765kV Jabalpur PS-2 > 765kV Jabalpur-2 765kV Jabalpur PS-3 > 765kV Jabalpur-3, 400kV Bina Power > 400kV BPSCl	16
289	WR	WR-I	Maharastra	Boisar	Powergrid	400	Tarapur 1&2, Padghe, Vapi, A'bad (PG) 1&2, Magarwada 1&2,	Tarapur 1&2, Padghe, Vapi, Aurangabad 1&2 Navsari 1&2,	Tarapur 1&2, Padghe, Vapi, A'bad (PG) 1&2, Magarwada 1&2,	0	0	Magarwada 1 > Navsari 1, Magarwada 2 > Navsari 2.	5
290	WR	WR-II	Madhya Pradesh	GWALIOR	Powergrid								0
291	WR	WR-II	Madhya Pradesh	Itarsi	Powergrid	400	Jabalpur 1,2,3,4 Bhopal 1&2, Indore 1&2, Khandawa 1&2, Satpura,	Jabalpur 1,2,3,4 Bhopal 1&2, Indore 1&2, Khandawa 1&2, Satpura,	Jabalpur 1,2,3,4 Bhopal 1&2, Indore 1&2, Khandawa 1&2, Satpura,	0	0	NIL	6
292	WR	WR-II	Madhya Pradesh	Jabalpur	Powergrid	400	Itarsi 1,2,3,&4, Vindhychal 1&2, 400kV Jabalpur pool 1&2, 400kV Sasan 1 400kV Sasan 2	Itarsi 1,2,3,&4, Vindhychal 1&2, 400kV Jabalpur pool 1&2, 400kV Sasan 1 Vindhychal 4	Itarsi 1,2,3,&4, Vindhychal 1&2, 400kV Jabalpur pool 1&2, Vindhychal 3 Vindhychal 4	0	0	Sasan 2> Vindhychal 4	5
293	WR	WR-II	Madhya Pradesh	Khadwa	Powergrid	400	Dhule-1, Dhule-2, Itarsi-1, Itarsi-2, Seoni-1, Seoni-2, Rajgarh-1, Rajgarh-2, Rajgarh-3, Rajgarh-4, Betul-1, Betul-2	Dhule-1, Dhule-2, Itarsi-1, Itarsi-2, Seoni-1, Seoni-2, Rajgarh-1, Rajgarh-2, Indore-1, Indore-2, Betul-1, Betul-2	Dhule-1, Dhule-2, Itarsi-1, Itarsi-2, Seoni-1, Seoni-2, Rajgarh-1, Rajgarh-2, Indore-1, Indore-2, Betul-1, Betul-2	4	-4	Rajgarh-3 > Indore-1, Rajgarh-4 > Indore-2	6

294	WR	WR-I	Chattisgarh	KORBA STPS	NTPC	400	Bhilai-1, Bhilai-2, Bhatapara, Raipur-1, Raipur-2, Pathadi, Korwa West, Vindhyachal-1, Vindhyachal-2, Birsinghpur-1, Birsinghpur-2	Bhilai-1, Bhilai-2, Bhatapara, Raipur-3, Raipur-4, Lanco, Korwa West, Vindhyachal-1, Vindhyachal-2, Vandhana, Balco	As per site survey	0	0	Raipur-1 > Raipur-3, Raipur-2 > Raipur-4, Pathadi > Lanco, Birsinghpur-1 > Vandhana, Birsinghpur-2 > Balco	6
295	WR	WR-I	Maharashtra	Mapusa	Powergrid	400	Kolhapur -1, Kolhapur -1	Kolhapur -1, Kolhapur -1	As per site survey	0	0	NIL	1
296	WR	WR-I	Chattisgarh	Raigarh	Powergrid	400	Raipur 1, Raipur 4, Raipur 2, Raipur 3 Rourkela 1, Rourkela 2 Rourkela 3, Sterlite	Raipur 1, Raipur 4, KWPCL, KSK, Sundergarh, Sterlite 1, Sundergarh 2, Sterlite 1, Kotra pool 1 Kotra pool 2.	Raipur 1, Raipur 4, KWPCL, KSK, Sundergarh, Sterlite 1, Sundergarh 2, Sterlite 1, Kotra pool 1 Kotra pool 2.	2	2	Raipur 2 > KWPCL Raipur 3 > KSK Rourkela 1 > Sundergarh, Rourkela 2 > Sterlite 1, Rourkela 3, > Sundergarh 2, Sterlite > Sterlite 1, Not identified > Kotra pool 1 Not identified > Kotra pool 2.	8
297	WR	WR-II	Madhya Pradesh	Satna	Powergrid	765	765KV Bina-1, 765KV Bina-2, 765KV Sasan-1, 765KV Sasan-2, 765KV V Pool-1, 765KV V Pool-2, 765KV Satna-1, 765KV Satna-2, 400KV Vindhyachal-1, 400KV Vindhyachal-2, 400KV Vindhyachal-3, 400KV Vindhyachal-4, 400KV Bina PG-1, 400KV Bina PG-2, 400KV Bina PG-3, 400KV Bina PG-4, 400KV Jaiprakash-1, 400KV Jaiprakash-2, 400KV Sasan-1, 400KV Sasan-2	765KV Bina-1, 765KV Bina-2, 765KV Sasan-1, 765KV Sasan-2, 765KV V Pool-1, 765KV V Pool-2, 765KV Gwalior-1, 765KV Gwalior-2, 400KV Vindhyachal-1, 400KV Vindhyachal-2, 400KV Vindhyachal-3, 400KV Vindhyachal-4, 400KV Bina PG-1, 400KV Bina PG-2, 400KV Bina PG-3, 400KV Bina PG-4, 400KV Nigrie-1, 400KV Nigrie-2, Not identified, Not Identified	765KV Bina-1, 765KV Bina-2, 765KV Sasan-1, 765KV Sasan-2, 765KV V Pool-1, 765KV V Pool-2, 765KV Gwalior-1, 765KV Gwalior-2, 400KV Vindhyachal-1, 400KV Vindhyachal-2, 400KV Vindhyachal-3, 400KV Vindhyachal-4, 400KV Bina PG-1, 400KV Bina PG-2, 400KV Bina PG-3, 400KV Bina PG-4, 400KV Nigrie-1, 400KV Nigrie-2,	2	-2	765KV Satna-1 > 765KV Gwalior-1, 765KV Satna-2 > 765KV Gwalior-2, 400KV Jaiprakash-1 > 400KV Nigrie-1, 400KV Jaiprakash-2 > 400KV Nigrie-2, 400KV Sasan-1 > Not identified, 400KV Sasan-2 > Not identified,	12
298	WR	WR-I	Madhya Pradesh	SEONI	Powergrid	765	765Kv Sipat-1, 765Kv Sipat-2, 765Kv Bina, 765Kv wardha-1, 765Kv wardha-2, 400Kv Khandwa-1, 400Kv Khandwa-2 400Kv Sadhpura, 400Kv Bhilai.	765Kv Bilaspur-1, 765Kv Bilaspur-2, 765Kv Bina, 765Kv wardha-1, 765Kv wardha-2, 400Kv Khandwa-1, 400Kv Khandwa-2 400Kv Sadhpura, 400Kv Bhilai.	-	0	0	765Kv sipat-1->765Kv Bilaspur-1, 765Kv sipat-2->765Kv Bilaspur-2	8

299	WR	WR-II	Gujrat	Vapi	Powergrid	400	Boiser, Kala-1, Suzen, Kala-2, KAPP-1, KAPP-2, Kawas-1, Kawas-2	Boiser, Kala Line, Suzen Line, Not Identified, Not Identified, Not Identified, Not Identified, Not Identified, Navsari	Boiser, Kala 1, Suzen Line, Kala 2, KAPP-1, KAPP-2	4	-4	Kala-1 > Kala Line, Kala-2 > Not Identified, KAPP-1 > Not Identified, KAPP-2 > Not Identified, Suzen > Suzen Line, Kawas-1 > Not Identified, Kawas-2 > Not Identified, Not Identified > Navsari	3
300	WR	WR-I	Maharastra	Wardha	Powergrid	765	Mauda 1&2, Parli PG 1&2, Akola 1&2, Aurangabad 1&2, Seoni765 1&2, 765kV Raipur PS 1,2 Raipur 1&2, 765kV Aurangabad 1,2, 765kV Aurangabad 3,&4 765kV Raipur PS 3&4,	Mauda 1&2, Parli PG 1&2, Akola 1&2, Aurangabad 1&2, Seoni765 1&2, 765kV Raipur PS 1,2 Raipur 1&2 Warora 1&2.	-	6	-6	Not in contract->Warora 1&2 765kV Aurangabad 1,2-> Not identified at site. 765kV Aurangabad 3,&4-> Not identified at site. 765kV Raipur PS 3&4-> Not identified at site.	17
301	WR	WR-II	Gujrat	Dehgam	Powergrid	400	Sami-1, Sami-2, Ranchodpura-1, Ranchodpura- 2, Nagda-1, Nagda-2, Pirana-1,Pirana-2, Wanakbori-1, Wanakbori-2, Soja-1, Soja-2, Pirana-3, Pirana-4, Jhanor-1, Jhanor-2	Sami-1, Sami-2, Ranchodpura-1, Ranchodpura-2, Nagda-1, Nagda-2, Pirana-1,Pirana-2, Wanakbori, Wanakbori(Future), Soja, Soja(Future), Gandhar-1, Gandhar-2, ICT Bays.	Sami-1, Sami-2, Ranchodpura-1, Ranchodpura-2, Nagda-1, Nagda-2, Pirana-1,Pirana-2, Wanakbori, Wanakbori(Future), Soja, Soja(Future), Gandhar-1, Gandhar-2,	2	-2	Wanakbori-2 > Wanakbori(Future) Soja-2 > Soja(Future) Pirana-3 > Gandhar-1, Pirana-4 > Gandhar-2, Wanakbori-1 > Wanakbori Soja-1 > Soja	7
302	WR	WR-I	Chattisgarh	Raipur	Powergrid	400	Bhadrawadi-1 Bhadrawadi-2 Bhadrawadi-3 NSPCL-1 NSPCL-2 Wardha-1 Wardha-2 Raigarh-1 Raigarh-2 Raigarh-3 Raigarh-4 JPL-1 JPL-2 Sipat-1 Sipat-2 Sipat-3 Pathadi, KSTPS-1, KSTPS-2, Bhatapara, Bhilai-1, Bhilai-2.	Chandrapur-1, Not available, Not available, BESCL-1, BESCL-2, Wardha-1, Wardha-2, Raigarh-1, KWPCCL, KSK-3, KSK-4, Tamnar-1 Tamnar-2 Sipat-1, Sipat-2, Sipat-3, Not available Korba-3, korba-4, Bhatapara Bhilai-1, Bhadravati-3, Raipur Pooling-1, Raipur Pooling-2.		2	-2	Bhadrawadi-1- >Chandrapur-1, Bhadrawadi-2->Not Identified Bhadrawadi-3->Not Identified NSPCL-1->BESCL-1 NSPCL-2->BESCL-2 Raigarh-3->KSK-3 Raigarh-4->KSK-4 JPL-1->Tamnar-2 JPL-2->Not Identified Pathadi->Not Identified, KSTPS-1->Korba-3 KSTPS-2->korba-4, Bhilai-2->Bhadravati-3 Not in contract->Raipur Pooling-1, Not in contract->Raipur Pooling-2.	12

303	WR	WR-II	Madhya Pradesh	Damoh	Powergrid	400	Birsinghpur 1, Birsinghpur 2, Bhopal 1, Bhopal 2, Katni 2 Katni	Birsinghpur 1, Birsinghpur 2, Bhopal 1, Bhopal 2, Katni 2 Katni 1	Birsinghpur 1, Birsinghpur 2, Bhopal 1, Bhopal 2, Katni 2 Katni 1	1	1	Katni > Katni 2 Not identified > katni 1	6
304	WR	WR-II	Gujrat	Bachhau	Powergrid	400	Mundra-1, Mundra-2, Ranchodpura-1, Ranchodpura-2, Essar TPS-1, Essar TPS-2, Versana-1, Versana-2	Mundra-1, Mundra-2, Ranchodpura-1, Ranchodpura-2	Mundra-1, Mundra-2, Ranchodpura-1, Ranchodpura-2, Essar TPS-1, Essar TPS-2, Versana-1, Versana-2	0	0	Essar TPS-1 > Under Construction, Essar TPS-2 > Under Construction, Versana-1 > Under Construction, Versana-2 > Under Construction	8
305	WR	WR-I	Maharastra	Parli	Powergrid	400	Parli 1&2, Solapur pG 1&2, Wardha 1&2, Bhadrawati, Pune New 1&2, Dhariwal TPS	MSETCL Parli 1&2, Solapur pG 1&2, Wardha 1&2, Bhadrawati-1, Pune 1&2, Bhadrawati-2.	Parli 1&2, Solapur pG 1&2, Wardha 1&2, Bhadrawati, Pune GIS 1&2, Dhariwal TPS	0	0	Parli 1>MSETCL Parli 1 Parli 2>MSETCL Parli 2 Bhadrawati>Bhadrawati-1, Pune New 1> Pune 1 Pune New 2> Pune 2 Dhariwal TPS>Bhadrawati-2	6
306	WR	WR-I	Maharastra	Pune	Powergrid	400	Lonikhand, Kalwa, Pune New 1, Pune New 2, Pune New 3, Pune New 4.	Lonikhand, Kalwa, Parli 1, Parli 2, Aurangabad 1, Aurangabad 2,	As per SLD	0	0	Pune New 1>Parli 1 Pune New 2>Parli 2 Pune New 3>Aurangabad 1 Pune New 4>Aurangabad 2	6
307	WR	WR-I	Maharastra	Navi Mumbai	Powergrid	400	Kalwa, Pune PG, Kala-1, Kala-2	Kalwa,Lonikhand, Vapi-1, Vapi-2	Kalwa,Lonikand.	0	0	Pune PG > Lonikhand, Kala-1 > Vapi-1, Kala-2 > Vapi-2	1
308	WR	WR-II	Gujrat	Navsari	Powergrid	400	Jhanor-1, Jhanor-2, KAPP-1, KAPP-2, Magarwada-1, Magarwada-2	Gandhar-1, Gandhar-2, Kala, Vapi, DGEN-1, DGEN-2	Jhanor-1, Jhanor-2, Magarwada-1, Magarwada-2, DGEN-1, DGEN-2	0	0	Jhanor-1 > Gandhar-1, Jhanor-2 > Gandhar-2, KAPP-1 > Kala, KAPP-2 > Vapi, Magarwada-1 > DGEN-1, Magarwada-2 > DGEN-2	3
309	WR	WR-II	Gujrat	Pirana	Powergrid	400	Vadodara-1, Vadodara-2, Dehgam-1, Dehgam-2, Dehgam-3, Dehgam-4	Vadodara-1, Vadodara-2, Dehgam-1, Dehgam-2, TPGL-1, TPG-L-2	Vadodara-1, Vadodara-2, Dehgam-1, Dehgam-2, TPGL-1, TPG-L-2	0	0	Dehgam-3 > TPGL-1, Dehgam-4 > TPGL-2	6
310	WR	WR-II	Gujrat	Gandhar(Jhanor)	NTPC	400	GPEC, Suzen, Dehgam 1&2, Navsari 1&2	GPEC, Suzen, Dehgam 1&2, Navsari 1&2	GPEC, Suzen, Dehgam 1&2, Navsari 1&2	0	0	NIL	0
311	WR	WR-I	Maharastra	Sholapur	Powergrid	765	Kolhapur-1, Kolhapur-2, Karad, Parli PG-1, Parli PG-2, Sholapur NTPC-1, Sholapur NTPC-2 Lamboti 765KV Raichur-1, Raichur-2, Aurangabad-1, Aurangabad-2, Pune	Kolhapur-1, Kolhapur-2, Karad, Parli PG-1, Parli PG-2, Sholapur NTPC-1, Sholapur NTPC-2 Lamboti 765KV Raichur-1, Raichur-2, Aurangabad-1, Aurangabad-2, Pune	Kolhapur-1, Kolhapur-2, Karad, Parli PG-1, Parli PG-2, Sholapur NTPC-1, Sholapur NTPC-2 Lamboti 765KV Raichur-1, Raichur-2, Aurangabad-1, Aurangabad-2, Pune	6	6	Not identified > Lamboti Not identified > Raichur-1, Not identified > Raichur-2, Not identified > Aurangabad-1, Not identified > Aurangabad-2, Not identified > Pune	10
312	WR	WR-II	Madhya Pradesh	Shujalpur	Powergrid	400	Bina-1, Bina-2, Nagda -1, Nagda -2	Bina-1, Bina-2, Nagda -1, Nagda -2	Bina-1, Bina-2, Nagda -1, Nagda -2	0	0	NIL	4

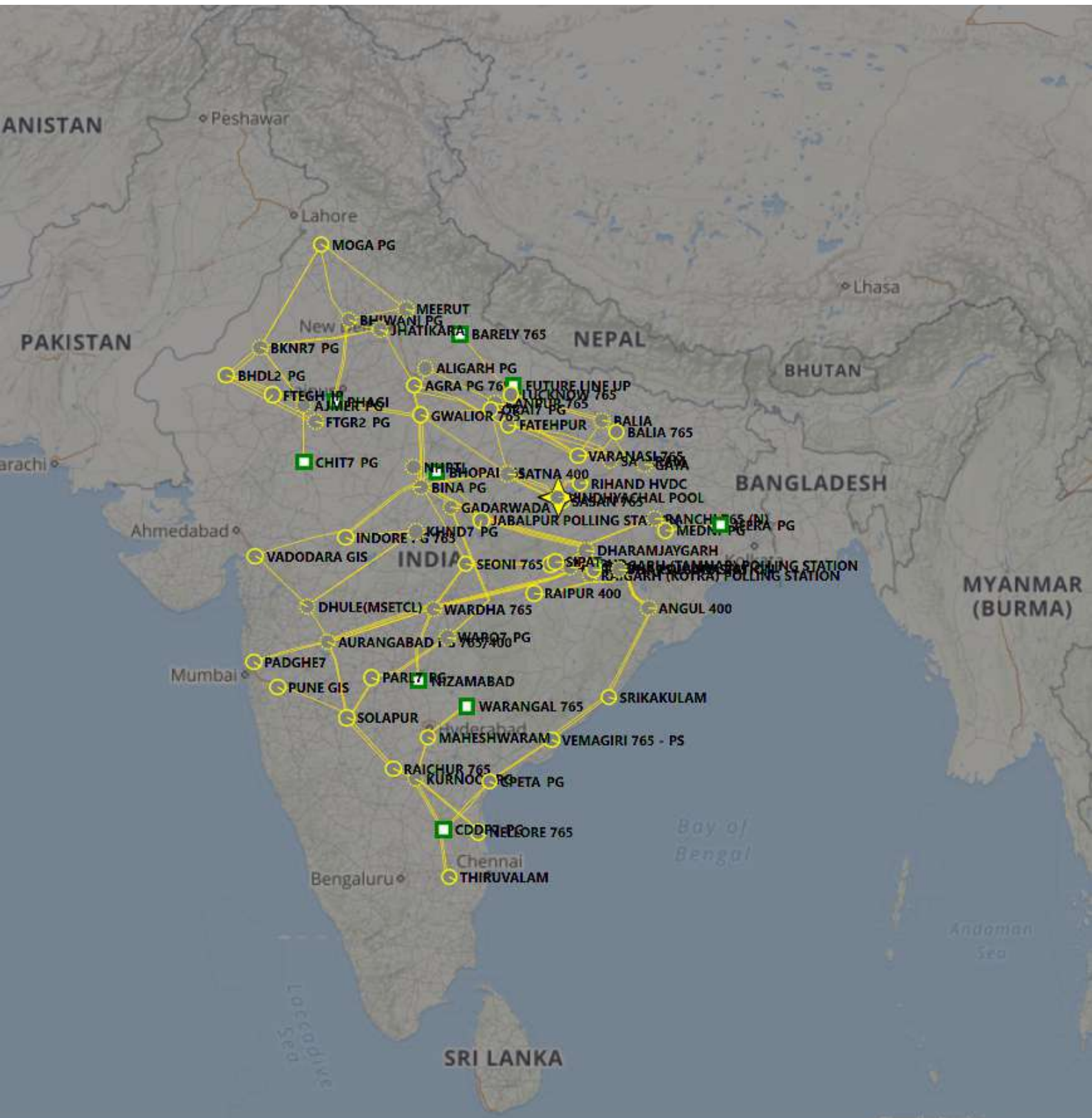
313	WR	WR-II	Gujrat	Kakrapar	NPCIL	220	Vav 1&2, Vapi 1&2, Haldarwa 1&2	Vav 1&2, Vapi 1&2, Haldarwa 1&2 UKAI	-	1	1	Not in contract-> Ukai	4
314	WR	WR-II	Gujrat	Kawas	NTPC	220	Haldarwa 1&2, Vav 1&2, Navsari 1&2	Haldarwa 1&2, Vav 1&2, Dastan 1&2	Haldarwa 1&2, Vav 1&2, Navsari (GIS) 1&2	0	0	Navsari 1 > Dastan 1 Navsari 2 > Dastan 2	3
315	WR	WR-II	Gujrat	Gandhar	NTPC	220	Haldarwa 1&2	Haldarwa 1&2	Haldarwa 1&2	0	0	NIL	4
316	WR	WR-I	Chattisgarh	765/400kV Raigarh(Kotra) Pooling Station	Powergrid	765	765kV Raigarh (Tamnar) PS-1, 765kV Raigarh (Tamnar) PS-2, 765kV Raipur PS-1, 765kV Raipur PS-2, 765kV Champa PS, 400kV Raigarh-1, 400kV Raigarh-2, 400kV RKM-1, 400kV RKM-2, 400kV Athena-1, 400kV Athena-2, 400kV SKS-1, 400kV SKS-2, 400kV Korba-1, 400kV Korba-2, 400kV DB-1, 400kV DB-2, 400kV Visa-1, 400kV Visa-2	765kV Raigarh (Tamnar) PS-1, 765kV Raigarh (Tamnar) PS-2, 765kV Raipur PS-1, 765kV Raipur PS-2, 765kV Champa PS, 400kV Raigarh-1, 400kV Raigarh-2, 400kV RKM-1, 400kV RKM-2, 400kV Athena-1, 400kV Athena-2, 400kV SKS-1, 400kV SKS-2, 400kV Korba-1, 400kV Korba-2, 400kV DB-1, 400kV DB-2, 400kV Visa-1, 400kV Visa-2, 400kV Visa Steel-1, 400kV Visa Steel-2, 400kV NTPC-1 (COSMOS), 400kV NTPC-2 (COSMOS)	765kV Raigarh (Tamnar) PS-1, 765kV Raigarh (Tamnar) PS-2, 765kV Raipur PS-1, 765kV Raipur PS-2, 765kV Champa PS, 400kV Raigarh-1, 400kV Raigarh-2, 400kV RKM-1, 400kV RKM-2, 400kV Athena-1, 400kV Athena-2, 400kV SKS-1, 400kV SKS-2, 400kV Korba-1, 400kV Korba-2, 400kV DB-1, 400kV DB-2, 400kV Visa-1, 400kV Visa-2, 400kV Visa Steel-1, 400kV Visa Steel-2, 400kV NTPC-1 (COSMOS), 400kV NTPC-2 (COSMOS)	4	4	400kV SKS-1 > 400kV SPGCIL-1, 400kV SKS-2 > 400kV SPGCIL-2, 400kV Korba-1 > 400kV KWPCIL-1, 400kV Korba-2 > 400kV KWPCIL-2, 400kV Visa-1 > 400kV Visa Power-1, 400kV Visa-2 > 400kV Visa Power-2, Not applicable->400kV Visa Steel-1 Not applicable->400kV Visa Steel-2 Not applicable->400kV NTPC-1 (COSMOS not applicable->400kV NTPC-2 (COSMOS)	15
317	WR	WR-I	Chattisgarh	765/400kV Raipur Pooling Station	Powergrid	765	765kV Raigarh (Kotra) PS-1, 765kV Raigarh (Kotra) PS-2, 765kV Champa-1, 765kV Champa-2, 765kV Wardha-1, 765kV Wardha-2, 765kV Wardha-3, 765kV Wardha-4, 400kV Raipur-1, 400kV Raipur-2, 400kV GMR-1, 400kV GMR-2	765kV Raigarh (Kotra) PS-1, 765kV Raigarh (Kotra) PS-2, 765kV Champa-1, 765kV Champa-2, 765kV Wardha-1, 765kV Wardha-2, Future Extension, Future Extension, 400kV Raipur-1, 400kV Raipur-2, 400kV GMR-1, 400kV GMR-2	765kV Raigarh (Kotra) PS-1, 765kV Raigarh (Kotra) PS-2, 765kV Champa-1, 765kV Champa-2, 765kV Wardha-1, 765kV Wardha-2, 765kV Wardha-3, 765kV Wardha-4, 400kV Raipur-1, 400kV Raipur-2, 400kV GMR-1, 400kV GMR-2	0	0	NIL	9
318	WR	WR-I	Chattisgarh	765/400kV Raigarh(Tamnar) Pooling Station	Powergrid	765	765kV Raigarh (Kotra) PS 1&2, 400kV Jindal Power 1,2,3,& 4, 400kV TRN 1 & 2, 400kV Jayaswal Nico 1&2, 400kV Sarda 1&2	765kV Raigarh (Kotra) PS 1&2, 400kV Jindal Power 1,2,3,& 4.	765kV Raigarh (Kotra) PS 1&2, 400kV Jindal Power 1,2,3,& 4, 400kV TRN 1 & 2.	6	-6	400kV TRN 1 & 2 > Not identified 400kV Jayaswal Nico 1&2 > Not identified 400kV Sarda 1&2 > Not identified.	8

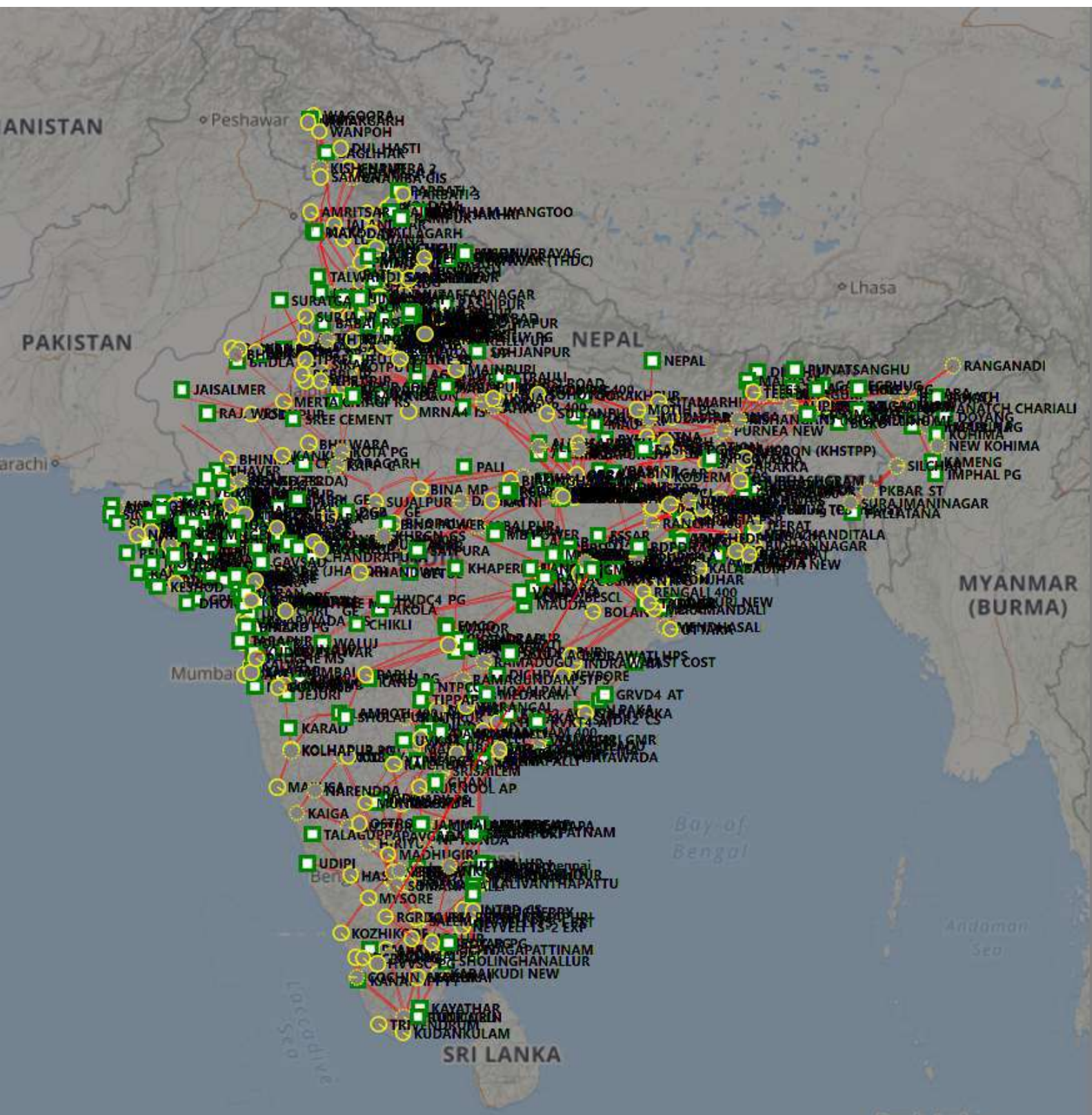
319	WR	WR-I	Maharastra	765/400kv Aurangabad Station	Powergrid	765	765kV Wardha 1, 765kV Wardha 2, 765kV Wardha 3, 765kV Wardha 4, 76kV Padghe (PG) 1 76kV Padghe (PG) 2, 765kV Dhule , 400kV Boisar 1 400kV Boisar 2 400kV Wardha 1 400kV Wardha 2 400kV Aurangabad 1 400kV Aurangabad 2	765kV Wardha 1, 765kV Wardha 2, 765kV Wardha 3, 765kV Wardha 4, 76kV Padghe (PG) 1 76kV Padghe (PG) 2, 765kV Dhule , 400kV Boisar 1 400kV Boisar 2 400kV Wardha 1 400kV Wardha 2 400kV Aurangabad 1 400kV Aurangabad 2 400kV Ankola 1 400kV Ankola 2	765kV Wardha 1, 765kV Wardha 2, 765kV Wardha 3, 765kV Wardha 4, 76kV Padghe (PG) 1 76kV Padghe (PG) 2, 765kV Dhule , 400kV Boisar 1 400kV Boisar 2 400kV Wardha 1 400kV Wardha 2 400kV Aurangabad 1 400kV Aurangabad 2 400kV Ankola 1 400kV Ankola 2	6	6	Not identified > 400kV Wardha 1, Not identified > 400kV Wardha 2, Not identified > 400kV Aurangabad 1, Not identified > 400kV Aurangabad 2, Not identified > 400kV Ankola 1, Not identified > 400kV Ankola 2.	8
320	WR	WR-II	Gujrat	Vadodara GIS	Powergrid	765	765kV Indore, 765kV Dhule, 400kV Pirana 1 & 2, Asoj 1 & 2, DGEN 1&2	765kV Indore, 765kV Dhule, 400kV Pirana 1 & 2, 400kV Asoj 1 & 2,	-	2	2	DGEN 1&2-> Not available.	3
321	WR	WR-I	Chattisgarh	765/400kV Dharamjaygarh	Powergrid	765	765kV Jharsuguda 1 ,2,3 & 4, 765kV Ranchi 1 & 2, 765kV Champa, 765kV Jabalpur Pool 1 , 2,3 & 4, 400kV BALCO 1 &2, 400kV Vandana 1 &2, 765kV WR Pool.	765kV Jharsuguda 1 ,2,3 & 4, 765kV Ranchi 1 & 2, 765kV Champa, 765kV Jabalpur Pool 1 , 2,3 & 4, 400kV BALCO 1 &2, 400kV Vandana 1 &2, 765kV Bilaspur,	-	0	0	765kV WR Pool >765kV Bilaspur	12
322	WR	WR-II	Madhya Pradesh	765/400kV Jabalpur Pooling station	Powergrid	765	765kV Dharamjaygarh-1, 2, 3 & 4, 765kV Bina-1, 2 & 3, 765kV Bhopal, 400kV Jabalpur-1 & 2, 400kV MB Power-1 & 2, 400kV Jhabua-1, 2	765kV Dharamjaygarh-1, 2, 3 & 4, 765kV Bina-1, 2 & 3, 765kV Bhopal, 400kV Jabalpur-1 & 2, 400kV MB Power-1 & 2, 400kV Jhabua-1, 2	765kV Dharamjaygarh-1, 2, 3 & 4, 765kV Bina-1, 2 & 3, 765kV Bhopal, 400kV Jabalpur-1 & 2, 400kV MB Power-1 & 2, 400kV Jhabua-1, 2	0	0	NIL	10
323	WR	WR-II	Madhya Pradesh	765/400kV Gwalior	Powergrid	765	765kV Bina 1,2 & 3, 765kV Jaipur 1 & 2, 765kV Agra 1 & 2, 765kV Satna 1 & 2	765kV Bina 1,2 & 3, 765kV Jaipur 1 & 2, 765kV Agra 1 & 2, 765kV Satna 1 & 2	765kV Bina 1,2 & 3, 765kV Jaipur 1 & 2, 765kV Agra 1 & 2, 765kV Satna 1 & 2	0	0	NIL	6
324	WR	WR-II	Chattisgarh	Vin IV Switchyard	NTPC	400	400kV V'Pool 1 400kV V'Pool 2	Vindhyachal Pooling -1 Vindhyachal Pooling -2	Vindhyachal Pooling -1 Vindhyachal Pooling -2	0	0	400kV V'Pool 1 > Vindhyachal Pooling -1 400kV V'Pool 2 > Vindhyachal Pooling -2	2
325	WR	WR-II	Chattisgarh	Vindhychal Pool	Powergrid	765	765kV Rihand III 1 & 2, 765kV Satna 1 & 2, 765kV Sasan, 400kV Sasan 1 & 2, 400kV Vin IV 1 & 2, DB(MP) 1&2	765kV Rihand III 1 & 2, 765kV Satna 1 & 2, 765kV Sasan, 400kV Sasan 1 & 2, 400kV Vin IV 1 & 2, 400kV Rihand III 1&2 400kV Future-1,2,3,4	-	4	4	DB(MP) 1&2-> Not available Not in contract->400kV Rihand III 1&2 Not in contract->400kV Future-1,2,3,4	11
326	WR	WR-I	Maharastra	Dhule (PVT)	Bhopal dhule company transmission LTD	765	765kV Aurangabad, 765kV Vadodara, 400kV Dhule(MSETCL) 1 & 2	765kV Aurangabad, 765kV Vadodara, 400kV Dhule(MSETCL) 1 & 2 HVDC-1,2,3,4	-			Not in contract->HVDC- 1,2,3,4	5
327	WR	WR-I	Maharastra	400KV Kolapur (PG)	Powergrid	400	Karad-1, Karad-2, Mapusa-1, Mapusa-2, Solapur-1, Solapur-2,	Karad-1, Karad-2, Mapusa-1, Mapusa-2, Solapur-1, Solapur-2,	-	0	0	-	3

328	WR	WR-II	Gujrat	Magarwada GIS	Powergrid	400	400kV Navsari 1 & 2, 400kV Boisar 1&2	400kV Navsari 1 & 2, 400kV Kala 1&2	-	0	0	400kV Boisar 1&2->400kV Kala 1&2	2
329	WR	WR-II	Maharashtra	UT DNH - Kala GIS	Powergrid	400	400kV Vapi -1, 400kV Vapi -2, 400kV Navi Mumbai -1, 400kV Navi Mumbai -2	400kV Vapi -1, 400kV Vapi -2, 400kV Navsari -1, 400kV Navsari -2	400kV Vapi -1, 400kV Vapi -2, 400kV Kudus-1, 400kV Kudus-2	0	0	400kV Navi Mumbai -1 > 400kV Navsari -1, 400kV Navi Mumbai -2 > 400kV Navsari -2	2
330	WR	WR-I	Chattisgarh	Bhatapara	Powergrid	400	Not in contract	Korba Khedamara	As per site survey	NA	NA	Not in contract > Korba Not in contract > Khedamara	2
331	WR	WR-I	Chattisgarh	Bilaspur	Powergrid	765	Not in contract	765KV- Seoni I & II, Sipat I & II, Korba, Ranchi. 400KV- Mahan I & II, Aryan I & II, Lanco I & II.	765KV- Seoni I & II, Sipat I & II, Korba. 400KV- Mahan I & II, Aryan I & II, Lanco I & II.	NA	NA	Not in contract > Seoni I & II, Not in contract > Sipat I & II, Not in contract > Korba, Not in contract > Ranchi. Not in contract > Mahan I & II, Not in contract > Aryan I & II, Not in contract > Lanco I & II	10
332	WR	WR-I	Chattisgarh	NTPC Sipat	NTPC	400	Not in contract	765KV- Bharari I Bharari II 400KV- Ranchi 1&2, Raipur 1&2 Raipur 3 Korba.	-	NA	NA	Not in contract > Bharari I Not in contract > Bharari II Not in contract > Ranchi 1&2 Not in contract > Raipur 1&2 Not in contract > Raipur 3 Not in contract >Korba.	4
333	WR	WR-II	Gujrat	VARSANA	GETCL	400	Not in contract	Adani-1. Adani-2 Adani-3, Bachau-1, Bachau-2, Hadala-1, Tappar-1, Tappar-2, Tappar-3, Tappar-4 Nakhatrana-1, Nakhatrana-2,,		0	0	Not in contract->Adani-1. Not in contract->Adani-2 Not in contract->Adani-3, Not in contract->Bachau-1, Not in contract->Bachau-2, Not in contract->Hadala-1, Not in contract->Tappar-1, Not in contract->Tappar-2, Not in contract->Tappar-3, Not in contract->Tappar-4 Not in contract- >Nakhatrana-1, Not in contract- >Nakhatrana-2,,	3

334	WR	WR-II	Gujrat	AMRELI	GETCL	400	Not in contract	400KvJ etpur-1, 400Kv Jetpur-2, 400Kv Chorania, 400Kv Hadala, 400Kv kasor-1, 400kv kasor-2, 400Kv shapoorji-1, 400Kv shapoorji-2, 400Kv pipava-1, 400Kv pipava-2, 220kv Dhasa-1, 220kv Dhasa-2, 220kv s'kundala-1, 220kv s'kundala-2, 220kv Inox-1, 220kv Inox-2.	-	-	-	Not in contract->400Kv Jetpur-1, Not in contract->400Kv Jetpur-2, Not in contract->400Kv Chorania, Not in contract->400Kv Hadala, Not in contract->400Kv kasor-1, Not in contract->400kv kasor-2, Not in contract->400Kv shapoorji-1, Not in contract->400Kv shapoorji-2, Not in contract->400Kv pipava-1,Not in contract-> Not in contract->400Kv pipava-2, Not in contract->220kv Dhasa-1, Not in contract->220kv Dhasa-2, Not in contract->220kv s'kundala-1, Not in contract->220kv s'kundala-2	6
335	SR	SR - I	Andhra Pradesh	Vemagiri	APTRANSCO		Gautmi 1&2, Nunna 1,2,3&4,Vemagiri PGL (GMR) 1&2, Konaseema 1&2, Kalpaka 1&2, Gazuwaka 1&2, Jegrupadu Extn (GVK) 1&2						8
336	SR	SR - II	Andhra Pradesh	Kaiga Atomic Power Stn	NPCIL		Narendra 1&2, Guttur 1&2,Sirsi- 2						2
337	SR	SR - II	Karnataka	Narendra 765	Powergrid		Kolhapur-1&2,Narendra- 1&2,Madhugri-1,2						5
338	SR	SR - II	Tamil Nadu	Nagapattanam PS	Powergrid		Neyveli -1, Trichy-1,Salem new- 1,2						4
339	SR	SR - II	Tamil Nadu	Neyveli TS I	NLC		Neyveli TS2, Neyveli TS2exp, Madurai 1&2						3
340	SR	SR - II	Tamil Nadu	PFBR Kalpakkam	NPCIL		Kancheipuram 1 &2,Arni 1&2,Sirucheri 1&2						3
341	SR	SR - I	Andhra Pradesh	Hyderabad	Powergrid		Wardha-1,2,Ghanapur-1,2						2
342	SR	SR - I	Andhra Pradesh	Vemagiri(765)-PS	Powergrid		Gazuwaka ,Vijayawada						1
343	SR	SR - I	Andhra Pradesh	Khammam-765	Powergrid		Khammam 1&2,						2
344	WR	WR-II	Madhya Pradesh	Birsinghpur	MPPTCL		Birsinghpur-1&2						7
345	WR	WR-II	Chattisgarh	VINDYACHAL	Powergrid		Jabalpur PG 1&2, Singrauli 1&2, Satna 1,2.3&4, Sasan 1&2, KSTPS 1&2						6
346	WR	WR-I	Chattisgarh	765/400kV Champa Pooling Station	Powergrid		765kV Raigarh(Kotra), 765kV Raipur PS 1 & 2, 765kV Dharamjaygarh , Kurushetra HVDC 1 & 2, 400kV KSK 1 ,2,3 & 4, 400kV Lanco 1 &2						11
347	WR	WR-I	Maharastra	765/400kV Padghe(PG) Station	Powergrid		76kV Aurangabad (PG) 1 & 2, 400kV Kudus 1&2, 400kV Kolhapur(PG), 400kV Pune(gis)						2

348	WR	WR-I	Maharastra	765/400kv Pune GIS	Powergrid		765kV Solapur 1&2, 400kV Solapur STPP 1&2, 400kV Kolhapur, 400kV Aurbd(existing) 1&2, 400kV Parli(exs) 1&2, 400kV Padghe(GIS), 400kV HEGL 1,2						5
349	WR	WR-II	Madhya Pradesh	BINA 1200kV	Powergrid								1
350	SR	SR - I	Andhra Pradesh	NP Kunta	Powergrid								
351	NR	NR-II	Haryana	Kurukshetra					As per site survey	0	0	NIL	6





List of lines for PMU installation in NER

Sl. No.	Region	Name of the Line	Length in ckt km	Charged at	Voltage Level in kV
1	NER	Tezu -Namsai S/c	95	132	132
2	NER	Pasighat - Roing	108	132	132
3	NER	Roing - Tezu	72	132	132
4	NER	Bongaigaon - salkati-II D/C line (Lenth is for Bongaigaon - salkati-II only)	1	220	220
5	NER	Balipara - Tezpur	9	220	220
6	NER	Misa - Kopili-III	76	220	220
7	NER	Salakati - BTPS-I	3	220	220
8	NER	Salakati - BTPS-II	3	220	220
9	NER	Misa - Kopili-I	73	220	220
10	NER	Misa - Kopili-II	73	220	220
11	NER	Misa - Dimapur-I	124	220	220
12	NER	Misa - Dimapur-II	124	220	220
13	NER	Misa - Samaguri-I	34	220	220
14	NER	Misa - Samaguri-II	34	220	220
15	NER	Mariani - Mokokchung I	49	220	220
16	NER	Mariani - Mokokchung II	49	220	220
17	NER	Aizwal - Kolasib	66	132	132
18	NER	Kolasib - Badarpur	107	132	132
19	NER	Agartala - Agartala-I	8	132	132
20	NER	Agartala - Agartala-II	8	132	132
21	NER	Aizwal - Kumarghat	133	132	132

List of lines for PMU installation in NER

Sl. No.	Region	Name of the Line	Length in ckt km	Charged at	Voltage Level in kV
22	NER	Aizwal -Melriat- Zemabawk(LILO	10	132	132
23	NER	Aizwal -Melriat- Zemabawk	7	132	132
24	NER	Badarpur - Badarpur	1	132	132
25	NER	Badarpur - Jiribam	67	132	132
26	NER	Badarpur - Khliehriat	77	132	132
27	NER	Badarpur - Kumarghat	119	132	132
28	NER	Dimapur - Imphal	169	132	132
29	NER	Doyang - Dimapur-I	93	132	132
30	NER	Doyang - Dimapur-II	93	132	132
31	NER	Gohpur - Nirjuli (Itanagar)	43	132	132
32	NER	Imphal - Imphal	2	132	132
33	NER	Jiribam - Aizwal	172	132	132
34	NER	Jiribam - Haflong	101	132	132
35	NER	Jiribam - Loktak-II	82	132	132
36	NER	Salakati - Gaylemphug	49	132	132
37	NER	Khandong - Haflong	63	132	132
38	NER	Khandong - Khliehriat-I	42	132	132
39	NER	Khandong - Khliehriat-II	41	132	132
40	NER	Khandong - Kopili I	11	132	132
41	NER	Khliehriat - Khliehriat	8	132	132
42	NER	Kumarghat - R.C.Nagar (Agarthala)	104	132	132

List of lines for PMU installation in NER

Sl. No.	Region	Name of the Line	Length in ckt km	Charged at	Voltage Level in kV
43	NER	Loktak - Imphal-II	35	132	132
44	NER	Nirjuli - Ranganadi	22	132	132
45	NER	Kopili - Khandong II	12	132	132
46	NER	Dimapur - Dimapur (PG) (LILO portion)	0	132	132
47	NER	Dimapur (PG) - Kohima (LILO portion)	0	132	132
48	NER	Silchar - Srikona I	1	132	132
49	NER	Silchar - Srikona II	1	132	132
50	NER	Silchar - Badarpur I	19	132	132
51	NER	Silchar - Badarpur II	19	132	132
52	NER	Part of Silchar - Hailakandi I	30	132	132
53	NER	Part of Silchar - Hailakandi II	30	132	132
54	NER	Imphal (state) - Ningthoukong	0	132	132
55	NER	Imphal (state) - Imphal	0	132	132
56	NER	Ranganadi - Ziro	45	132	132
57	NER	Bishwanath Chariali - Bishwanath Chariali (Pavoi) I	13	132	132
58	NER	Bishwanath Chariali - Bishwanath Chariali (Pavoi) II	13	132	132
59	NER	Mokokchung - Mokokchung I	1	132	132
60	NER	Mokokchung - Mokokchung II	1	132	132

List of lines for PMU installation in Sikkim

Sl. No.	Region	Name of the Line	Length in ckt km	Charged at	Voltage Level in kV
1	ER-II	Rangpo - New Melli I	26	220	220
2	ER-II	Rangpo - New Melli II	26	220	220
3	ER-II	Rangit - Karseong (upto LILO point)	61	132	132
4	ER-II	Karseong - Siliguri (upto LILO point)	31	132	132
5	ER-II	Siliguri - Meli	92	132	132
6	ER-II	Meli - Chuzachen	21	132	132
7	ER-II	Rangpo - Chuzacheng I (upto LILO)	1	132	132
8	ER-II	Rangpo - Gangtok	17	132	132
9	ER-II	Gangtok - Rangpo	73	132	132
10	ER-II	Rangpo - Rangit	3	132	132
11	ER-II	Rangit - Rammam	27	132	132

1. **Inter-Regional and Tie Lines Lines:** It is very important to monitor the power flow on inter regional lines, though the SCADA provides this data but high sampling rate data furnished by PMUs would help in getting accurate frequency response of regions as well as proper functioning of automatic generation control. Therefore, PMU need to be placed on all inter-regional lines so that power flow can be assessed.
2. **HVDC and FACTS devices:** With the large integration of HVDC and FACTS devices in the system, it is very important that their interaction with existing system is monitored. The high sampling rate data provided by PMU would help in understanding the controller interactions and getting insights into their features. The PMUs need to be placed at AC-DC boundary and converter transformer or coupling transformer. With more numbers of power electronic devices in grid, it is possible that sub-synchronous resonance may be observed at various locations.. The reporting rates of samples need to be higher to capture the SSR phenomenon. Hence PMUs having ability to measure SSR frequencies can be installed at strategically locations.

Elements to be covered:

- (i) At Both ends of Inter connecting lines between HVDC side AC switchyard with connecting AC Sub Station.
 - (ii) All Converter Transformer (HV side)
 - (iii) At STATCOM/SVC station Coupling Transformer (LV & HV sides) including the individual STATCOM/SVC.
3. **Renewable Energy Generation Pooling points:** The RE generation is coming across all Indian power system at very fast pace, the monitoring of RE generation is very important considering must-run status of this generation. RE based generation are required, by CEA Technical Standards of Connectivity to the Grid, to perform various dynamic performances such as LVRT, HVRT etc. The performance can be assessed better if high resolution data will be available and PMU placement at low voltage side of transformer at pooling station would help in providing that.

With Upcoming Ultra Mega Green Solar Power Project integrations in EHV grid, change in angle variations are expected on existing transmission system and the consequences in respect to operating constraints in evacuations especially in pockets where concentrated Renewable Generation. Moreover, these changes occur very fast due to the inherent intermittency of RE sources, particularly wind and solar, as well as other associated weather influences. As a sample case, in Western Region, Rewa Solar Park has an Installed Capacity of 750 MW, and the

angular separation pattern is closely following the Solar Generation pattern as shown below:

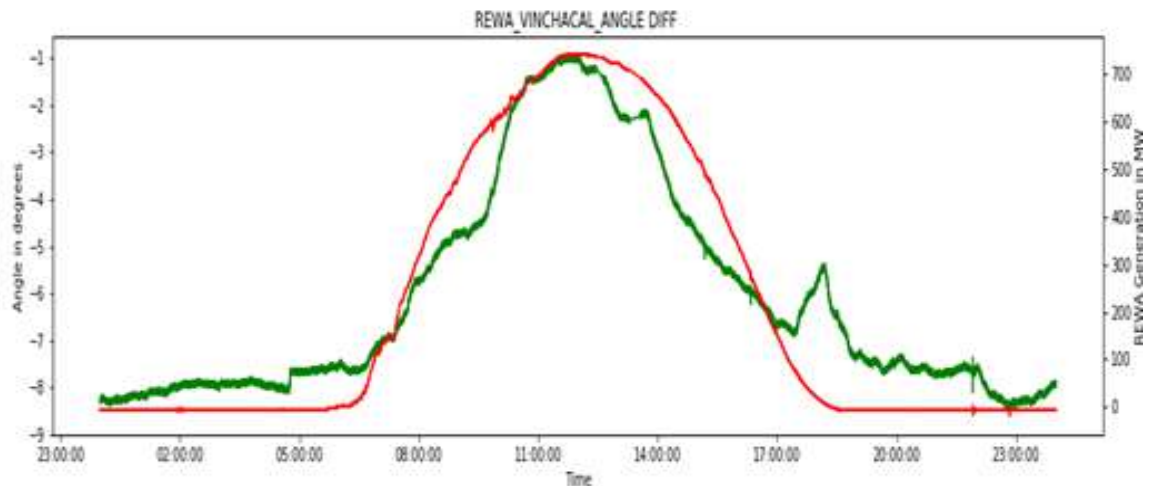


Figure: REWA Solar UMPP Angular Difference Correlation with Solar Generation

There is a variation of about 8 degrees is observed in the between Rewa and Vindiyachal nodes in the span of three hours. This emphasises the importance of PMU data at solar stations. Currently PMUs are installed at 400 kV side only however PMUs are equally important at 220 kV level as well.

Elements to be Covered:

- (i) On all outgoing feeders including bus sectionalizer or tie line between two stages of generating stations having different tariffs or different ownership or both
- (ii) High Voltage (HV) side & Low Voltage side of Transformers
- (iii) Reactive Power sources & Sinks shall be measured through Synchrophasor
- (iv) All CB and isolators shall be wired to Synchrophasor device as digital signals.

4. **Islanding, Separation & Restoration:** The expected benefits from PMU installations at strategic locations include early detection of islanding conditions and remedial action by SPS (special protection scheme). Key placements can assistance with the restoration process, and resynchronization back into the main grid. Black-start investigations of alternative system configurations, including operation of transmission lines at reduced voltages with bypassing of transformers are enabled with detailed phasor measurements of potential overvoltage locations. Similarly, the PMU data can be utilized for resynchronization with data for bus and line voltage magnitude and angle along-with frequency.

Elements to be Covered: At both ends of line connected black start stations or

restoration path lines (both ends including CB and isolators).

5. **State Estimation errors:** The observability of the complete system is very important therefore, the locations where the state estimation errors are high and continuously show such behavior may be the candidate locations.

Further, during URTDSM Phase-I, PMUs are envisaged only on 400 kV and 765 kV lines only. Linear State Estimator (LSE) application developed by IITB and installed under URTDSM Phase-I at various control centre i.e. RLDCs/NLDC/SLDC. After the configuration and setting up of linear state estimator, it is observed that two islands are being formed for each voltage level (400 kV & 765 kV). To avoid multiple network islands, PMU should also be placed on Interconnecting Transformers (ICT) at EHV level

Elements to be Covered:

- a) Substation shall have Three phase Bus voltage measurements through PMUs & Circuit breakers and isolator position shall be wired to PMU for Linear State Estimator for topology processing and full observability.
 - b) Reactive Power sources & Sinks shall be measured through Synchrophasor to avoid MVAR mismatch in Linear State Estimation.
 - c) All 765/400 kV, 400/220 kV Inter Connecting Transformers (ICT) should have PMU on both sides (LV & HV).
6. **Power Flow Gates:** The high-power corridors after large generating complexes like Sikkim hydro, Mundra UMPP, Vindhyachal-Sasan-Rihand complex etc. The power flow on these gates need to be monitored therefore the lines emanating from these complexes can have PMU placement.
7. **Major load centers:** Load models are important for off-line stability studies as well as real time monitoring. It is difficult from simulation programs models to select a proportion of load to be of induction motor type. In addition, electronic load is growing whereas incandescent lighting (resistive load) is decreasing. However, load simulation programs do not often reflect the changing nature of power loads with respect to changes in the electrical behavior and penetration of power electronic devices. While PMUs placed at load centers will not reveal changes in the makeup of loads, they can reveal changes in the electrical characteristics and behavior of aggregated loads. PMUs should be installed at appropriate radial load feeding substations so that the load sensitivities to system frequency and voltage changes can be monitored. FIDVR (Fault Induced Delayed Voltage Recovery) based events can be better analysed.
8. **Angular Difference monitoring locations:** Phase angle difference is directly correlated with system stress, and can be used as a strategic measurement of grid

security both pre- and post- contingency. For improved wide-area phase angle difference monitoring and situational awareness, it is useful to monitor the angle difference across major transmission interfaces across the grid, including both on a local- and wide-area basis. These interfaces are defined by key stress patterns driving the need to monitor these interfaces. The PMUs which will be the most valuable for angle difference monitoring need to be identified for PMU placement.

9. **Major Generating Stations:** In a generation station, it is desirable to measure all the line currents (including the step-up transformer) and both the high-side and low-side voltages. The PMU placement at these locations in generators will provide good insights into governor frequency control, excitation control, PSS tuning etc.

In order to confirm the mathematical model correctness used for simulation studies, model validation using PMU data plays a key role. International grid standards like NERC Reliability standards requirements have accepted Synchrophasor based model validation as an effective way to verify generator real and reactive power capability and control systems and assure their appropriate responses during system disturbances. Synchro phasor-based model validation is more economical and accurate than validation methods that take the model off-line for performance testing.

Hence placement of PMUs on GT LV side for thermal/gas/nuclear based generation for 132kV and above generating station is required/recommended.

Elements to be covered:

- (i) At 400 kV and above Generating stations (132 kV in case of NER).
 - (ii) Individual Unit of rating 200MW and above for Coal/lignite, 50MW and above for gas turbine and 25 MW and above for Hydro units shall have PMU placed at the terminals of the generator(s) at either the HV or LV side of the Generator Transformers.
 - (iii) In case of plant having multiple units ,PMU can be placed on 50 percent of the units
10. **System Protection Scheme monitoring:** The monitoring of the inputs for SPS activation is also very important; it can also help in validating the accuracy of SPS action. SPS operation can be very well validated using the PMU data. Therefore, all the points where SPS based scheme inputs are derived may be allocated PMUs.
11. **Experience based locations known for small signal stability related issues:** The nodes in the grid which have in history observed the cases of Low frequency Oscillations negative damping, Ferro resonance, Sub-synchronous resonance, out

of step protection etc. shall be considered for PMU placement. A high-resolution data capturing may be recommended for such PMUs.

The details of analytics suggested by CTU

1. Real time Automated Event Analysis tool (using AI, Machine learning and big data)
Tool for making an automated event driven dashboard comprises of Notification of event, type of fault and characteristics of the event, display of event location (indicating PMU Location) on Grid map, Drill down capability with additional displays for each type of event. It should have machine learning capabilities and it should identify and display historical events of similar nature and gives information related to operator action taken on past events.
2. Event monitoring for early warning system (using AI, Machine learning and Big data)
It detects events and slow trends in PMU measurements. This will assist system operators in a.) Identifying stress levels in both apparatus and system, b.) Provide guidance towards meaningful real time contingency selection and analysis, c.) Provide easy summary reports for case study preparation, post event analysis and archival purposes.
3. WAMS based contingency analysis and static security assessment
Static security assessment tool improves operator assist feature of grid monitoring and makes it adaptive and interactive. This tool is meant to provide and perform what-if simulations and integrate power of data mining with intuition and insights of operators. This will help in improving grid operation efficacy.
4. Oscillation Source location
This tool is required to identify, detect, and locate Oscillations, present in the grid. It shall have capability to monitor multiple oscillation modes simultaneously in real time. It shall Identify the source of the oscillation and display in unified real time dashboard to take corrective action.
5. Response of Windfarm and solar PV farms for LVRT, reactive power etc.
With integration of large windfarms and solar PV farms at EHV levels these analytics assumes big importance. The grid code requires that these farms provide low voltage ride through (LVRT) features and also some kind of reactive power support during faults in the neighboring transmission network. With PMU measurements the adherence to grid code can be verified in real operating conditions (not just lab environment) and over complete life of the windfarms. If any problems or mismatch in performance is observed, it can be rectified early.
6. Control of HVDC and STATCOM for damping system oscillations
This is the usage of WAMS measurements for actual automatic control applications. This was one of the original thoughts behind going for WAMS installation. The power system oscillations that originate in a post fault event or spontaneous oscillations can be damped quickly using controllers of HVDC and FACTS (like STATCON) devices. It improves the overall transfer capacity of a power corridor. Lot of actual projects are now under operation in the USA and China. India must take up such projects for capacity building for the future.

URTDSM Applications Required in Indian Power System		
S.No.	Application Name	Used in
1	Voltage Stability Monitoring: Measurement based dynamics provide voltage sensitivities; monitoring of key corridors or load pockets; scatter plots for power-voltage and power-angle monitoring.	Austrian Power Grid, Red Electrica de Espana
2	Detection of disturbances: Recognition of short circuits by watching the currents, and indication of loss of load, or loss of generation by watching the frequencies.	Red Electrica de Espana, FINGRID
3	Online monitoring of Inertia.	AEMO
4	Identification of source of Oscillation.	ISO New England
5	Identification of stressed corridors	-
6	ROCOF calculation over variable window	WECC
7	Island identification/detection	MISO, Red Electrica de Espana, Swissgrid, North American power grid
8	Locating contributions to poorly damped or unstable oscillations	WECC
9	Model Validation	MISO , Austrian Power Grid, GCC Interconnection Authority
10	Higher frequency sub-synchronous oscillation analysis and early warning of resonance	-
11	Big Data Analytics	-

Note: 1

POWERGRID is in view that Philosophy for PMU location as decided in Joint meeting of all the five Regional Standing committee meeting held on 5th March 2012 should not be altered as the panel of expert constituted on URTDSM Project recommended the same. The panel having renowned International and National experts from IIT Kanpur, NIST etc. under the chair of Dr. Arun G. Phadke. Moreover, the present sub-committee should provide direction for including 'additional' PMUs as desired by system operator based on their feedback. In the sub-committee meeting held on 14-09-2022, CTUIL also expressed similar views.

The present recommendation of sub-committee for minimum location of PMUs (as mentioned in Clause 6.4(d) shall be also challenging in implementation, as there would be need for maintaining transmission lines database at central level by designated nodal agency on which PMU has been already installed at one end under different schemes/packages/TBCB projects etc. by different implementation agencies. There would be issue in finalising PMU Bill of Quantities as both end of line bays may be implemented by different agency under different schemes/packages/TBCB projects etc. This would lead to further delay in executing these projects.

The Section 4.2 and Clause 6.4(e)-vii describing analytics under phase-I may not represent complete picture. The Analytics such as VADR and Supervised Zone-3 analytics are not inherently designed for protection class. The VADR detects and logs conditions of power swings and load encroachment and does not that of fault condition. The Supervised Zone-3 analytics can issue block signal in above conditions if closed loop control is implemented in field otherwise the generation of block signal shall be logged for operators for further analysis. The above scenarios (power swings and load encroachment) which are dealt by these two analytics generally appears to the candidate relay 'after' the fault. In addition, PMU data frequency under URTDSM project (25 samples/second) also does not envisage enough samples (only 2-3 samples during fault) to do any fault duration analysis. Hence, the same principal is utilised by IITB in designing analytical applications. Further, alternate methods have been developed in the Line parameter estimation and CT/CVT calibration to decouple their inter dependencies.

As per Clause 6.4(d)-xii, Fiber Optic should be covered under Phase – II for all the above locations of the URTDSM project. However, Separate project shall be allocated for installing OPGW required for URTDSM Phase II. Further, the analytics recommended for phase-II in the report may require additional deliberation to access the feasibility for implementation, data requirement and solution available in the market.

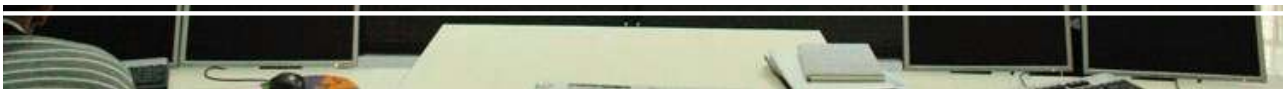
It may be also noted that the Quantity of PMUs required in line with recommendations of this report for the URTDSM Project Phase – II, Clause 6.4(d) may require upgradation of existing URTDSM control centre equipment. The same may also be included in the project at this stage itself, as it may need additional planning/design/execution time.

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Report of the Sub-Committee on PMU Placement and Analytics under URTDSM Phase II



Formation of the Sub-Committee

In the 10th NPC Meeting held on 9th April 2021 it was decided to form a sub-committee.



"After deliberations, NPC decided that a Sub-Committee would be formed under the Chairmanship of Member Secretary, WRPC with representatives from POSOCO, CTU, POWERGRID, all RPCs/NPC. The Sub-Committee shall discuss on the uniform philosophy of PMU locations, new analytics and requirement of up gradation of Control Centre under URTDSM project and submit its recommendations to the NPC.



Consequently, the sub-committee was formed vide NPC Letter NO. 4/MTGS/NPC/CEA/2021/285-298 dated 20.09.2021 based on nominations received at NPC.

URTD SM Project Phase-I

- A Pilot Project was implemented with 52 Phasor Measurement Units (PMUs) installed all over the Country progressively from 2008 to 2010.
- A Detailed Project Report (DPR) was prepared in 2012 for implementation of 1740 PMUs on Pan-India basis.
- The Project was agreed for implementation in a Joint Meeting of all the five Regional Standing Committees on Power System Planning held on 5th March 2012. The installation of the PMUs was taken up in two stages. Stage-I -1186 PMUs; Stage-II-483 PMUs

Table 1: Proposed Stage-I

Region	Sub-stations		No of Transmission line		PMU		Nodal PDC	MPDC	SPDC	Main & B/U NLDC
	ISTS	STU	ISTS	STU	ISTS	STU				
NR	74	42	394	224	206	120	6	9	1	
WR	49	18	456	135	234	71	11	4	1	
ER	51	31	395	149	202	79	4	5	1	
SR	57	16	338	90	178	47	6	4	1	
NER	9	5	69	24	36	13	0	3	1	
Total	240	111	1652	622	856	330	27	25	5	
	351		2274		1186		57			2

Table 2 : Proposed Stage-II

Region	Sub-stations		No of Line		PMU	
	ISTS	STU	ISTS	STU	ISTS	STU
NR	9	55	40	211	21	111
WR	11	58	64	280	33	145
ER	-	13	-	50	-	26
SR	3	55	10	199	5	105
NER	9	17	26	45	14	23
Total	32	198	140	785	73	410
	230			925		483

URTD SM Project Phase I & II

- CERC granted in principle approval for the project in Sept'2013 with 70% funding from PSDF & 30% equity from POWERGRID.
- CERC granted in principle approval for the implementation of URTDSM Phase-I and advised to take up Phase-2 after receiving feedback on Phase-I performance from POSOCO.
- POWERGRID took up the implementation of URTDSM Project in Jan'2014 and 1409 PMUs are installed in Stage-I of Phase-I of the Project (the increase in quantity of PMUs was due to addition of new bays etc. at the substations).
- In line with agreed philosophy in Joint Meeting of all the five Regional Standing Committees on Power System Planning held on 5th March 2012.
- POWERGRID took up the requirement of URTDSM Phase – II in all Regional Power Committees. During the discussion on finalization of PMU quantity for URTDSM phase-II, requirement of additional measurements emerged. POSOCO also desired additional Analytical software using PMU data.

PMU Placement criteria & Analytics in Phase – I

PMU locations under Phase – I	Under URTDSM Phase I, 6 Analytics were developed in association with IIT Bombay:
<ul style="list-style-type: none"> • All 400 kV stations in State and ISTS grids. • All generating stations at 220 kV and above. • HVDC terminals and inter-regional and inter-national tie lines. • Both ends of all the transmission lines at 400kV and above: State and ISTS sector. • Analytics under Phase – I 	<ul style="list-style-type: none"> • Line Parameter Estimation • Vulnerability Analysis of Distance Relay (VADR) • Linear State Estimator • Supervised Zone-3 distance protection scheme to prevent unwanted tripping of backup distance relay • CT/CVT Calibration • Control for improving system security

Status of Phase – I (Broad configuration of PMUs, PDCs and infrastructure used)

- The PMUs procured are having 2 set of voltage, 2 set of current measurement & some (16) digital input configuration.
- The utilization of measurement inputs of PMU depends on the bay configuration at substations. In cases where there is one line & ICT or reactor only, one set of current input is utilized, and other input remains unutilized
- The PMUs are measuring line and bus voltages as per the configuration of installation. PMUs installed are of the Measurement class and wired up in the metering core of CVT/CT.
- Nodal PDC at strategic substations, Master PDC at all SLDCs, super PDC at 5 RLDCs, Main & backup PDC at NLDC have been installed and are fully functional.
- POSOCO's initial pilot project & States PMUs were also integrated with the URTDSM project.
- In Phase-I, PMUs were installed at only those 400 kV lines which had connectivity of the fiber optic network.
- The number of PMUs installed on 132kV lines is 5nos., 220kV lines is 179nos., 400kV Lines is 1093nos., 765kV lines is 148nos.

Applications under URTDMS Phase – I.

- PMU based real time monitoring applications
 - Real time event and alarm processing
 - Visualization of frequency, Rate of change of frequency, Voltage, Power flows and Angle difference
 - Visualization of angular difference data, real-time angular separations, Real time monitoring and analysis, obtaining angular differences.
 - Geographical network diagram provides information about the system through visual objects representing network element
 - Contour display allows overview of the voltage/frequency profile for the entire grid, Voltage Contour visualization
 - Oscillatory Stability Management (OSM)- helps in monitoring the low frequency oscillations or small signal stability issues in the system

Off-line usages under URTDMS Phase – I.

- Off-line Applications/usages:
 - Primary frequency Response assessment requires high resolution data of frequency for any event.
 - Oscillation Detection - The poorly damped oscillations indicate the review of controller settings in power system stabilizers of units.
 - The high-resolution data helps in monitoring the operation of various transmission line protection schemes
 - Synchro phasor has helped to find the issues in time synchronization in event loggers
 - PMU also helped RLDCs in validating the Power system stabilizer tuning process with high sampled data
 - Post-Disturbance Analysis

Existing features of URTDSM

Time Series Derivation Framework (TDF) TDF is the user interface of the Historian Application provided by OEM M/s GE and is being used in Control room to plot the events which occurred

Spectral Analysis (using E-Tera Phasor Analytics)

- Power Spectral Density (PSD) is very useful tool to identify oscillatory signals in time series data and their amplitude
- Coherency, is a measure of frequency domain correlation between two signals.
- Cross Spectral Density (CSD): Cross spectral Density as a measure of frequency domain covariance between two signals

Utilization of PMU data for taking real time decisions and offline Analysis at RLDCs and NLDC:

- PMU helped in synchronization of NEW-SR grid by helping control room operator in taking appropriate decisions in real time through the access of high-resolution data in real time.
- The availability of PMU visualization helped in taking informed decisions in real time when any abnormality was observed in PMU placed on AC side of HVDC converter station
- The availability of PMU data at LV side of pooling station of RE based generation sources helped in monitoring the operation in real time. The various power electronic based controls in RE generation plant for low voltage ride through (LVRT), reactive support at pooling station and power park control are closely monitored using PMU data.
- The transmission system has also observed integration of state of art power electronic devices, these devices act in time span of milliseconds. The response can be observed at control centers with availability of PMU data. The response of FACTS devices is observed well with PMU placed at coupling transformer of STATCOM/SVC.
- Power-system restoration: The PMUs are well-suited for online monitoring of angles, and thus are helpful for the operator during a power restoration by monitoring of standing phase angle (SPA) difference across a breaker, which connects two adjacent stations whose excessive difference can damage equipment.

Feedback on applications under Phase – I - Improvements required in the Existing PMUs data Streaming/GUI

- Improvement required in the visualization /GUI
 - Adding trends of phase voltage and current, Trending system is having a capability to show only 8 signals
 - Capability to visualize data for larger time window, PMU with high sampling rate required at few locations, Option to select reference angle
 - Font and axis size, Integration with different make of PMU, Portability of display, Non-generation of alarms
- OSM related issues
 - Right Eigen Vector plot of modes not observed
 - Availability of statistical functions is not there
- System Utilization related issues
 - Data storage is currently configured to store 1 YEAR
 - 16 Digital slots are currently available in each PMU where only 5 are used, Each PMU can monitor 2 elements, spare slot available can be used to integrate new lines
- Infrastructure related issues
 - Voltage discrepancy in voltage measurement is observed in some PMU
 - Standby communication links have not been implemented in URTDSM project
 - Frequent time synchronization issues arise in PMU's data due to the GPS issue
 - Loss of PPS (Pulse per second) is a common cause in case of URTDSM PMUs
- Historian
 - Access to historian data through autonomous software interface is a must requirement for any new WAMS infrastructure

Feedback on applications/Analytics under Phase – I - Software's developed by IIT Bombay

- Line Parameter Estimation:- Application of total least squares (TLS) method is used to estimate line parameters.
- Online vulnerability analysis - PMU measurements to identify relays that are vulnerable to insecure tripping.
- Linear State Estimation:- PMU has the capability to directly measure the magnitude and angle of bus voltage and current, hence, LSE is possible.
- CT/CVT Calibration:- It is difficult to ascertain accuracy of any instrument transformer at site, once it is installed.
- Supervised Zone-3 Distance Protection:- Distance relays are widely used for transmission line protection. These relays also provide remote backup protection for transmission lines.
- Control Schemes for Improving System Security

Analytics under Phase – I & way forward

- PMUs should not only be limited to post event analysis and should be employed for Dynamic State Estimation, threats forecasting and alarming systems in real time.
- Several equipment's such as ICTs, Bus Couplers were not configured in the LSE. Lack of observability & lack of communication link also led to problems in PMUs LSE.
- Logic based analytical tools for enhanced situational awareness, Advance development platforms for retrieval and visualization of phasor data, etc. may be added in the existing system.
- POSOCO informed that the POSOCO pilot project & States PMUs were also integrated with the URTDSM project. However, the data was not complete, and it led to formation of Islands and therefore State estimation of complete system is not available with the existing installed PMUs.
- The network and the network topology database need to be updated by putting extra effort and therefore the network database of PMU based LSE can be exactly aligned with the actual system
- Additional PMUs should be installed at substations which are critical from system point of view, by laying of the Fiber Optic under Phase – II of the URTDSM project.
- An engine can be developed which will enable the SCADA topology and network database to be imported in the PMU based LSE. The database should be common for both the systems (SCADA & PMU LSE).

Recommendation 1 : Improvements in applications available in URTDSM-I

Graphical User Interface for visualization of system dynamics :

- Trending of phase voltage and current, Trending of all dynamic power system parameters
- Option to select reference angle, Downloading of historical data should be made more user friendly
- Capability to visualize data for larger time window, Portability of display
- Non-generation of alarms, Integration with different make of PMU
- Modal analysis issues in URTDSM Analytics

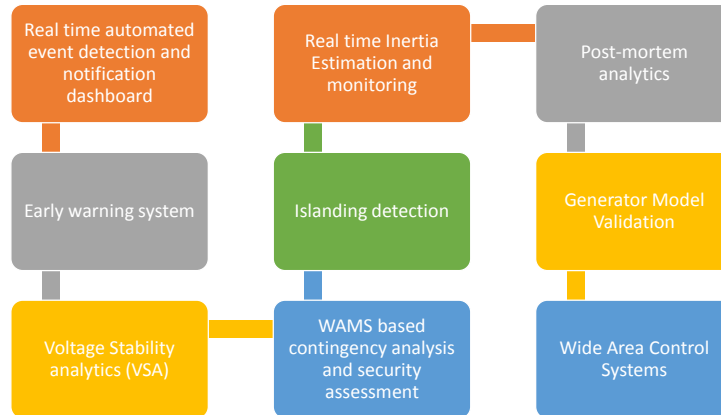
Oscillation Detection, monitoring and analytics:

- Capability to detect power system oscillations from dynamic measurements, Capability to monitor, classify oscillation modes in real time, Real-time display for oscillation monitoring , Oscillation location, Map Displays, Oscillation Severity, Alarms, Logic based analytical tools for enhanced situational awareness

Linear State Estimator :

- Database Integration, Bad data detection and conditioning, Observability analysis, Topology detection, Sampling rate, Single-Line diagrams, Scalability, Expanded observability

Recommendation 2: New applications for deployment in URTDSM-II



Recommendation 3: Improvements in system infrastructure

- 16 digital slots are currently available in each PMU where only 5 are used rest can be utilized for isolator points of line, bus, and line reactors etc.
- Each PMU can monitor 2 elements, spare unused i/p available can be used to integrate new lines / ICT from same substation (Non- SAS SUBSTATIONS)
- Logic/tool must be developed to detect Voltage discrepancy in phase measurement errors and generate alarms.
- Adopting main and standby philosophy in data communication between PMU & PDC and between PDC & PDC to avoid any data loss.
- Strengthening of time reference / GPS source and stringent daily monitoring by substation on daily basis for time synchronization.
- loss of PPS (Pulse per second) should not occur due to the disturbance of PPS cable during maintenance activities.
- Dead band defined in PMU data for frequency, voltage and df/dt , should not cause discrepancy in values.
- Data storage and Historian: Data storage should be configured to store and retain data at least up to one year. Since the population of PMUs is expected to increase manifold in the coming years, the standards / best practices need to be established for Indian power system. A separate sub-committee may be constituted to formulate a criteria for data archival and retention. For the time being data beyond one year shall be stored and made easily accessible for real-time and off-line applications depending upon the space utilization.

....contd

Recommendation 3: Improvements in system infrastructure

- PMU Testing: PMU standards conformance tests shall be performed to verify whether the PMU meets the requirements of IEC/IEEE 60255-118-1 under steady-state, transient, and dynamic power system conditions, and the associated data transfer requirements as given in IEEE Std C37.118.2 or communication requirements given in IEC 61850.
- PMU field commissioning tests shall include routine visual inspection, insulation test, wiring check, basic functionality check, etc., as required by the relevant standards.
- PDC must be able to handle off nominal conditions such as high rates of incoming data, incorrect timestamps, and unsupported protocols. PDC must be able to achieve the availability and reliability target levels consistent with the application.
- Sampling rate: Installation of PMU with high sampling rate is recommended at a few locations to monitor sub-synchronous resonance, very low frequency governor modes and control modes. PDC should have capabilities to store data of higher sample rate PMU apart from existing 25 Hz.
- Redundant and reliable high speed communication system is vital for PMU based Wide Area monitoring system. Fiber Optic connectivity between the substation identified for placement of PMU and control center is strongly recommended.

Recommendation 4: PMU Placement Strategy

The limiting constraints in installation of additional PMUs include

- The hardware requirement of the PDCs & Master PDCs as the current PDCs may not have enough memory to process the additional data from the PMUs.
- Hardware and communication requirements will also be required to be changed and upgraded.

Since the PMUs in Phase-I are M type PMUs and are connected to metering core of CT/CVTs, the committee recommends that under Phase-II, M-type PMUs are to be procured and connected to the metering core.

Recommendation 4: Minimum criteria for PMU placement under URTDSM-II.

- At one end of all 400 kV and above transmission lines
- At the HV side of all ICTs connected to 220 kV and above
- On HV side of coupling transformer of SVC/STATCOM for measurement of HV Bus voltage and current of coupling transformer
- At one end of line wherever FSC/ TCSC are installed
- At one end of line wherever FSC/ TCSC are installed
- On HV side of converter transformers for measuring HVAC bus voltage and current of converter transformer on each converter station.
- On both ends of Inter-regional and trans-national tie lines and on boundary buses for such lines
- At the Generating Transformers (GTs) at LV side (having HV side of 220kV and above) of the Generating units with capacity above 200 MW for Thermal units, 50 MW for Hydro units and 100 MW for Gas units.
- On all 220kV substations for measuring voltage of 220 kV bus and current of two lines/transformer catering to load centers.
- All 132 kV and above ISTS lines in NER & Sikkim and important load centers.
- At RE developer end of the evacuating line connecting the Renewable Energy Pooling Stations (PS) to point of interconnection with the grid of 50MW and above.
- Islanding, Separating & Restoration Points- At one end of line which is connected to black start stations along with circuit breaker status via synchro phasors.
- Fiber Optic should be covered under Phase – II for all the above locations of the URTDSM project
- At all ICTs, Bus reactors, Switchable line reactors of critical substations

Recommendation 4: Future Considerations & integration of State PMUs.

- Requirement of PMUs under Phase-II, as per philosophy, be framed for the planned system up to 2024. Thereafter CTUIL may include the provisioning of PMUs in the scope of planned projects as per the above philosophy.
- The placement of PMUs for special cases such as Islanding, Separating & Restoration Points and ICTs, Bus reactors, Switchable line reactors of critical substations, load centres of NER shall be suggested by POSOCO in consultation with RPCs & CTU.
- Existing PMUs & PMUs planned in future by States should be integrated with the URTDSM Project.
- PMUs in the future projects should be made part of the system with improvements in the PDCs capabilities incorporated in the new Project.
- PMU & PDC consoles at CTUIL, RPCs and CEA- Since CTUIL is entrusted with planning ISTS system, it is recommended that PMU & PDC consoles along with redundant, dedicated & secure communication link up to CTUIL premises be provided for CTUIL. The Power flow, Voltage, Angle data of PMU shall be integrated with CTUIL Planning system software for System studies, System planning of ISTS system, in consumable form, through standard protocols along with visualization. Similar facilities should be made available at all RPCs and CEA if the same is not covered under Phase I.
- The up gradation of PDCs and control center equipment's be reviewed once in two (2) years, so that they can handle the data due to incremental PMU population in the system.

....contd.

Recommendation 4: Future Considerations & integration of State PMUs.

- PGCIL was of the view that 5 out of 6 analytics developed in Phase-I would not work, due to adoption of the above PMU placement philosophy (in all these 5 analytics PMU is required at both ends). The analytics viz Line parameter estimation, CT/CVT calibration are complementary to each other, where, in one analytic the CT/CVTs are assumed to be accurate and in the other the line parameters are assumed to be accurate (the reference used for one analytic is dependent on the other) and therefore the result of this analytics are not found to be much of use. The Online Vulnerability analysis and Supervised Zone-3 distance protection are protection class analytics and the results needs validation through DRs. The Zone-3 power swing blocking setting is available in all the relays and has been reported to be implemented by all the utilities as per recommendation of the Committee on the blackout of 2012. Further, the Load encroachment tripping in Zone-3 can be addressed through proper setting of Zone-3 in the relay, which has also been reported to be complied by all the Utilities as per the recommendation of the Committee on the blackout of 2012. Control System for improving system security analytic and the above four analytics, however, shall to be used wherever PMUs are available at both ends and the results be validated.
- The relevant orders of Ministry of Power, Government of India and CEA/CERC regulations for cyber security compliance should be followed. The directives of CERT-In for time synchronization of PMUs should be followed in view of cyber security.
- Training module should be incorporated in Phase-II of URTDSM project for the State Utilities, CTU, POSOCO, CEA and RPCs.



Thank You

Note: 1

POWERGRID is in view that Philosophy for PMU location as decided in joint meeting of all the five Regional Standing committee meeting held on 5th March 2012 should not be altered as the panel of expert constituted on URTDSM Project recommended the same. The panel having renowned international and National experts from IIT Kanpur, NIST etc. under the chair of Dr. Arun G. Phadke. Moreover, the present sub-committee should provide direction for including 'additional' PMUs as desired by system operator based on their feedback. In the sub-committee meeting held on 14-09-2022, CTUIL also expressed similar views.

The present recommendation of sub-committee for minimum location of PMUs (as mentioned in Clause 6.4(d)) shall be also challenging in implementation, as there would be need for maintaining transmission lines database at central level by designated nodal agency on which PMU has been already installed at one end under different schemes/packages/TBCB projects etc. by different implementation agencies. There would be issue in finalising PMU Bill of Quantities as both end of line bays may be implemented by different agency under different schemes/packages/TBCB projects etc. This would lead to further delay in executing these projects.

The Section 4.2 and Clause 6.4(e)-vi describing analytics under phase-II may not represent complete picture. The Analytics such as VADR and Supervised Zone-3 analytics are not inherently designed for protection class. The VADR detects and logs conditions of power swings and load encroachment and does not that of fault condition. The Supervised Zone-3 analytics can issue block signal in above conditions if closed loop control is implemented in field otherwise the generation of block signal shall be logged for operators for further analysis. The above scenarios (power swings and load encroachment) which are dealt by these two analytics generally appears to the candidate relay 'after' the fault. In addition, PMU data frequency under URTDSM project (25 samples/second) also does not envisage enough samples (only 2-3 samples during fault) to do any fault duration analysis. Hence, the same principal is utilised by IITB in designing analytical applications. Further, alternate methods have been developed in the Line parameter estimation and CT/CVT calibration to decouple their inter dependencies.

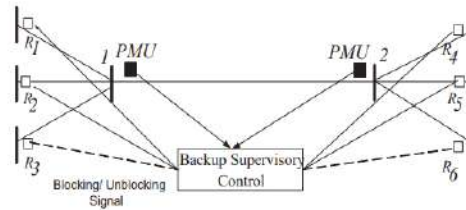
As per Clause 6.4(d)-xi, Fiber Optic should be covered under Phase – II for all the above locations of the URTDSM project. However, Separate project shall be allocated for installing OPGW required for URTDSM Phase II. Further, the analytics recommended for phase-II in the report may require additional deliberation to access the feasibility for implementation, data requirement and solution available in the market.

It may be also noted that the Quantity of PMUs required in line with recommendations of this report for the URTDSM Project Phase – II, Clause 6.4(d) may require upgradation of existing URTDSM control centre equipment. The same may also be included in the project at this stage itself, as it may need additional planning/design/execution time.

PGCIL note salient features

- The PMU location philosophy should not be altered, since the panel of expert under the chair of Dr. Arun Phadke has recommended it.
- Database of location of PMUs.
- Analytics VADR (vulnerability Analysis of Distance Relays) & Zone-3 supervised protection- not designed for protection class.
- CT/CVT calibration and Line Parameter estimation analytics.
- Upgradation of FO and control center infrastructure.

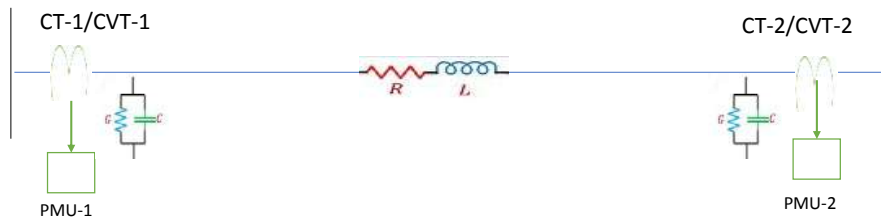
Z-3 Supervised protection & relay vulnerability analytics



Supervisory backup protection of a single transmission line with PMUs at both ends.

- Specialized schemes will be specific to critical lines wherein PMUs will be placed at both ends of a line i.e., fault observability in mode.
- Logic to detect the fault on line section 1-2 with PMU1 & PMU2 measurements and decide to block or trip relays R to R6.
- If there is a fault in section 1-2, then enable zone-3 tripping of R1 to R6. if there is no fault in section 1-2 and due to Power Swing/Load encroachment, the relays R1-R6 senses these conditions as Zone-3 fault, then block the tripping of relays R1 to R6.
- Issue : fault detection on line section 1-2, will require the CTs used to obtain measurements from PMU1 & PMU2 are accurate during fault condition. With metering class CTs, it is highly impossible, since these CTs would saturate under fault conditions.
- **All the Distance Protection Relays (DPR) have Zone-3 blocking/unblocking facility. The Zone-3 of DPRs is blocked on power swing detection through their internal algorithm. No mal-function of this blocking has been observed so far, if it is set in relays. If Zone-3 is set considering the load encroachment properly, the relays will not trip under these conditions. Low voltage issues at other buses is now a remote possibility with strong fault levels.**
- **For this application it may be advisable to use P-type PMUs with inputs from protection class CTs.**

Line parameter estimation & CT/CVT calibration



CT/CVT calibration

- The residual is used for identifying the bad data and also improving the estimate of the voltage.
- This residual is monitored for a long time, may be in terms of weeks, and if the error is consistent then it can be flagged as erroneous CVT.
- The erroneous CVTs can be identified locally, and the CVTs with less errors are then separated out to start the calibration process.
- Issue : CT/CVTs are of 0.2 accuracy class, if it has to be done locally, the CT/CVTs at remote end and line parameters used to estimate the voltages at end 1 should be accurate.

Line parameter estimation

- Issues : The CT/CVTs at either end should be accurate. Line parameters are static and does not change much.
- Easy way out : A portable PMU can be used to estimate line parameters where it is suspected that the parameters are erroneous also same facility can be used for CT/CVT calibration. Separate investment for this analytics is not desirable.

Phase – II of URTDSM - PMU Placement Criteria

PGCIL Comments

POWERGRID informed that the impact of additional PMUs locations and WAMS analytics will be:

- i. The number of PMUs initially envisaged in Phase II would increase to about 2500.
- ii. This increase in number of PMUs will also affect the performance of Phasor Data Concentrator (PDC) and other equipment at the Control Centre Location at SLDC, RLDC and NLDC, RPCs which may also need upgradation / installation.
- iii. The additional WAMS analytics shall also require additional hardware.
- iv. In view of the increase in PMU population, the existing configuration of Nodal PDC, MPDC, SPDC & Main & B/U NLDC also needs to be seen whether these additional PMUs can be accommodated in the infrastructure of Phase-I. Also, it needs to be seen whether the Nodal PDC, MPDC, SPDC & Main & B/U requires up-gradation or additional hardware is required for accommodating the additional PMUs in Phase-II.
- v. Communication related issues are also required to be considered to accommodate the additional PMUs under Phase-II.

Phase – II of URTDSM - PMU Placement Criteria

CTU, NRPC & SRPC Proposals

CTU has proposed following locations:

- All 132 kV and above ISTS lines in NER & Sikkim
- All 132 kV and above ISGS in NER & Sikkim.
- (Additional factor of “distance between such stations” for extent of Wide Area Measurement also to be accounted for Placement in NER.)

NRPC (in 45th TCC, 48th NRPC meeting) and SRPC (in TCC & 37th SRPC meeting) have proposed following locations:

- Generating Transformers (GTs) at LV side (having HV side of 220kV and above).
- FACTS devices such as STATCOM, SVC, FSC, TCSC etc.
- HVDC Converter transformers
- Phase Shifting Transformers
- Renewable Energy Pooling Stations (PS).

New Analytics under URTDSM Project Phase – II.

PGCIL, NRPC & SRPC Proposals

NRPC & SRPC: Additional WAMS analytics for URTDSM Phase – II were proposed by NRPC (in 45th TCC, 48th NRPC meeting) and SRPC (in TCC & 37th SRPC meeting) as follows:

- Real time Automated Event Analysis tool
- Oscillation Source location tool/engine.
- Real time Inertia Estimation Tool
- Big data analytics tool/engine

POWERGRID: POWERGRID has suggested following analytics for the Phase – II:

- Real time Automated Event Analysis tool (using AI, Machine learning and big data)
- Event monitoring for early warning system (using AI, Machine learning and big data)
- WAMS based contingency analysis and static security assessment
- Oscillation Source location
- Response of Windfarm and solar PV farms for LVRT, reactive power etc.
- Control of HVDC and STATCOM for damping system oscillations

Phase – II of URTDSM - PMU Placement Criteria

POSOCO Proposals

POSOCO has proposed

- Placement at all Inter-regional lines.
- HVDC & FACTS Devices
- Renewable Energy Generation Pooling Points.
- On all outgoing feeders including bus sectionalize or tie line between two stages of generating stations having different tariffs or different ownership or both
 - High Voltage (HV) side & Low Voltage side of Transformers
 - Reactive Power sources & Sinks shall be measured through Synchro phasor
 - All CB and isolators shall be wired to Synchro phasor device as digital signals
- Islanding, Separating & Restoration Points
- Points where State Estimation error chances are high
 - Substation shall have Three phase Bus voltage measurements through PMUs & Circuit breakers and isolator position shall be wired to PMU (for Linear State Estimator) for topology processing and full observability
 - Reactive Power sources & Sinks
 - All 765/400 kV, 400/220 kV Interconnecting Transformers (ICT) on both sides (LV & HV).
- Power Flow Gates
- Major Load Centres
- Angular Difference Monitoring Locations.
- Major Generating Stations-
 - At 400 kV and above Generating stations (132 kV in case of NER).
 - Individual Unit of rating 200MW and above for Coal/lignite, 50MW and above for gas turbine and 25 MW and above for Hydro units shall have PMU placed at the terminals of the generator(s) at either the HV or LV side of the Generator Transformers.
 - In case of plant having multiple units, PMU can be placed on 50 percent of the units
- System Protection Scheme Monitoring
- Experience based locations known for small signal stability related issues.

New Analytics under URTDSM Project Phase - II.

POSOCO Proposals

- POSOCO has recommended following analytics
 - Voltage Stability Monitoring: Measurement based dynamics provide voltage sensitivities; monitoring of key corridors or load pockets; scatter plots for power voltage and power-angle monitoring.
 - Detection of disturbances: Recognition of short circuits by watching the currents, and indication of loss of load, or loss of generation by watching the frequencies.
 - Online monitoring of Inertia.
 - Identification of source of Oscillation.
 - Identification of stressed corridors.
 - ROCOF calculation over variable window.
 - Island identification/detection.
 - Locating contributions to poorly damped or unstable oscillations.
 - Model Validation.
 - Higher frequency sub-synchronous oscillation analysis and early warning of resonance.
 - Big Data Analytics



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Government of India
केंद्रीय विद्युत् प्राधिकरण
Central Electricity Authority

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No.: WRPC/Protect/NPC/2022/

दिनांक: 14.10.2022

To,
The Member Secretary, NPC
Central Electricity Authority
New Delhi – 110066

विषय: "एयूएफएलएस (AUFLS) योजना का अध्ययन करने और df/dt सेटिंग्स के लिए एक समान दृष्टिकोण तैयार करने के लिए उप-समिति" की रिपोर्ट - के संबंध में।
Subject: Report of the "Sub-Committee to study AUFLS Scheme and to work out a uniform approach for df/dt settings"- reg.

Ref: NPC Division letter no. 4/MTGS/NPC/CEA/2020 dated 19.01.2021

Please find enclosed herewith the final report of the sub-Committee constituted by NPC vide letter under reference on following TOR:

- To examine the AUFLS scheme for all Indian Grid currently deployed and suggest any revision for the same
- To examine the df/dt settings in different regions for all India grid and suggest a suitable approach for effective working of the same.

Submitted for needful please.

भवदीय /Yours faithfully

Enclosed: As above.

(P. D. Lone)

सदस्य संयोजक/Member Convener)

Copy to : All members as per list.

Acknowledgement

The Committee acknowledges the cooperation extended by NPC, RPCs, POSOCO and CTU for giving their valuable inputs to finalize the recommendations for finalizing AUFLS stages.

The Committee also acknowledges and extends gratitude to the sincere efforts of Shri Sachin K. Bhise EE, and Shri Deepak Sharma EE, WRPC, whose inputs and suggestions has helped in putting all the inputs in proper perspective and giving shape to this report.

The committee would also like to thank Shri Rahul Shukla, CM & Shri Aman Gautam, Manager, NLDC POSOCO for arranging presentation and painstaking efforts taken to provide comments and helping in the drafting of the report.



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October 2022

Report of the Committee on Automatic Under frequency Load shedding



National Power Committee
CEA

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Abbreviations and Symbols

AC	Alternating Current
D	Load Frequency Dependence MW/Hz
DC	Direct Current
COI	Centre of Inertia
F	Frequency
FFR	Fast Frequency Response
GW	Gigawatt
GWh	Gigawatt-hour
GW•s	Gigawatt-second
H	Inertia
IBR	Inverter-Based Resource
kW	Kilowatt
kWh	Kilowatt-hour
LR	Load Response
MW	Megawatt
MWh	Megawatt-hour
MW•s	Megawatt-second
NLDC	National Load Dispatch Centre
PMU	Phasor Measurement Unit
PV	Photovoltaics
RLDC	Regional Load Dispatch Centre
RE	Renewable Energy
RoCoF	Rate of change of frequency also known as df/dt
SCADA	Supervisory Control and Data Acquisition
UFLS	Under-frequency Load Shedding

Definitions

‘Area Control Error’ or ‘ACE’	means the instantaneous difference between a control area’s net actual and scheduled interchange, taking into account the effects of Frequency Bias and correction of meter error. Mathematically, it is equivalent to: $\text{ACE} = \text{Deviation } (\Delta P) + (\text{Frequency Bias}) (K) * (\text{Deviation from nominal frequency}) (\Delta f) + \text{meter error};$
‘Automatic Generation Control’ or ‘AGC’	means a mechanism that automatically adjusts the generation of a control area to maintain its Interchange Schedule Plus its share of frequency response;
‘Demand’	means the demand of active power in MW;
‘Demand Response’	means variation in electricity usage by end customers/control area manually or automatically, as per system requirement identified by concerned load despatch centre;
‘Frequency Response Characteristics’ or ‘FRC’	means automatic, sustained change in the power consumption by load or output of the generators that occurs immediately after a change in the control area’s load-generation balance, and which is in a direction to oppose a change in interconnection’s frequency. Mathematically it is equivalent to $\text{FRC} = \text{Change in Power } (\Delta P) / \text{Change in Frequency } (\Delta f)$
‘Governor Droop’	in relation to the operation of the governor of a generating unit means the percentage drop in system frequency which would cause the generating unit under governor action to change its output from zero to full load;
‘Inertia’	means the contribution to the capability of the power system to resist changes in frequency by means of an inertial response from a generating unit, network element or other equipment that is coupled with the power system and synchronized to the frequency of the power system;
‘Nadir Frequency’	means minimum frequency after a contingency in case of generation loss and maximum frequency after a contingency in case of load loss;
‘Reference contingency’	means the maximum positive power deviation occurring instantaneously between generation and demand and considered for dimensioning of reserves;
‘Tertiary Reserve’	means the quantum of power which can be activated, in order to restore an adequate secondary reserve. Fast Tertiary Reserve Response shall come into service starting from five (5) minutes and shall sustain up to thirty (30) minutes. Slow Tertiary Reserve Response shall come into service starting from fifteen (15) minutes and shall sustain up to sixty (60) minutes;

1. Executive Summary

1. In the 2nd NPC meeting dated 16-July-2013, AUFLS scheme was adopted at a national level and comprised four stages of UFLS at 49.2 Hz, 49.0 Hz, 48.8 Hz and 48.6 Hz. Prior to that, each region adopted a three-stage plan for flat UFLS, with similar settings.
2. The above calculation of load relief was based on the methodology adopted by Zalte Committee recommendations, formed in WR, after the July 2012 blackout. Zalte committee was formed to review the defense mechanism for WR after the July 2012 blackout. Zalte Committee while formulating the AUFLS plan considered the factors such as frequency dependence of loads, voltage dependence of loads and seasonal variations of the loads.
3. NPC regularly reviewed the quantum of load to be shed in each region, based on the increasing demand. In the 9th NPC meeting, it was informed that the loads expected to be shed were on the much higher side. Accordingly, it was decided to form a group to examine the same.
4. In Jan 2021, a committee under Member Secretary, WRPC was formed to examine the AUFLS scheme for All India Grid and give recommendations. Also, the Committee was to examine the df/dt setting for different regions and suggest a suitable approach for effective working of the same.
5. Although governors were enabled before 2012, the response observed was not satisfactory. After the 2012 blackout, the Indian Power system implemented many reforms and Regulations, notably the DSM from 2014. Many efforts to bring transient response of governors as an aid to intercept the runaway frequency were taken by the Hon'ble CERC. Today RGMO/FGMO is widely implemented also many States have Automatic Demand Management System (ADMS) in place.
6. In a conventional large grid, due to sufficient number of synchronous machines and hence rotating mass, lack of adequate system inertia has largely not been of a concern. Global experience suggests that RE integration driven displacement of conventional synchronous generators has an impact on the rotating mass (inertia) in the system, particularly during higher penetration of renewable. Considering a significant growth in RE, and ambitious RE integration targets for Indian power system, the AUFLS and df/dt schemes may require periodic reviews.
7. Though the system is now integrated and strong, however it is desired that various frequency control actions are able to restore the frequency to its target value. These

frequency controls (primary, secondary, and tertiary) operating in continuum shall act in respective time domains to maintain frequency at or nearby its target value i.e., 50 Hz.

8. The safe, secure, and reliable operation of grid requires that the nadir frequency should be at least 0.2 Hz above the first stage of under frequency load shedding scheme under different system loading conditions. This implies that the nadir frequency shall be above or 49.4Hz, if the first stage trigger frequency adopted is 49.2Hz. System Operator, accordingly, may estimate and maintain the reserves
9. The nadir frequency is a function of the system inertia & primary response and in real time the system inertia varies and depends on the rotating masses running in the system. Therefore $\frac{df}{dt}$ AFLS scheme would be the appropriate choice to address the inertia response and the first stage of the AUFLS is required to be set by considering, where the final system frequency would settle, which depends on the primary response.
10. Many important capital city islanding schemes are being designed as per the direction of ministry. Islanding should occur below the last stage of AUFLS scheme with sufficient margin of 0.3-0.4 Hz below the last stage, as there is no further defense mechanism. At present last stage is at 48.8Hz. The present Committee recommended last stage is 48.6Hz which is above the Island trigger frequency of 48.0/47.9Hz generally adopted by more than 0.6Hz. The last Stage-II trigger frequency setting recommended is 48.0Hz. Though it overlaps with the pre-Islanding Load Shedding plan, it will not affect the performance of formation of Island, since it is certain that at these system frequencies, the system has disintegrated into two or more parts/Islands.
11. Under presence of governor action in normal frequency range, and more so with the hysteresis controller characteristic of the RGMO, care should be taken to not over-shed and raise the frequency to alarming levels in the initial stages of load relief. All the generators are expected to operate in FGMO for frequency going above 50 Hz, therefore any increase in frequency above 50 Hz is expected to be counter acted by FGMO.
12. As long as the system is integrated, the benefits of the large inertia and governor are definitely seen. However, parts of a system can isolate, suddenly bringing down the inertia and heavy falls in frequency can be seen. Inertia falls have been seen recently in cases of Mumbai blackout in Oct 2020 and Feb 2022. The only way to implement this using additional load shedding below 48.6 Hz.

13. The Committee, assuming a very conservative response of RGMO/FGMO, adopted the estimation methodology of Load Shedding quantum, based on the regulation of generators and the frequency dependence of load.
14. The Committee also reviewed various international practices being followed and tried to arrive suitable plan for the Indian Power Grid.
15. Two Approaches towards the design of AUFLS was discussed and it was decided to stick with Approach A, which is a traditional AUFLS plan with load shedding quantum as a percentage of the peak demand. The Approach B was also discussed, and it was decided that this can be adopted in future, when the communication system up to the load centers and the Wide Area monitoring becomes mature.
16. **Approach A**

The committee proposed the following two tier AUFLS scheme:

- a. When system is integrated – Stage I-A to I-E.

A demand disconnection of 20% is envisaged in this stage with trigger frequency for disconnection starting from 49.2 Hz to 48.6 Hz for I-A and I-E respectively.

The feeders on which the Stage I-A to E relays have been installed should be excluded from all type of load shedding schemes such as ADMS, SPS, any other planned Load Shedding Scheme, LTS, Island Loads, preparatory Island loads identified for shedding or any other emergency load shedding schemes etc.

- b. When system has split into more sub-systems – Stage II-F to II-H.

A demand disconnection of 18% is envisaged in this stage with trigger frequency for disconnection starting from 48.4 Hz to 48.0 Hz for Stage II-F & Stage II-H respectively.

The loads wired under this scheme shall not include any loads as given under (a) above. No planned preparatory islanding scheme loads that are wired up for Load shedding shall be covered in this stage. The feeders identified for implementation under Stage II-F to H, preferably, shall be feeders emanating from EHV stations.

17. The Stage-IE recommended by this committee is on 48.6Hz and the Stage-II-H is recommended at 48Hz. A desperate measure load shedding under Stages-II F to H in three stages will come into play when the system has separated, and unplanned Islands have been formed. Islanding schemes are proposed to be done at 48.1 /48.0

Hz (which is in general implemented for all the Islanding scheme design). So, Islanding schemes philosophy requires to be suitably accommodative to this.

18. The last part of the report is with respect to ROCOF relays also known as df/dt relays. With the integration of the grid, the earlier severe contingencies like loss of the largest station in the grid, generally does not trigger the df/dt relays on a system wide scale during the high and moderate system loading conditions. The df/dt rates for credible and less severe contingencies (3-5% of loss of generation) during the off-peak period and high RE generation may touch 0.1Hz/sec. Now a days, the settings available in numerical relays is 0.01Hz/sec. However, during light loading conditions and high RE generation (wind & Solar), the df/dt rates of 0.1Hz/sec and higher could be seen in the system for severe contingencies. A philosophy as to how this could be addressed and the df/dt could be implemented is discussed under this part. Introduction of wide area controls would make df/dt based load shedding a comprehensive tool to tackle the severe contingencies during operation of grid with low system inertia.

2. Introduction and background

1. Synchronous generators in India operate around a nominal 50 Hz frequency, and frequency reflects the balance of generation and load. The change in frequency allows a continuous balance of generation and load at all times. UFLS is a critical safety net designed to stabilize the balance between generation and load when an imbalance between generation and load causes frequency to fall rapidly (e.g., during large generation loss or an islanded operation). Automatic disconnection of loads, typically through tripping of pre-designated load feeders, is intended to help recover frequency back to acceptable levels so that generation can rebalance, and frequency can stabilize to within reasonable levels.
2. UFLS operations serve to prevent large-scale outages from occurring, however, the system is planned, designed, and operated in such a way that these types of safety nets only occur as a last resort for extreme or unexpected disturbances. The concept of UFLS and other safety nets is that controlled tripping of portions of the system loads may mitigate the potential for a larger and more widespread blackout. UFLS schemes are designed to disconnect pre-determined loads automatically if frequency falls below specified thresholds. All UFLS frequency thresholds are set below the expected largest contingency event in each Interconnection to avoid spurious load disconnection, and they are set to coordinate with generator under frequency protection to avoid the tripping of generators when they are required the most.
3. The Indian Power system, initially comprised of four independent synchronous grids (North, West, South and East with North-East grids), had deployed AUFLS comprising of flat under frequency load shedding scheme (UFLS) as well as df/dt (ROCOF) load shedding scheme to disconnect the loads in the event of contingencies of generation loss. The integration of the regional grids took place in a planned manner. A major twin blackout happened on 30th and 31st July 2012 when the NEW grid (North+East+North-East+West grids) were already synchronized and at that time Southern grid was an independent synchronous system. With the integration of the Southern grid in Dec 2013, the All-India Power system has since then been one synchronous grid.
4. In the 30th and 31st July 2012 blackout, the Western and Southern grids survived on both occasions. East and Northeast survived on the first day only. The Northern region collapsed in both the blackouts.

5. Subsequent to the blackout of July 2012, the Zalte Committee was appointed in the Western region. The committee revised the loads that should be tripped in the WR, in the AUFLS plans.
6. In the second meeting of NPC held on 16th July 2013, NPC decided to adopt recommendations in Zalte committee report for determination of quantum of load for AUFLS in all the regions. NPC decided to implement AUFLS scheme with 4 stages of frequency viz. 49.2, 49.0, 48.8 & 48.6 Hz in all the regions and upgrade the tripping frequency setting. (Zalte Committee had 3 stages 48.8 Hz, 48.6 Hz and 48.2 Hz).
7. In the 8th meeting of NPC held on 30th Nov 2018, it was decided to modify the existing AUFLS scheme by raising the frequency by 0.2 Hz for four stages of AUFLS i.e., 49.4, 49.2, 49 and 48.8 Hz.
8. In the 9th meeting of NPC held on 22nd Nov 2020, it was pointed out that the quantum of loads to be shed were much higher than the Zalte Committee calculations. It was decided to constitute a Sub-committee under the chairmanship of Member-Secretary-WRPC with representatives from POSOCO and RPCs to study the AUFLS scheme and submit its report to NPC. NPC Secretariat vide letter No. 4/MTGS/NPC/CEA/2020/01-06 dated 1st Jan 2021 had asked for nomination from all the RPCs. Based on the receipt of nominations from all the RPCs, the Sub-Committee was formed vide CE, NPC letter dated 19th Jan 2021. The copy of letter is enclosed as *Annexe-1*.

Designation & Organization	Name of Member	Constitution of the Committee
Member Secretary, WRPC	Sh. Satyanarayan S.	Chairman
Member Secretary, NPC	Smt. Rishika Sharan	Member
Sr. General Manager, NLDC	Sh. Rajiv Porwal	Member
Superintending Engineer(P), WRPC	Sh. P.D. Lone (Shri J.K. Rathod is transferred on deputation)	Member Convener
Superintending Engineer, NERPC	Sh. B. Lyngkhoi	Member
Executive Engineer, SRPC	Ms. N.S. Malini	Member
Executive Engineer, ERPC	Sh. P.P. Jena	Member

Executive Engineer, NRPC	Sh. Reetu Raj Pandey EE (Sh. Ratnesh Kumar EE transferred)	Member
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Terms of Reference (TOR) of the Sub-Committee:

- a) To examine the AUFLS scheme for all Indian Grid currently deployed and suggest any revision for the same
- b) To examine the df/dt settings in different regions for all India grid and suggest a suitable approach for effective working of the same

Proceedings of the sub-Committee:

- a) The Committee met on 7th Apr 2021, 7th Dec 2021, 06th Sept 2022 and 12th Oct 2022 through online meetings. The Committee took time to formulate the design steps. Several changes had taken place in the grid after the Zalte Committee report was first published in 2012. Notably the DSM regulations were introduced since 2014 and are in place with amendments. Also, regulations on governor action also bore fruit and the RGMO/FGMO response is being monitored rigorously, since then. The earlier settings, as discussed in the Zalte Committee report, did not have a large number of generators providing governor response in 2012 in the normal frequency range. Also, the first load relief settings were lower starting at 48.8 Hz, which got progressively increased, yet keeping the same one Hz load relief. So, there was a need to study the impact on each setting carefully, on the frequency correction post load shedding, due to RGMO/FGMO. Another problem was the df/dt relays as a scheme would not operate as earlier desired due to non achievement of triggering criteria, because of the increase of inertia due to integrated operation of the entire grid; newer challenges of wind and solar generation and their loss would still give the df/dt relays a role to provide local relief.
- b) The power number observed for the recent events using PMU data is around 10000 MW/Hz. It is considered that a contingency involving tripping of largest generation plant (reference contingency) of around 5000 MW may cause frequency fall to 49.50 Hz from 50 Hz. Frequency response characteristics indicate that frequency in this case would recover to 49.70 Hz (considering FRC of around 15000 MW/Hz).

- c) The last challenge was seen from isolated incidents at Mumbai in 12th Oct 2020 and 27th Feb 2022 blackouts, where a small part would separate due to loss of synchronism or contingencies driven causes respectively. Now the designer has to plan on saving the grid from losing integrity and at the same time has to make provisions in case the integrated operation is lost, and the grid breaks up in two or more parts due to voltage collapse or rotor angle instability. To put all these aspects together takes time.
- d) The major reason of the increase in load shedding targets was the adoption of load shed quantum on the basis of observed power number (MW/Hz), at some point of time in NPC meetings, instead of the load frequency dependency number D (confusingly has same units of MW/Hz). As already mentioned above at the time of the Zalte Committee the RGMO/FGMO was not significant. So, there is a need to revisit the Zalte Committee design considerations and adopt the same to the newer challenges mentioned. The Zalte Committee report is included in Annex-2.
- e) International practices also indicates that Indian Power System should go for more stages and shed more load. Earlier the individual grids were isolated in India, like WR, NR, SR, ER + NER. With integration, no doubt the advantages in terms of increased observed power number have come. But the designer has to be aware that in case of disintegration, the inertia would suddenly reduce, and this disturbance of generation loss can become a higher disturbance (percentage wise) in the deficit system. Hence more stages are required. These stages would not at all operate in integrated case, but in separation may be a lifesaver.

We now proceed to mention the AUFLS scheme design considerations.

3. Theoretical aspects of important factors in the design considerations of AUFLS:

Following factors must be understood before proceeding to design of AUFLS.

1. Load frequency Dependence D (MW/Hz):

Observed Power Number λ (MW/Hz):

Frequency influence of generators in normal frequency and emergency range:

System Inertia H:

Because there is some confusion in the minds of working engineers, we now proceed to discuss each factor in detail, giving examples and finally proceed to form the design specifications and the scope of the problem.

a) Load frequency Dependence D (MW/Hz):

Let us assume that all generators in an ac system are operating at constant MW load on the machines. Also assume that the frequency is steady at rated frequency of 50.0 Hz.

Now when a generator trips, the frequency drops sharply and continues to do so for time. After some time, the frequency has steadied down and settled to a steady state value. Why did the frequency reach and stayed at the steady state value?

Let us assume that the generation loss has caused a one Hz drop in the frequency.

(Remember: No governors actions so far is assumed)

The answer to the above can be found in load frequency dependence D. D signifies that when the system frequency drops, the net load value comes down.

Load frequency dependency $D = 1.5\%$ means that if frequency falls by 1% the load demand falls by 1.5 %. For a 50 Hz system, as in India, if frequency falls by 2%, then the load demand has fallen by 3%. But 2% frequency drop means 1 Hz frequency drop. (50 Hz = 1 p.u. = 100%).

So, in this example, after generation was lost, the frequency steadied at 49 Hz. That is 2% change in frequency. It implies that $D = 1.5\%$. In other words, the demand drop is 3% of the load.

So, all the following statements are identical:

2. $D = 1.5\%$

Demand drop = 3%

A demand drop of 3% in AUFLS will bring the frequency up by 1Hz. (The load shedding problem)

All the above is true assuming no generation rise due to drop in frequency. That is governor action in this frequency range is not there.

The Zalte Committee, by assuming $D=1.5\%$, essentially designed a 3% demand relief per stage, to raise the frequency up by one Hz. But due to various reasons (of voltage, frequency, and seasonal variations) it multiplied the demand requirement of 3% by a factor of 1.7, the reasons being demand itself changes (due to voltage and frequency change), so that by shedding ($3\% \times 1.7 \approx 5\%$) of demand, you end up raising the frequency by one Hz. The number 1.7 used is purely heuristic.

The assessment of value of D at the time of tripping is discussed in subsequent sections.

b) What is the value of D ?

Since D is very important, it is also of interest to know, what should be the value of D , to be assumed while solving the AUFLS problem?

It is clear that loads are frequency dependent. Each load, like air conditioner, induction motors, etc., is frequency dependent. It is very easy to take such loads in the laboratory and measure the frequency dependence D . Such a work done by EPRI, is given in reference book of Prabha Kundur (1).

But **nobody** can tell what the exact amount of frequency dependent loads like air conditioners or induction motors, for example, are on, in the grid at any point of time. Efforts to estimate them are largely in the research area as that would require wide-scale measurements.

In other words, the value of D is not constant and estimate of D has to be made in advance, so that the AUFLS quantum and stages can be decided. That will require a huge number of measurements. Therefore, while designing the AUFLS scheme, the estimate of different loading scenarios and the impact of D on the Nadir frequency and final settling frequency is required to be assessed based on past events and experiences. Unfortunately, since D is a variable, each 500 MW trip of generation does not give the same drop in frequency.

No doubt, historically and empirically, value of D has been assumed as 1.5%. ***This was even before the days of the Zalte Committee when the Regional Protection Committees assumed the value as 1.5%. Frequency dependency of loads has reduced significantly with the introduction of power electronics-based drive load, VFD drives,***

etc. hence value of D needs to be revisited once. With integration of inverter-based resources in the grid this load frequency dependence needs to be revisited in future. The expected reduction in inertia value due to integration of RE based resources may require periodic revision of this aspect.

Suppose that the average D was 3%, instead of the assumed 1.5%, at the time a generator trips. This would result in higher settling in frequency. Hence by conservatively designing the UFLS scheme $D=1.5\%$, we can still have favorable results, if D is higher at the moment of the trip. However, if D was only 1% average, the frequency rise would be there, but resulting settling frequency would be less than the target value one Hz. But it is okay, as now the load dispatcher can manually control.

The main idea of flat UFLS is to ensure that the system survives, first automatically and then manually the load dispatcher would correct. Unfortunately, under the control actions of RGMO (which does not allow generation drop as frequency is rising up to 50.0 Hz) and/or if D is higher than assumed, there is a strong danger of over-correcting. Hence initial stage targets are kept lower than lower stage targets. A pure linear FGMO does not suffer from this problem. Draft IEGC and IEGC 2010 mandate the linear FGMO operation above 50 Hz. However, the same has not been implemented completely. Even in case of a low frequency prevailing before a credible or severe contingency, the frequency should not be ideally below 49.7Hz on a continual basis and these low frequency operations have been seen to be for a shorter period. Also, low frequency operation of the grid is unviable to the States who are overdrawing from the grid. In addition to DSM penalties, ADMS shall come into play to address this. This makes the problem of stage wise load relief design a little complex. To appreciate this problem let us first discuss other related issues beginning with the observed power number.

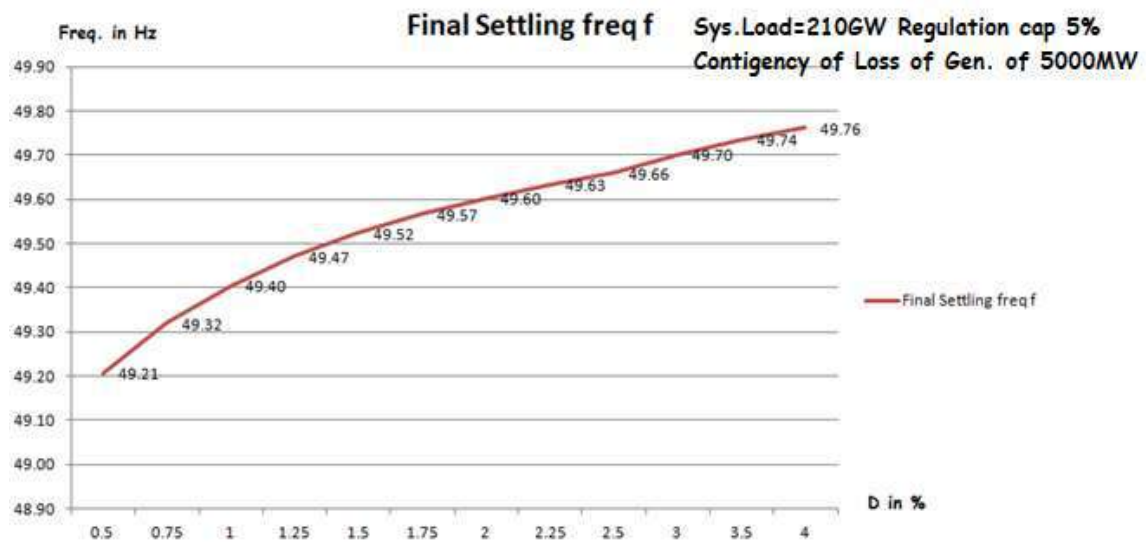


Figure 3.1

c) Observed Power Number λ (MW/Hz):

Power Number or power system stiffness λ (MW/Hz) means the MW needed to be lost/(gained) to raise/(lower) frequency by one Hz. Measurement of the power number is done by power system engineers worldwide. Upon loss of a generation or load throw off, the ratio of Generation Lost/Frequency difference is the power stiffness.

This number, no doubt, gives some idea of the average frequency drop to be anticipated when the generation is lost.

When governor action in the normal frequency range was not enabled, the observed power number essentially is the same as the load frequency damping D. This figure formed the basis of AUFLS load quantum determination in the earlier days.

However, when generators start changing the generation (by enabling governors or RGMO), the situation is different. Suppose a 2000 MW generation trip results in 0.2 Hz frequency change, the observed power number is 10,000 MW/Hz as per above definition. However, all the governors if they gave support of 500 MW transiently, the above formula would give (1500/0.2) 7500 MW/Hz. Since we have factored out change in generation, if system size is 200000 MW, 7500 MW is 3.75% of demand and D therefore is 1.875% in this case. That way D can be estimated. Using observed power number, the same system has 10000 MW loss and D appears to be 2.5%, while it is only 1.875%.

Unfortunately, the rise in generation pickup due to governor pick up is not readily available, but in principle one could co-relate if one has the required data.

The more important point in this example is we should shed 7500 MW per stage to raise the frequency up by one Hz and not 10,000 MW. Therefore, while revisiting the stage wise anticipated load relief, this point has to be kept at the back of the calculations.

d) Frequency influence of generators in normal frequency and emergency range:

Turbo Generators are equipped with a non-by passable mechanical governor that saves it during over speed conditions or emergency control area. It is a mechanical governor with a frequency droop of about 5%. It is also equipped with electronic governors to a CMC. Frequency influence characteristics can also be introduced in the CMC and can be used to. RGMO is an example of the frequency influence that can be used to increase the generation by a maximum amount of 5% of MCR. In RGMO when the frequency starts rising, the generation raised by RGMO is not reduced till frequency crosses a higher value. This means that when load is shed, frequency rises. But the generation of RGMO that had picked up would remain till frequency goes higher and the frequency reaches 50Hz. In the present problem, it means that earlier stages should not over shed, and raise the frequency to the extent of correcting the frequency to the fringe ranges of emergency control (usually 51.8 to 55 Hz), which is a remote possibility.

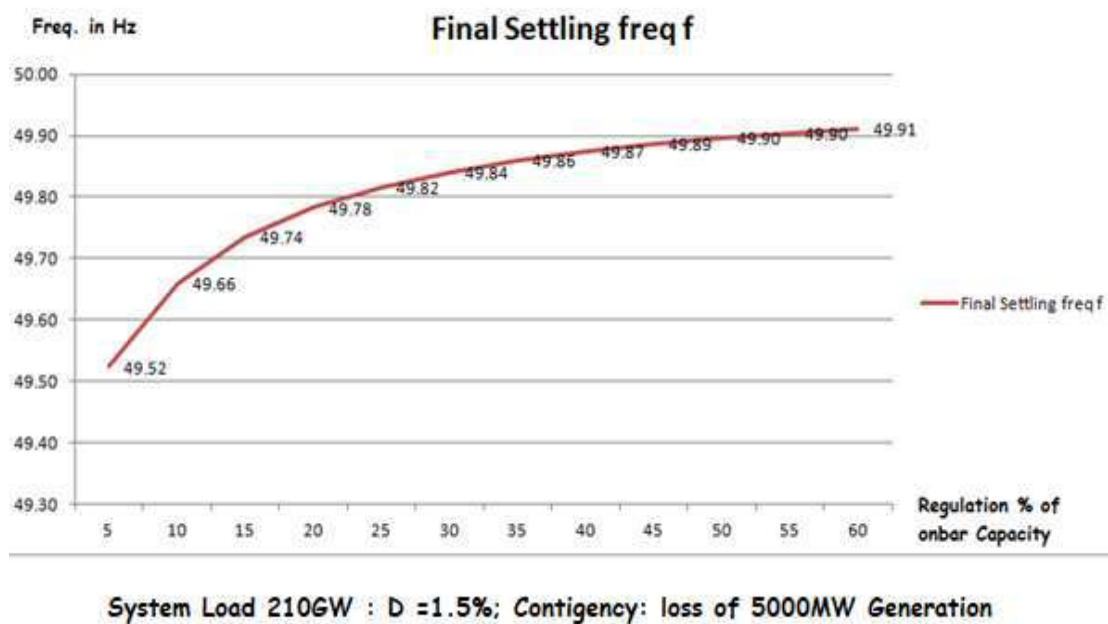


Figure 3.2

e) Role of System Inertia H:

System inertia H has increased, due to interconnections of the grid. This has two noticeable impacts.

- a) The initial rate of change of frequency, df/dt , reduces.
- b) It makes the disturbance appear smaller, as compared to independent regional operations of earlier days. A 5000 MW generation loss, in earlier days of an average regional size 50000 MW is a 10% disturbance. In a 200000 MW grid, it is only 2.5%

It may also be cleared that the settling frequency is in NO way related to H. It depends only on D. However, when governor action is there, the regulation through governor improves the settling frequency.

From our perspective, as long as the Indian Power System is integrated, the first five stages can handle generation losses and maintain integrated system. A few examples of generation loss are given by POSOCO and are given in Annexure I. It is seen that the grid is able to manage with RGMO and D such that the first stage frequency is not reached.

It would be a nightmare if opposite of (b) above happens and triggers any of the Stage I-A to E and system disintegrates immediately after the triggering of the AUFLS stages. Under such conditions, the importing regions (just before the separation) will experience it as a large disturbance resulting in rapid drop in frequency, whereas the exporting region will experience a different kind of disturbance with loads already shed under AUFLS and an over rich generation region, resulting in rapid rise in frequency. This rapid rise of frequency in the exporting region can only be addressed through the FGMO action of generators. At present the generators have not switched over completely from RGMO to FGMO. However high frequency droop governor correction, as a mechanical back, is always there in every generator.

Also, in earlier days, when regional grids were isolated. So even in the extreme case of total regional blackout, other regions could always assist in start-up power. But with integration of grids to an All-India grid, this situation is dreadful to imagine. The Black start alone may not be sufficient considering a worst dark blackout.

Restoration could take up much longer times. The good part is in a system split, there would be an over and a under generated island. But a relay engineer now is

forced and needs to add additional stages as followed by international community.

It cannot be over emphasized that All-India targets must be met. If one is reaping the rewards of integration of the grids. The AUFLS now must be very strictly implemented by all stake holders, and when the relays operate the requisite quantum of load MUST be shed.

f) Role of Voltage and Frequency dependence

The Zalte Committee also discussed voltage dependence factors. It may be noted that when it was designed, the first stage was already at 48.8 Hz. Further drop in frequency can also cause voltage problems and so more load was required to be shed. Currently the first stage is at 49.4 Hz and voltages overall are on the higher side, so this calculation can be dropped for the initial stages. Frequency dependence is D and is already elaborated above.

g) Role of Seasonal factors

In Zalte Committee seasonal factors is mentioned. Broadly seasonal load variations in demand are known. The Zalte Committee added an ad-hoc factor, so that if you want to disconnect 2% load plan for at least 4% or so of connected loads, so that one eventually ends up at 2% actually, handling for various other factors like Planned load shedding, emergency load shedding, reduced load on feeder etc.

In WR, for where the Zalte report was primarily written, Gujarat has almost all feeders connected to UFLS. They always met the regional target, as they had wired a huge quantum of loads in UFLS. They reaped huge benefits in 1990s to 2000s as they more or less survived the regional blackouts in WR in spite of the fact of being physically located as tail ends of the grid.

While the above approach was a regional adjustment for WR, as an All-India approach, there is a need to state clearly that all regions have to contribute their targets. If a region plans to connect 4% of connected demand internally, so that it can meet the agreed or specified target of 2%, it is okay. States and regions, have to finalize the internal workings. At an All-India level, the specified targets MUST be met. India being a diversified entity in its underlying unity, the targets must be met by each State/Region.

How to achieve this is no doubt left for regional RPCs to decide/plan, but All-India targets in this report must be met.

h) Reasons for failure of AUFLS schemes WRPC Inspection:

Inspection of AUFLS done by RPC Secretariats, in the past have revealed following abnormalities.

- a) UFLS feeder is already in planned or emergency load shedding.
- b) Substation authorities do not have power to change feeder in case the feeder is already under planned or unplanned load shedding.
- c) Feeders are coming in the area of high frequency during split. Load shedding is not distributed amongst the grid and in particular to load importing areas,
- d) Very few load shedding is done in primarily importing areas of the state.

The above are just a few observations. Hence in this revision, there is demarcation of AUFLS at national level, up to 48.6Hz. socializing cannot be acceptable for system frequency below 48.6Hz.

Before discussing our recommendations, there is a need to look at international experience, in particular the Continent of Europe.

4. International Practices of AUFLS

POSOCO representative shared the various international practices to give the quantum of load shedding at each stage of under-frequency in terms of percentage of total load. This makes interesting reading. **Annexure II** gives details.

a) Continental Europe:

Important points from Continental Europe experience are:

Cumulative demand disconnected is 45 % of total load at Continental Europe level. In Great Britain system, the value is 50% of national load.

It is important to note that there is a gap of 1Hz from 50 Hz for initiation of UFLS at 49 Hz. However, there are stringent regulations to control the frequency and all constituents adhere to maintain interchange for controlling frequency. The final stage of demand disconnection is 48 Hz mostly. Almost 50% of the load is to be shed.

Frequency quality defining parameters of the synchronous areas

	CE	GB	IE/NL	Nordic
standard frequency range	± 50 mHz	± 200 mHz	± 200 mHz	± 100 mHz
maximum instantaneous frequency deviation	800 mHz	800 mHz	1 000 mHz	1 000 mHz
maximum steady-state frequency deviation	200 mHz	500 mHz	500 mHz	500 mHz
time to recover frequency	not used	1 minute	1 minute	not used
frequency recovery range	not used	± 500 mHz	± 500 mHz	not used
time to restore frequency	15 minutes	15 minutes	15 minutes	15 minutes
frequency restoration range	not used	± 200 mHz	± 200 mHz	± 100 mHz
alert state trigger time	5 minutes	10 minutes	10 minutes	5 minutes

Frequency quality target parameters referred to in Article 127:

Table 2

Frequency quality target parameters of the synchronous areas

	CE	GB	IE/NL	Nordic
maximum number of minutes outside the standard frequency range	15 000	15 000	15 000	15 000

Table 4.1

Automatic low frequency demand disconnection scheme characteristics:					
Parameter	Values SA Continental Europe	Values SA Nordic	Values SA Great Britain	Values SA Ireland	Measuring Unit
Demand disconnection starting mandatory level: Frequency	49	48,7 – 48,8	48,8	48,85	Hz
Demand disconnection starting mandatory level: Demand to be disconnected	5	5	5	6	% of the Total Load at national level
Demand disconnection final mandatory level: Frequency	48	48	48	48,5	Hz
Demand disconnection final mandatory level: Cumulative Demand to be disconnected	45	30	50	60	% of the Total Load at national level
Implementation range	± 7	± 10	± 10	± 7	% of the Total Load at national level, for a given Frequency
Minimum number of steps to reach the final mandatory level	6	2	4	6	Number of steps
Maximum Demand disconnection for each step	10	15	10	12	% of the Total Load at national level, for a given step

Table 4.2

b) NERC:

North American Electric Reliability Corporation (NERC) standard PRC-006-2 stipulates that Automatic Underfrequency Load Shedding shall handle an imbalance of up to 25%.

c) New Zealand

AUFLS technical requirements report incorporated by reference into the Electricity Industry Participation Code 2010 on 21 December 2021 by the Electricity Industry Participation Code Amendment (Automatic Under-Frequency Load Shedding Systems) 2021, mentions a net demand disconnection of 32% in various stages.

d) Powertech Consultant:

In line with recommendation of consultant appointed by “Taskforce on Power System Analysis under Contingencies” in December 2012 as a follow up of the recommendations of Enquiry Committee under Chairperson, Central Electricity Authority (CEA) on Grid Disturbances of 2012 in Indian Grid. The number of steps and quantum of load shedding at each step is in line with recommendations of consultant Powertech labs. Section 3.2 of Task-III report of POWERTECH Labs Inc indicates that UFLS relays are generally designed for load-generation mismatch of up to 25%. The

same has been recommended for Indian grid based on summation of regional variations of demand.

5. Scope and Formulation of AUFLS Plan for Indian Power system

Scope:

While formulating the AUFLS it is required to try and predict whether the system is integrated or a part of the system has separated, from the past experiences. It is likely that the system remains integrated, if the frequency is well above 49.4 Hz, for most of the times. It can be safely assumed that in today's integrated Indian grid (200 GW), if the frequency drops below 48.8 6 Hz, then there is a high probability that a part of the system is disintegrated. (Example Mumbai Blackout dated 12-10-2020)

There are always two parts in a split grid problem, an over-generated island and an under-generated island. Usually, as backed by numerous experiences, over-generated islands have a greater probability of survival. The under-generated islands must do urgent and quick load shedding. In WR, Gujarat state had always wired maximum loads for UFLS, and **not** surprisingly they have always survived as a state power system. Hence sticking to a load shedding plan always pays in the long run.

In this design proposal, we may assume any frequency drop below 48.8 Hz as a case of system separation. So that gives the designer two windows.

(i) Above 48.6Hz, and (ii) Below 48.6 Hz.

Once a part of the system is below 48.6Hz, we expect a maximum seriousness and a desired to shed loads, almost mercilessly. **This is much better than losing the entire part-system and starting from black-start. Hence Socializing is not allowed in this part. In the first part requisite quantum is to be shed.** For below 48.6Hz, it is clear that if we do not shed the loads, this system is going to go dark, in all probability and eventually, so better to shed the loads and survive. Maybe the probability of such occurrences is very rare, once in ten or twenty years. Still a load shed at this stage, is the best option available.

Not only that, **this is our only insurance in an under-generated island.**

6. Theoretical aspects

It is necessary to understand the concept of dynamic frequency response during normal and severe contingency, so that an approach towards formulation of the AUFLS and df/dt based Load Shedding schemes can be decided. The simplified/elementary mathematical model and interpretation of these mathematical equations is described below for better understanding and deciding the approach.

Let us try to understand as to how the system behaves initially when a generation loss or demand increase takes place, step by step:

- (i) A simple linear model of primary Automatic Load Frequency Control (ALFC) is considered for understanding the dynamics of the system.
- (ii) The system is originally running in its normal state with complete power balance, that is, $P_G^0 = P_D^0 + \text{losses}$. The frequency is at normal value f^0 . Where P_G^0 & P_D^0 is the steady state generation and load of the system before any disturbance (disturbance is increase in load/loss of generation). All rotating equipment represents a total kinetic energy of " W_{kin}^0 " MW sec.
- (iii) By connecting additional step load, load demand increases by ΔP_D which we shall refer to as "new" load which is also synchronous to generation loss. (If load demand is decreased then new load is negative). The generation immediately increases by ΔP_G to match the new load, that is $\Delta P_G = \Delta P_D$.
- (iv) It will take some time for the control valve in the speed governing system to act and increase the turbine power. Until the next steady state is reached, the increase in turbine power will not be equal to ΔP_G . Thus, there will be power imbalance in the area that equals $\Delta P_T - \Delta P_G$ i.e., $\Delta P_T - \Delta P_D$. As a result, the speed and frequency change. This change will be assumed uniform throughout the area. The above said power imbalance gets absorbed in two ways. 1) By the change in the total kinetic K.E. 2) By the change in the load, due to change in frequency. Since the K.E. is proportional to the square of the speed, the area K.E. is

$$W_{kin} = W_{kin}^0 \left(\frac{f}{f^0} \right)^2 \quad \text{MW sec}$$

The "old" load is a function of voltage magnitude and frequency. Frequency dependency of load can be written as

$$D = \frac{\partial P_D}{\partial f} \quad \text{MW/Hz}$$

$$\text{Thus, } \Delta P_T - \Delta P_D = \frac{d}{dt}(W_{kin}) + D\Delta f$$

$$\text{Since } f = f^0 + \Delta f$$

$$\begin{aligned}
W_{kin} &= W_{kin}^0 \left(\frac{f^0 + \Delta f}{f^0} \right)^2 = W_{kin}^0 \left[1 + 2 \frac{\Delta f}{f^0} + \left(\frac{\Delta f}{f^0} \right)^2 \right] \\
&\approx W_{kin}^0 \left(1 + 2 \frac{\Delta f}{f^0} \right) \\
\frac{d}{dt} (W_{kin}) &= 2 \left(\frac{W_{kin}^0}{f^0} \right) * \frac{d}{dt} (\Delta f)
\end{aligned}$$

Substituting the above in eq. (1)

$$\Delta P_T - \Delta P_D = 2 \left(\frac{W_{kin}^0}{f^0} \right) * \frac{d}{dt} (\Delta f) + D \Delta f \quad \text{MW}$$

dividing this equation by the generator rating P_r and by introducing per unit inertia constant

$$H = \frac{W_{kin}^0}{P_r} \quad \text{MW sec/MW (or sec)}$$

$$\therefore \Delta P_T - \Delta P_D = \left(\frac{2H}{f^0} \right) * \frac{d}{dt} (\Delta f) + D \Delta f \quad \text{pu MW}$$

The ΔP 's are now measured in per unit (on base P_r) and D in p.u. MW per Hz. Typical H values lie in the range 2 – 8 sec. Laplace transformation of the above equation yields

$$\begin{aligned}
\Delta P_T(s) - \Delta P_D(s) &= \left(\frac{2H}{f^0} \right) s \Delta f(s) + D \Delta f(s) \\
&= \left(\left(\frac{2H}{f^0} \right) s + D \right) \Delta f(s)
\end{aligned}$$

$$\text{i.e., } \Delta f(s) = \frac{1}{\left(\frac{2H}{f^0} \right) s + D} * (\Delta P_T(s) - \Delta P_D(s))$$

$$\Delta f(s) = G_p(s) [\Delta P_T(s) - \Delta P_D(s)]$$

$$\text{Where } G_p(s) = \frac{1}{\left(\frac{2H}{f^0} \right) s + D} = \frac{\left(\frac{1}{D} \right)}{\left(1 + s * \frac{2H}{f^0 * D} \right)} = \frac{K_p}{1 + s T_p}$$

$$\text{Where } K_p = \frac{1}{D} \text{ \& } T_p = \frac{2H}{f^0 * D}$$

The dynamic response, by making a reasonable assumption that the action of speed governor plus turbine generator is instantaneous compared with rest of the power system and the effect of the same is introduced in the following equation.

$$\Delta f(s) = -(\Delta \text{ Load increase or } \Delta \text{ Gen loss}) * \left(\frac{R K_p}{R + K_p} \right) * \left(\frac{1}{s} - \frac{1}{s + \frac{R + K_p}{R T_p}} \right) \dots (2)$$

Where “R” is the regulation of the governor.

$$\Delta f(t) = -(\Delta \text{ Load increase or } \Delta \text{ Gen loss}) * \left(\frac{R K_p}{R + K_p} \right) * \left(1 - e^{-\left(\frac{R + K_p}{R T_p} \right) t} \right)$$

$$\Delta f(t) = -(\Delta \text{ Load increase or } \Delta \text{ Gen loss}) * \alpha * (1 - e^{-\beta t}) \dots \dots \dots (3)$$

$$\text{Where } \alpha = \left(\frac{RK_p}{R+K_p} \right) \& \beta = \left(\frac{R+K_p}{RT_p} \right)$$

Interpretation:

When the load/generation is suddenly increased / decreased by say 2%, certainly it must have come from somewhere as the load increase of 2% (step load if considered) has been met instantaneously.

In the milliseconds following the closure of the switch (of a step load), the frequency has not changed a measurable amount, speed governor would not have acted and hence turbine power would not have increased. In those first instants the total additional load demand of 2% is obtained from the stored kinetic energy, which therefore will decrease at an initial rate of 2% MW. Release of KE will result in speed and frequency reduction. As seen in eq. (3) above,

Initially, frequency changes (reduces) at the rate of $(\Delta \text{ Load increase or } \Delta \text{ Gen. loss}) * \alpha * \beta$ Hz / sec. As the time “*t*” increases governor regulation “*R*” comes into play and the frequency reduction causes the steam valve to open and result in increased turbine power. Further, the “old” load decreases at the rate of *D* MW / Hz.

In conclusion, the contribution to the load increase of 2% is made up of three components: (a). Rate of decrease of kinetic energy from the rotating system, (b). Increased turbine power and (c) “Released” old customer load.

Initially the components (b) and (c) are zero. After that, component (a) keeps decreasing and components (b) and (c) keeps on increasing. Finally, the frequency and hence the KE settle at a lower value and the component (a) becomes zero.

As $t \rightarrow 0$, the rate of fall of freq is highest and the rate of fall reduces. The df/dt relay therefore will come into play during the initial period. The higher the severity of contingency and lower the inertia, the rate of fall would be high. This factor will decide the development of the plan of df/dt . After the frequency reaches the frequency Nadir, the governor will respond and pull back the frequency and subsequently the frequency would settle at a higher value than the frequency Nadir and frequency will settle at that point. This settling of frequency would be useful in deciding the design plan for the flat frequency load shedding scheme (AUFLS). Keeping this background in mind, the plan

for selection of frequency for stages, df/dt rates and quantum of load shedding of the AUFLS and df/dt has been described in the following sections.

7. Selection criterion for trigger frequency for lower end and upper end Stage:

The selection of trigger frequency for the lowest Stage and the highest stage depends on number of factors as has been discussed above in the previous sections. The factors affecting the trigger frequency is required to be analysed in depth and the same is given in this section.

There was a disagreement amongst the members regarding the frequency setting for the Stage-A of AUFLS. POSOCO was of the view that the Stage-A frequency setting can be kept at 49.4Hz and subsequent stage frequencies could be 0.2Hz lower for a five stage AUFLS, for following reasons;

- (i) Under the credible contingency of loss of largest generating station, the frequency falls to around 49.5 Hz, therefore the trigger frequency for Stage-A should be 0.1Hz below the Nadir frequency which comes out to be 49.40 Hz and subsequent stages can be triggered with a 0.2Hz difference.
- (ii) The Thermal/Hydro/Gas and specially the RE generator low frequency trip setting needs to be obtained and frequency setting for the last stage should be above the trip setting of these generators, so that the generators should not trip before the last stage AUFLS trigger frequency. In the recent past when the frequency dipped below 49.5Hz, RE generators (wind units) tripping was reported in SR.
- (iii) The inertia of the system would come down due to huge RE penetration and convertor/inverter applications in the drive loads, this aspect also requires to be considered while deciding the Stage-A AUFLS, trigger frequency.

The above observations of POSOCO were deliberated at length and the following views were expressed as counter argument to above.

- (i) Thermal/Hydro generators low frequency trip setting generally in the range 47.5 Hz
- (ii) For RE generators especially Wind:
 - For RE generators, CEA standard operating range is 49.5 to 50.2 Hz
This was discussed thoroughly in view of the penetration of wind generation of @ 22000 MW and any tripping of these units before frequency reaching the 1st stage is not desirable.
 - CEA standards have defined the normal operating frequency range of 49.5 to 50.2 Hz for rated output. However, it remained silent on the performance of Wind generators at frequencies other than the operating range of 49.5-50.2Hz.

It should be ensured that the generators shall not trip, if the frequency falls below the operating frequency range. However, it is possible that at lower frequencies, the output of the generating unit may fall, if governors are not enabled. Therefore it is also recommended that the governors on the wind generators be enabled and accordingly this enabling provision be included in the CEA regulations.

- (iii) The effect of variable “D” under various operating points is discussed under this para and the following table gives the final settling frequency for a system of 210GW having only 5% capacity under RGMO/FGMO (this being very conservative approach) with a droop of 5% for different values of D. In all probabilities the value of D would be 1-3.5% for various real time scenarios. The settling frequency for D=1% is 49.4Hz, where the load dependence on frequency is linear. Therefore, the variable D in worst case could settle the frequency to 49.4Hz, for a credible contingency of 5000MW. The estimation of final settling frequency has been done as per the approach given under “B)-a)” section below. D therefore in worst case will have an effect of 0.1 to 0.15Hz on the final settling frequency (compared with assumed value of 1.5%). **Therefore, even if it is assumed to be around 1.5%, it can turn out to be a good assumption for all practical purposes.**

Effect of variation of D on the final settling frequency for a contingency of 5000MW

Sta ge	freq (a)	Gen (b)	Load (c)=(b)	Gen Loss (d)	D in % (e)	D Pu MW/Hz (f)=((e*c/ (a/100))/c	Gen (reg) 5% gen resp ond (g)= b*5/ 100	R reg (h)	R Hz/p .u. MW (i)=2 .5*b /g	FRC β (j)=f +1/i	Δf (k)= (d/b)j	Final Settli ng freq f (l)=a- k	Gen increa se throug h Gov (m)=g /i	Load drop due to freq depende nce (n)=(e*b)/(0.01*a *k	LS reqd.= Load- Gen (o)
A	50.00	210000	210000	5000	0.5%	0.01	105 00	5%	50	0.03	0.79	49.21	210	1667	4642
A	50.00	210000	210000	5000	0.75 %	0.015	105 00	5%	50	0.04	0.68	49.32	210	2143	3937
A	50.00	210000	210000	5000	1.00 %	0.02	105 00	5%	50	0.04	0.60	49.40	210	2500	3408
A	50.00	210000	210000	5000	1.25 %	0.025	105 00	5%	50	0.05	0.53	49.47	210	2778	2996
A	50.00	210000	210000	5000	1.50 %	0.03	105 00	5%	50	0.05	0.48	49.52	210	3000	2666
A	50.00	210000	210000	5000	1.75 %	0.035	105 00	5%	50	0.06	0.43	49.57	210	3182	2396

A	50.00	210000	210000	5000	2.00 %	0.04	105 00	5%	50	0.06	0.40	49.60	210	3333	2170
A	50.00	210000	210000	5000	2.25 %	0.045	105 00	5%	50	0.07	0.37	49.63	210	3462	1980
A	50.00	210000	210000	5000	2.50 %	0.05	105 00	5%	50	0.07	0.34	49.66	210	3571	1816
A	50.00	210000	210000	5000	3.00 %	0.06	105 00	5%	50	0.08	0.30	49.70	210	3750	1551
A	50.00	210000	210000	5000	3.50 %	0.07	105 00	5%	50	0.09	0.26	49.74	210	3889	1344
A	50.00	210000	210000	5000	4.00 %	0.08	105 00	5%	50	0.1	0.24	49.76	210	4000	1178

Table 7.1

(iv) A credible contingency of 5000 MW (for a 210000MW system , 2.4% of total generation) in the grid due to loss of generation or rise of load is considered in the estimation sheet with Frequency dependence load factor ‘D’ of 1.5% and governor droop of 5% (with only 5% of generation capacity expected to respond under RGMO/FGMO). With this contingency, new operating frequency would settle at 49.52 Hz from the initial frequency of 50 Hz. However, there is a considerable reduction in D due to introduction of VFDs, power electronic based drive loads, RE generation etc. in the system. The fall of frequency could be steep, and the Nadir frequency would be around 49.4 Hz, but the frequency, finally, would settle to 49.52Hz. **In conclusion, for a credible contingency of loss of highest generating station in the system of @5000MW, would settle the system frequency at 49.52, with Nadir frequency would certainly touch 49.4Hz, even during the system inertia is high.** It appears from the estimates that at off peak load conditions and when RE generation (wind & solar) is high the Nadir frequency could easily fall below 49.4Hz. The calculations based on the approach explained in B) below for a system of 210GW, having regulation capability of 5% of total capacity on bar, D of 1.5%, the settling frequency for a credible contingency of 5000MW would be 49.52Hz.

Credible contingency of 5000MW on the final settling frequency																				
Stage	freq	Gen	Load	Change in load/ Gen Δ "G/L" ***	Pu Δ "G/L"	D in %	D freq dependance	D MW/ Hz	D Pu MW/ HZ	Gen (reg) 5% gen response	R reg	R Hz/p u MW	FRC β	Δfo	Final Settling freq f	Gen increase through Gov	Load drop due to freq dependence	LS reqd.= Load-Gen	With 20% safety margin for stage-A to CLS reqd & 40% for Stage-D & E	% of total load
A	50.00	210000	210000	5000	0.02	1.5%	0.015	5000	0.03	10500	5%	50	0.05	0.48	49.52	210	2381	3584	4301	2.05%

Table 7.2

- (v) It requires to note that all the regions in their OCC meetings, are reviewing the primary response of the generators in their regions. The primary response of the generators have increased and therefore the kind of steep fall in the frequency which was being experienced in the past have now been flattened.
- (vi) **The primary function of AUFLS is to respond as a defense protection mechanism, if the settling frequency is equal to or lowers than the trigger frequency of the respective Stages and not to respond to the rate of change of frequency. df/dt is the primary defense protection mechanism which shall respond for the rate of change of frequency.**
- (vii) If the Stage-IA frequency of 49.4Hz, is adopted, the Stage-A AUFLS may get triggered, when the system inertia is low, even for credible contingency & contingencies of less severity, resulting in unnecessary load shedding even though the final settling frequency would be higher than the trigger frequency of 1st Stage. **It is also pertinent to note that the load connection to system is not automatic and is manual, though the load shedding is automatic. Once the load is shed through AUFLS, it is difficult to bring back the load into system immediately and it takes hours to bring back the load, since the loads that have been shed are remote loads (in case of WR load shedding feeders are at 33kV and below level feeders which are at remote locations and it is required to communicate with the switching S/Stns for restoration of loads).**
- Therefore, the first stage (Stage-IA) trigger frequency can safely be adopted at 49.2Hz. The last stage (Stage-IE) trigger frequency can safely be adopted at 48.6Hz, in view of the above observations. The Stage I is further divided into 5 substages and the trigger frequencies for these Stages can be Stage-IA=49.2Hz, Stage-IB=49.0Hz, Stage-IC=48.8Hz, Stage-ID=48.7Hz and Stage-IE=48.6Hz. The trigger frequency difference for the last 3 stages is 0.1Hz,

since it is very likely that the system would be under severe stress below 48.8Hz and quick action is required to restore the frequency back to around 50Hz. Even after this, if the frequency falls further it is fair to assume that the system has disintegrated, and Islands have already been formed. Under such system conditions desperate measures are required to be taken and therefore Stage-II is being proposed. The trigger frequencies for Stage-II would be Stage-IIF=48.4Hz with 6% of Load shed; Stage-IIG=48.2Hz with 6% of Load shed & Stage-IIH=48.0Hz with 6% of Load shed.

8. The AUFLS stage wise quantum and their distribution among regions can be decided based on the following two alternative methods / philosophies:

a) Approach-A:

The estimate of Load shedding required under Stage-I-A, B, C, D & E, is made as per the calculation methodology adopted under alternative Approach-B

The combined effect of frequency dependence of load factor “D” and the regulation response of the generators “R” with following assumptions can be used to see the frequency settling point and load required to shed.

1. For simplicity assume a loss less system i.e., generation = load. This can be fairly a good assumption, since the system prior to disturbance is in steady state and system losses are approximately proportional to the loads. Further a Generation Loss has been considered which is similar to Load increase in $\Delta "G"$ Empirically the “frequency dependence of load” can be seen in the range of 1.5%. As has been seen in the previous sections ‘D’ in worst case scenario has little influence in the final settling frequency. So, it is fair to assume the “frequency dependence of load” as 1.5% in the peak period. Therefore, at a peak demand of 210000MW, the “frequency dependence of load” factor D if assumed to 1.5% the fall/decrease in load would be 6300MW/Hz for 1 Hz fall of frequency.

The generators are assumed to be running to their full capacity and therefore can provide 5% governor response through RGMO/FGMO as stipulated in IEGC. There could be some generators which may be running below the full load capacity and can provide more response also. However, on bar generators can provide 5% governor response through RGMO/FGMO during the above load scenario. This is a very conservative approach. For example, this translates to a regulation factor “R” of 50 Hz/p.u. MW on the new MW base of 10500MW (Old MW base being 210000MW) for the Stage-I-A.

In the calculations, it has been tried to establish, at what generation drop/load increase the frequency would settle to 49.2, 49.0, 48.8, 48.7 & 48.6 Hz respectively, as these being the Stages for Stage-I, identified for load shedding. The initial frequency is assumed to be at 50 Hz. If the frequency falls to 49.2 Hz due to either generation loss or demand rise, even after primary reserves

respond, the AUFLS 1st stage (i.e., Stage-I-A) will give relief. To estimate the Generation Loss/Demand Increase quantum (Generation loss has been estimated for estimating LS), with the Load dependence of frequency (D) and regulation factor (R), the system frequency settling at 49.2Hz what would be the “generation loss quantum” that would settle the frequency to 49.2 Hz. There will be a generator RGMO/FGMO response and load loss (due to frequency dependence) due to fall of frequency from 50Hz to 49.2 Hz. Now after the Stage-I A load shedding is triggered and gives load relief, the frequency will rise above 49.2Hz but will not reach 50Hz, since with the increase of frequency again the Loads will increase due to “D”. This increase in load is also required to be shed so that the frequency is restored to 50Hz. The steps involved are as given below.

- (i) Generation and loads assumed to be 210000MW
- (ii) Frequency drops to 49.2Hz from 50Hz
- (iii) Calculate D in p.u. MW/Hz,
- (iv) Calculate R in Hz/p.u. MW
- (v) Calculate change(drop) in load due to fall of freq from 50Hz to 49.2Hz (0.8Hz)
- (vi) Calculate β (FRC)=D+ 1/R
- (vii) Find f_0 = (loss of gen)/ β
- (viii) Find the settling freq. by adjusting the generation loss till f_0 become 49.2Hz.
- (ix) The new load and generation due to freq drop is calculated as follows.

$$\text{New Load (NL}_1\text{)} = \text{Initial Load (NL}_0\text{)} - \text{Load Drop (LD}_0\text{)} \text{ due to freq. fall. -- (1)}$$

$$\text{New Generation (NG}_1\text{)} = \text{Initial Gen. (NG}_0\text{)} - \text{Gen Loss} + \text{RGMO/FGMO. --(2)}$$

RGMO/FGMO response has been assumed to be very low.

Now to establish the Load generation balance (LGB) (so that frequency can be raised to 50 Hz), the Load Shedding (LS₁) quantum required can be estimated by comparing the new loads with the new generation. The difference between new load and new generation would be the load shedding quantum to raise the frequency above 49.2 Hz.

$$(\text{LS}_{11}) = (\text{NL}_1) - (\text{NG}_1) \text{ -----(3)}$$

- (x) With the LS₁ Load is shed, the Load-Generation balance is established, so the frequency will try to reach 50Hz. However again due to frequency rise from

49.2Hz to 50Hz, the load will increase because of load dependence on the frequency. With the assumed D and NL, the rise in load say NL_{11} is estimated. Now if this Load is added to LS_{12} , a perfect load generation balance will be achieved. Therefore, the load shedding quantum for Stage IA will be

$$\text{Load Shedding quantum in Stage-A (LS}_1\text{)} = LS_{11} + LS_{12}. \text{-----(4)}$$

- (xi) The LS quantum arrived at to raise the frequency to 50Hz from 49.2Hz was estimated for Stage-I-A. Even after Load Shedding (LS_1) under Stage-A as above, if suppose the frequency does not improve and keeps falling further to 49 Hz, the Stage-B of AUFLS would trigger.

Now for Stage-B, the Initial frequency assumed to be at 50Hz with a NL_2 & NG_2 to be same.

$$NL_2 = NL_1 - LS_1 \text{ and } NG_2 = NL_2$$

Now the steps (1) to (4) are repeated.

- (xii) The above steps are followed to arrive the LS quantum for each stage. It is assumed that at the start of every stage the initial frequency is 50Hz.

The quantum of load increase/ Generation loss is iteratively achieved so that the new system frequency settles at 49.2 Hz. The load shedding quantum required to establish load and generation balance is computed by carrying out load loss (due to 'D') due to frequency falling to 49.2 Hz and this increase due to raising the frequency to 50 Hz, the very negligible governor action and load loss due to AUFLS at 49.2 Hz. This approach has been extended to see where this frequency settles at 49.0, 48.8, 48.6 and 48.5 Hz and the adjusted load shedding quantum required to be wired up for AUFLS. Therefore, even if Stage-I A, B, C & D does not raise the frequency to 50Hz, the last Stage-E is capable to increase the frequency from 48.5Hz to 50 Hz, if the loads are shed is estimated for Stage-IE. This is even true for all the Stages-I B, C & D. So, each stage, independently, is capable to raise the frequency from the stage trigger frequency to 50Hz.

The calculations were done with the above assumptions, and it is observed that during the peak demand scenario (210000MW), a sudden 3% of demand rise or 3% generation loss of (6300MW) will lead to frequency falling to 49.43 Hz.

- (xiii) Stage-A (49.2 Hz) and Stage-B 49.0 Hz: The calculations done for a 210 GW system with initial frequency of 50 Hz is as given in the table below.

(xiv) The final calculations done are as follows for Stage-I-A to E.

D in %	1.5%		R reg	5%																	
Load	210000												Effect of both D & R							Load Shedding	
Stage	freq	Gen	Load	Change in load/ Gen Δ "G/L" ***	Pu Δ "G/L"	D in %	D freq dependance	D MW/ Hz	D Pu MW/ HZ	Gen (reg) 5% gen response	R reg	R Hz/p u MW	FRC β	Δ fo	Final Settling freq f	Gen increase through Gov	Load drop due to freq dependence	LS reqd.= Load-Gen	With 20% safety margin for stage-A to C LS reqd & 40% for Stage-D & E	% of total load	
		C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	W	X	
A	50.00	210000	210000	8400	0.04	1.5%	0.015	6300	0.03	10500	5%	50	0.05	0.80	49.20	210	5040	4681	5617	2.7%	
B	49.20	201810	201810	10100	0.05	1.5%	0.015	6153	0.03	10091	5%	50	0.05	1.00	49.00	202	6159	5550	6660	3.2%	
C	49.00	191912	191912	11500	0.06	1.5%	0.015	5875	0.03	9596	5%	50	0.05	1.20	48.80	192	7041	6325	7590	3.6%	
D	48.80	180604	180604	11780	0.07	1.5%	0.015	5551	0.03	9030	5%	50	0.05	1.30	48.70	181	7242	6455	9037	4.3%	
E	48.70	169004	169004	11850	0.07	1.5%	0.015	5206	0.03	8450	5%	50	0.05	1.40	48.60	169	7300	6484	9078	4.3%	

Table 8.1

The calculations were done with the above assumptions, and it is observed that during the peak demand scenario (210000MW), a sudden 4% of demand rise or 4% generation loss of (8400MW) will lead to frequency falling to 49.20 Hz in Stage-A.

The above estimates were done based on the assumed values of D, R and with a demand of 210000MW. The same was repeated for 150000MW system and the estimates are as follows.

D in %	1.5%		R reg	5%													
Load	150000									Effect of both D & R							
Stage	freq	Gen	Load	Chang e in load/G en Δ "G/L" ***	D in %	D Pu MW/H Z	Gen (reg) 5% gen respond	R reg	Hz/p u MW	FRC β	Δ fo	Final Settlin g freq f	Gen increas e through Gov	Load drop due to freq depend ce	LS reqd.= Load- Gen	With 20% safety margin for stage-A to C LS reqd & 40% for Stage- D & E	% of total load
		C	D	E	G	J	K	L	M	N	O	P	Q	R	S	T	X
A	50.00	150000	150000	6000	1.5%	0.03	7500	5%	50	0.05	0.80	49.20	150	3600	3343	4012	2.7%
B	49.20	144150	144150	7200	1.5%	0.03	7208	5%	50	0.05	1.00	49.00	144	4390	3956	4747	3.2%
C	49.00	137094	137094	8200	1.5%	0.03	6855	5%	50	0.05	1.20	48.80	137	5020	4510	5412	3.6%
D	48.80	129031	129031	8400	1.5%	0.03	6452	5%	50	0.05	1.30	48.70	129	5164	4603	6444	4.3%
E	48.70	120760	120760	8470	1.5%	0.03	6038	5%	50	0.05	1.40	48.60	121	5218	4635	6489	4.3%
													Stage A-C		11809		9.4%
													Stage D-E		9238		8.6%
													Grand Total		21047		18.1%

Table 8.2

From the above tables, it is seen that the % Load shedding quantum remains the same for 210000MW and 150000MW operating point of the system. Further it is required to consider that in real time the load shedding feeders could be under forced outage or unavailable due to other reasons and therefore an approximate safety factor assumptions can be made and the final AUFLS quantum for Stage-I-A to E can be recommended as given below.

S. No.	Stage	Frequency	Demand disconnection	
1	I-A	49.2 Hz	3.5%	
2	I-B	49.0 Hz	3.5%	
3	I-C	48.8 Hz	4%	
4	I-D	48.7 Hz	4.5%	
5	IE	48.6 Hz	4.5%	20%
Desperate measures- Load Shedding				
6	II-F	48.4 Hz	6%	
7	II-G	48.2 Hz	6%	
8	II-H	48.0 Hz	6%	18%
	Total			36%

Table 8.3

I) Stage I-A to E:

- (i) It is the responsibility of the State to shed loads that would trip the above quantum of demand as specified.
- (ii) State is free to shed loads anywhere in Stage I-A to E as per its convenience
- (iii) The feeders on which the Stage I-A to E relays have been installed should be excluded from all type of load shedding schemes such as ADMS, SPS, any other planned Load Shedding Scheme, LTS or any other emergency load shedding schemes etc.
- (iv) The figures are with respect to the maximum demand catered in the past.
- (v) When demand drops the connected feeders remain the same, so that overall, the demand will be commensurate with the expected targets.

II) Stage II-F to H:

- (i) The Stages II-F to H shall be connected to all load centers. In particular States shall connect loads where the load centers are importing from stations away from the load centers.
- (ii) It is strongly recommended that the distribution of loads under these stages be done uniformly throughout the State as far as possible.
- (iii) Depending on regional power flow, ensure that all importing loads are well covered.
- (iv) No planned preparatory islanding scheme loads that are wired up for Load shedding are covered in the above.
- (v) Feeders other than those covered under b)-(iii) and c)-(iv) should be wired up for implementation of Stages II-F to H.
- (vi) The feeders identified for implementation under Stage II-F to H, preferably, shall be feeders emanating from EHV stations, since under this stage it is assumed that the system has entered in emergency state and a reliable load disconnection is required under this stage.

b) Approach-B

The system may separate or remain integrated if the frequency touches any of the five stages of AUFLS i.e., 49.2,49.0,48.8,48.7 & 48.6Hz. Therefore, in this approach, the total load shedding quantum decided based on the calculation table is given below, for the current year (FY 2022-2023 or calendar year 2022), has been allotted LS quantum to each region based on the import/export of the Region during the last years (FY

2021-22 or calendar year 2021) all India peak demand. This is done for the 1st two stages of frequency 49.2 & 49 Hz, since during these two stages the import/export of the Regions needs to be controlled based on the internal generation available in that region. The tie line flows will ease out and the chances of Low Frequency Oscillations (LFOs) will be the least or controllable. In the 2012 blackout the frequency did not fall below 49.2 Hz initially, still the system got separated. Only after separation, the frequency in the importing regions fell below 49.2 Hz and those in exporting regions it increased above 50Hz. As brought out by the Enquiry Committee the quantum of LS operated, at that time, in import regions was not sufficient (AUFLS mal functions /in-operations).

While adopting this approach, there are two ways in which it can be implemented. In the first, the AUFLS quantum for importing & exporting regions can be kept fixed in a ratio decided (say 60:40 or 70:30 ...) based on the import/export during all India peak demand of last year. The all-India peak for last year has been considered, since during the peak period, the system is operated under stressed condition, and it is the most difficult period when series of unforeseen contingencies occur. At other than peak loading conditions of the system, there is a cushion available in the form of spinning reserves and other avenues to mitigate the series of contingencies. However, this cannot be expected to be true all the times.

Another way to address the variability of the Import/export of regions in real time, Wide area measurement systems (WAMS) using PMUs (Phasor Measurement Unit) is the best tool for monitoring and controlling. Under this, the inter-regional flow of power between regions would be monitored in real time and based on the imports of a region, the UFR's of importing region will automatically enabled and the UFRs in the export region would automatically be disabled based on the import/export quantum plus the power generation at the largest station of the region. When the frequency reaches the 1st stage, the load shedding relays would operate to give designated relief in those regions accordingly. There exists a possibility of selecting UFR relays and therefore the quantum automatically through a wide control system if the UFRs at the sub-transmission level having communication facility.

This approach was discussed and it was felt that this is a futuristic approach which can be implemented when the automation and communication becomes mature at transmission/distribution level. Also members felt that in the real time, the inter-regional power flow is not uni-directional, but changes season to season and even day

to day. The bidirectional exchange between regions has been observed and in case of some regions like SR, there are diurnal variations in exchange of power. The settings implemented would have to be dynamic during the day/season. When an integrated power system splits into sub-systems following cascaded outages, the sub-systems or islands are created in an unplanned way. The frequency, at which such splitting would occur, cannot be predicted. Therefore, it's not possible to design any post splitting UFLS to ensure survival of the islands. However, UFRs once installed, would operate whenever the threshold frequency is reached.

Therefore, the group felt that this approach may be thought of in future for implementation after ascertaining the fulfilment of communication requirements. But establishing proper communication to AUFLS feeders in far remote areas is also the most difficult and challenging task.

The detail of this approach B is given at Annexure-III

Comprehensive study on stage wise load shedding under AUFLS quantum with system load of 210 GW and 150 GW with D=1.5% and R=5% is given below:

For 210000 MW System load: The calculation table given in Table 8.4 below.

New Gen	New Load	Change in load Δ "L"	Pu Δ "L"	D in %	D freq dependa nce	D MW/Hz	D Pu MW/Hz	Gen (reg) 5% gen respond	R reg Hz/pu MW	FRC β	Δ fo	Δ Increas e in load due to increas e in freq	New Gen after freq increase	New Load after freq increase	
AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ
U6	V6	AC6-AB6	AD6/AC6			AG6*AC6/(0.01*B6)	((15/100)*AC6/(50/100))/AB6	AB6*5/(100*M6)		2.5*AB6/AJ6	AI6+I/AL6	AE6/AM6	AC6*AG6*0.8	AB6	AC6+AO6
201810	204960	3150	0.0154	1.5%	0.015	6149	0.030468	202	5%	2500	0.031	0.498	1531	201810	206491
191912	195651	3740	0.0191	1.5%	0.015	5965	0.030585	192	5%	2500	0.031	0.617	1810		
180604	184871	4267	0.0231	1.5%	0.015	5659	0.030709	181	5%	2500	0.031	0.742	2058		
169004	173362	4358	0.0251	1.5%	0.015	5329	0.030774	169	5%	2500	0.031	0.806	2097		
157323	161704	4381	0.0271	1.5%	0.015	4981	0.030835	157	5%	2500	0.031	0.867	2104		

Table 8.4 cont_

Effect of both D & R										Load Shedding apportionment																
Stage	freq	Gen	Load	Change in load/g Pu Δ "G/L" ***	D in % dependance	D freq	D MW/Hz	D Pu MW/Hz	Gen (reg) 5% gen respon d	R reg MW	R Hz/pu MW	FRC β Δ fo	Final Settling freq f	Gen increa se through Gov	Load drop due to freq depenc e	LS reqd.= Load- Gen	With 20% safety margin for stage-A to C LS reqd & 40% for Stage-D & E	New Gen after loss+ regulation	New load after loss of load due to freq dependen ce	With 20% safety margin for stage-A to C LS reqd & 40% for Stage-D & E	% of total load	Importing Region	Exporting Region	Ratio of LS sharing		
		C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
A	50.00	210000	210000	8400	0.04	1.5%	0.015	6300	0.03	10500	5%	50	0.05	0.80	49.20	210	5040	4681	5617	201810	204960	5617	3%	3370	2247	60-40
B	49.20	201810	201810	10100	0.05	1.5%	0.015	6153	0.03	10091	5%	50	0.05	1.00	49.00	202	6159	5550	6660	191912	195651	6660	3%	3996	2664	60-40
C	49.00	191912	191912	11500	0.0599	1.5%	0.015	5875	0.03	9596	5%	50	0.05	1.20	48.80	192	7041	6325	7590	180604	184871	7590	4%	5313	2277	70-30
D	48.80	180604	180604	11780	0.0652	1.5%	0.015	5551	0.03	9030	5%	50	0.05	1.30	48.70	181	7242	6455	9037	169004	173362	9037	4%	proportional to the peak demands		
E	48.70	169004	169004	11850	0.0701	1.5%	0.015	5206	0.03	8450	5%	50	0.05	1.40	48.60	169	7300	6484	9078	157323	161704	9078	4%	proportional to the peak demands		
																Stage A-C		16555				19867	9%			
																Stage D-E		12939				18114	9%			
																Grand Total		29494				37981	18%			

Table 8.4 210 GW system

For 150 GW system load: The calculation Table 8.5 given below.

New Gen	New Load	Change in load Δ "L"	Pu Δ "L"	D in %	D freq dependance	D MW/Hz	D Pu MW/Hz	Gen (reg) 5% gen respond	R reg	R Hz/pu MW	FRC β	Δ fo	Δ Increase in load due to increase in freq	New Gen after freq increase	New Load after freq increase
AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ
U6	V6	AC6-AB6	AD6/AC6			AG6*AC6/(0.01* π B6)	((1.5/100)*AC6/(50/100))/AB6	AB6*5/(100*MB6)		2.5*AB6/AJ6	AI6+II/AL6	AE6/AM6	AC6*AG6*0.8	AB6	AC6+AD6
144150	146400	2250	0.015369	1.5%	0.015	4392	0.030468	144	5%	2500	0.031	0.498	1093	144150	147493
137094	139760	2666	0.019073	1.5%	0.015	4261	0.030583	137	5%	2500	0.031	0.616	1291		
129031	132074	3043	0.023037	1.5%	0.015	4043	0.030707	129	5%	2500	0.031	0.741	1467		
120760	123868	3107	0.025087	1.5%	0.015	3807	0.030772	121	5%	2500	0.031	0.805	1495		
112411	115542	3131	0.027101	1.5%	0.015	3559	0.030836	112	5%	2500	0.031	0.868	1504		

Table 8.5 cont-

Effect of both D & R										Load Shedding apportionment																
Stage	freq	Gen	Load	Change in load/Gen $\Delta T_G/L$ ***	$Pu \Delta T_G/L$ D in %	D freq dependance	D Δf MW/Hz	D PU MW/Hz	Gen (reg) 5% gen respond	R reg	R Hz/cu MW	FRC β	Δf	Final Setting freq f	Gen increase through Gov	Load drop due to freq dependance	LS reqd= Load-Gen & 40% for regulation	With 20% safety margin for stage-A to after gen loss+ C LS reqd & 40% for Stage- D & E	New load after loss of load due to freq dependance	With 20% safety margin for stage-A to % of total C LS reqd & 40% for Stage- D & E	Importing Region	Exporting Region	Ratio of LS sharing			
		C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
					50.0k			HF250(CU/PS (15MW)C603 C600)C605	0.05100		23700M6	16-1005	F60M6	B6-06	B6-06	163M6	B705	VF-U6-406	38712	C6-E4-406	D6-F6	VF06	VF06	VF06	VF06	
A	50.00	150000	150000	6000	0.04	1.5%	0.015	4500	0.03	7500	5%	50	0.05	0.80	49.20	150	3600	3343	4012	144150	146400	4012	3%	2407	1605	60:40
B	49.20	144150	144150	7200	0.049948	1.5%	0.015	4395	0.03	7208	5%	50	0.05	1.00	49.00	144	4330	3956	4747	137094	139760	4747	3%	2848	1899	60:40
C	49.00	137094	137094	8200	0.059813	1.5%	0.015	4197	0.03	6855	5%	50	0.05	1.20	48.80	137	5020	4510	5412	129031	132074	5412	4%	3788	1624	70:30
D	48.80	129031	129031	8400	0.065101	1.5%	0.015	3966	0.03	6452	5%	50	0.05	1.30	48.70	129	5164	4603	6444	120760	123868	6444	4%	proportional to the peak demands		
E	48.70	120760	120760	8470	0.070139	1.5%	0.015	3720	0.03	6038	5%	50	0.05	1.40	48.60	121	5218	4635	6489	112411	115542	6489	4%	proportional to the peak demands		
																Stage A-C		11809				14171	9%			
																Stage D-E		9238				12333	9%			
																Grand Total		21047				27104	18%			

Table 8.5 150GW system

9. The problem of df/dt schemes:

Due to integration, df/dt schemes have following known issues:

- 1) The smallest df/dt rate measurable/settable by a relay is usually 0.05 Hz/sec and such relays are available.
- 2) As per an earlier study on df/dt in 2007, when ER and WR were integrated, is the reduction in df/dt below measurable levels. See Annexure.
- 3) The df/dt at the point of the separation is the highest. Relays must have a minimum of 6 cycles to detect this to prevent a mal-operation. Now a day a 3cycle sliding window validation of df/dt is available. Lower the number of cycles, the faster is the response, however the low cycle sliding window have an issue of mal-operations.
- 4) Hence reliability of df/dt as a regional scheme is not so good, though it can provide reliefs under certain scenario.
- 5) However, df/dt in region where a generation loss has takes place, tends to operate as the df/dt is relatively higher at loads which are electrically in proximity to such generators than those loads which are electrically far from the disturbance centre.

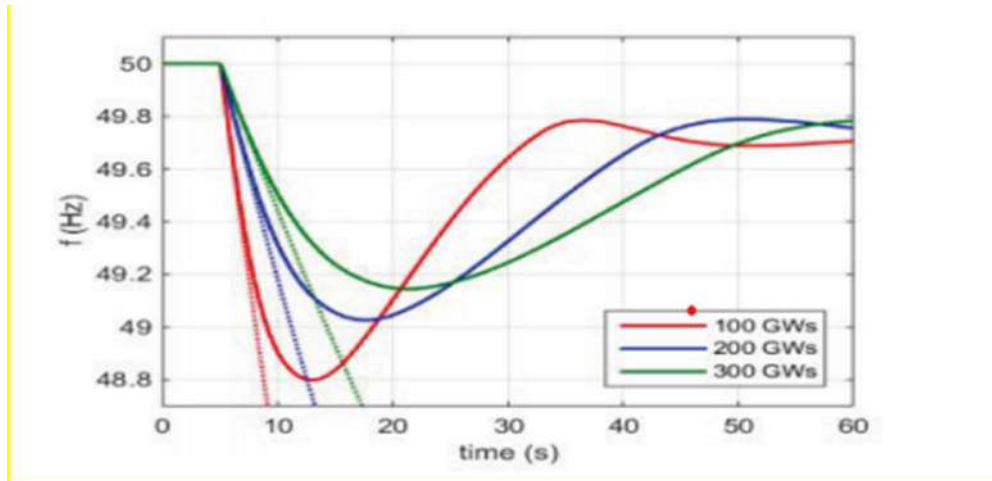
It is because of the above disadvantages, that this Committee emphasizes on flat AUFLS.

Reduced Inertia and role of df/dt:

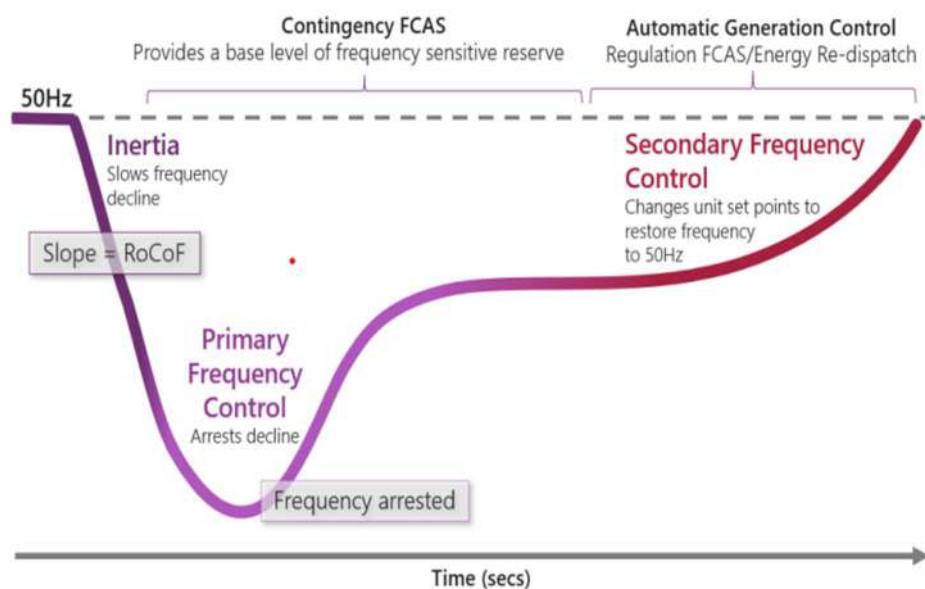
The Indian Electricity Grid Code mandates operation of power system within a narrow frequency band of 49.90 to 50.05 Hz, which is expected to be narrowed down further to 49.95-50.05 Hz, in the future. A frequency excursion is restricted by the combined response of system inertia, load response, primary frequency response of generators, initially. The wind and solar penetration is variable therefore during high penetration, the synchronous rotating inertia of the system reduces and during low penetration, it increases. Therefore, it is difficult to analyze and estimate the correct value of rotating inertia. This diminishing inertia has high impact on df/dt during credible/severe contingency.

Out of total installed capacity of 404.4 GW, RE amounts to 114.4 GW (as per CEA data July 2022). With the target of integrating 175 GW of RE installed capacity by 2022, the Indian grid is likely to experience relatively low inertia scenarios in the future. Reduced inertia will result in steep fall of frequency during severe contingency in the system.

Typical impact of decreasing inertia is shown below.



- 1) The system frequency response to a severe contingency shown below.



Within short time of contingency, the rate of fall of frequency is high, if the system inertia is not sufficiently large. Therefore, Kinetic energy stored in the rotating masses is unable to provide adequate damping to the change in frequency and the frequency is likely to fall sharply with high df/dt .

- 2) The rate of fall of frequency is also tightly coupled with electrical proximity of the loads where the contingency happens.

- 3) These two factors namely inertia of the system and proximity of loads to the contingency decides the rate of fall of frequency electrically nearby area where generation loss occurs.

Keeping in view the above theoretical aspect and the operation of the system at present and in near future, the following setting philosophy is proposed for df/dt .

Guiding principles for implementation of df/dt relays:

a) Enabling frequency for df/dt :

- The df/dt relays have 2 set of settings to be set, 1st is the enabling frequency, and the 2nd is the rate of fall of frequency. Once the enabling frequency is reached the relay is ready to operate and operates once the 2nd set i.e., rate of fall is detected.
- Assuming that a contingency may happen at any frequency. Therefore, enabling frequency of df/dt can be set below 50 Hz but should not be below 49.9 Hz as stipulated in IEGC. Enabling frequency should be set at 49.9 Hz. i.e., the relay should always be enabled when the system frequency is below 49.9Hz.
- Now a days with numerical protections relays commercially available are having a minimum settable rate of fall of frequency of 0.01Hz/sec. Further the validation cycle of the rate sensing available is from 1 cycle minimum with sliding window validation.
- For a large integrated system having high inertia, the rates of 0.05Hz/sec with a validation of 6 cycles is a better choice (relays may mal operate if they are set below 0.05Hz/sec. in a high inertia system and becomes too sensitive, since these relays are sensitive to the electrical proximity of disturbance from the relay location). The sliding window validation of 5-8 cycles will also tend to increase the reliability of these relays, rather than going for validation cycle below 6 cycles.

b) Df/dt relay setting philosophy:

Considering the theoretical aspects and the system inertia, the df/dt relay settings can be decided on the following principles.

Severe contingency of largest station generation loss, major corridor loss RE (wind and solar) generation penetration at that point of time in the region will have an impact on deciding initial and subsequent stages of df/dt .

➤ 1st Stage:

- Quantum: Largest generating station in the region or peak imports by the Region whichever is higher. The quantum shall be 30 % of the higher.
- Rate for RE rich region: Setting of df/dt shall be 0.1 Hz/sec for high RE generation system region when RE installed capacity $> \frac{1}{4}$ of total installed capacity.
- Rate for low RE region: Setting of df/dt shall be 0.05 Hz/sec when RE installed capacity $< \frac{1}{4}$ of total installed capacity.

➤ 2nd Stage:

- Quantum: Largest generating station in the region or peak import by the system whichever is higher. The quantum shall be 40 % of the higher.
- Rate for RE rich region: Setting of df/dt shall be 0.15 Hz/sec
For high RE generation region, when RE installed capacity $> \frac{1}{4}$ of total installed capacity.
- Rate for low RE region: Setting of df/dt shall be 0.1Hz/sec, when RE installed capacity $< \frac{1}{4}$ of total installed capacity

➤ 3rd Stage:

- a. Quantum: Largest generating stations in the region or peak import by the system whichever is higher. The quantum shall be 50 % of the higher.
- b. Rate for RE rich region: Setting of df/dt shall be 0.2 Hz/sec
For high RE generation region, when RE installed capacity $> \frac{1}{4}$ of total installed capacity.
- c. Rate for low RE region: Setting of df/dt shall be 0.25 Hz/sec, when RE installed capacity $< \frac{1}{4}$ of total installed capacity

Suppose if grid splits into several small areas, then df/dt at the point of separation is the highest and therefore provision of additional stages of df/dt based load shedding at the initial stage of credible contingency is required to be introduced in future to countermeasure diminishing inertia due to RE penetration. A system study to evaluate the value of diminishing inertia due to RE penetration is required to be estimated accurately at National level.

As brought out above the df/dt trigger frequencies given above would be experienced in the split grid operations. Therefore, the above df/dt scheme of arrangement can further be discussed at the regional level and RPCs in consultation with stake holders can decide the quantum of Load shedding required to be wired up.

Adaptive load shedding with df/dt is the most viable solution to arrest steep fall in frequency at initial stage of disturbance and a PMU based WAMS supervised system can be considered for implementation of df/dt , in future.

10. Conclusion

- 1) **AUFLS setting:** The AUFLS is divided in two groups i.e., Stage-I and Stage -II with %age of quantum of load shedding is given below:

<i>Sr. No.</i>	<i>Stage</i>	<i>Frequency</i>	<i>Demand Disconnection</i>	<i>Total Quantum of LS</i>
Stage-I Defense plan- Load Shedding				
1	I-A	49.2 Hz	3.50%	
2	I-B	49.0 Hz	3.50%	
3	I-C	48.8 Hz	4.00%	
4	I-D	48.7 Hz	4.50%	
5	I-E	48.6 Hz	4.50%	20%
Stage-II Desperate plan- Load Shedding				
6	II-F	48.4 Hz	6.00%	
7	II-G	48.2 Hz	6.00%	
8	II-H	48.0 Hz	6.00%	18%
Grand Total (Stage-I + II)				36%

Table 10.1

- 2) **df/dt setting:** The Stage-II feeders of AUFLS can be wired up for the df/dt relays also.

df/dt setting for high penetration RE region and low penetration RE region philosophy recommended is as follows.

Following terminology is used while deriving the quantum of load shedding.

RE rich: RE installed capacity >1/4 of Total installed capacity

RE low: RE installed capacity <1/4 of Total installed capacity

<i>Sr. No</i>	<i>Stage</i>	<i>'X' in MW = Largest generating station or peak import in the region whichever is higher</i>			
		<i>Enabling Frequency 'Hz'</i>	<i>df/dt setting 'Hz/sec'</i>		<i>Quantum of Load Shedding 'MW'</i>
			<i>RE rich</i>	<i>RE low</i>	
1	Stage 1	49.9	0.1	0.05	30% of 'X'
2	Stage 2	49.9	0.15	0.1	40% of 'X'
3	Stage 3	49.9	0.2	0.25	50% of 'X'

- | |
|---|
| <p><i>a) The validation shall be 6 cycles for 0.05 Hz/sec setting and 5-7 cycles for setting of 0.1Hz/sec and above on a sliding window basis.</i></p> <p><i>b) The quantum is for a region as whole, and the RPCs shall decide how to further distribute the quantum amongst the States.</i></p> |
|---|

Table 10.2

- 3) The quantum of load shedding required in above AUFLS Stages (Stage I & II) shall be decided on the basis of Regional Peak Loading conditions during the last year. The quantum shall be reviewed/revised by NPC accordingly and informed to RPCs by 1st of November. If the peak demand is lower than the last year peak demand, the settings will remain unchanged.
- 4) AUFLS should be distributed within the region by the RPCs by 1st December, in consultation with the stakeholders after receipt of the allocated load shedding quantum from NPC.
- 5) AUFLS relays under Stage-I should be implemented preferably on downstream network at 11/22/33 kV level.
- 6) AUFLS relays under Stage-II should be implemented on upstream network at EHV (66/110/132 kV) level so that load relief obtained is fast and reliable as it is a desperate measure for areas that have disintegrated.
- 7) As far as possible, the df/dt relays shall be installed on feeders electrically in proximity to Largest Generating Stations in the States or State Loads being fed through Import of power from ISTS network.
- 8) Feeders to be wired under AUFLS Stage-I, Stage-II and df/dt shall be connected to serving loads and shall not be under Planned/distress load shedding, SPS, ADMS, feeders etc. The AUFLS shall not include the preparatory LS for Islanding Schemes if any.
- 9) The feeders selected for AUFLS and df/dt shall not have RE generation or any other distributed generator connected to these feeders. In such cases instead of tripping the feeder, the relays can be installed to shed loads on the feeders. However, if this is not possible the low RE generation or distributed generation feeders shall be selected by proper ranking.
- 10) The df/dt load shedding is specific to regions and therefore, the quantum of load shedding required to be wired up under the df/dt scheme be discussed at regional levels in the RPCs. The RPCs in consultation with the stakeholders can decide on the quantum of Load shedding required to be wired up in Stage-1, 2 & 3 of the df/dt schemes. The trigger criteria can also be reviewed by the RPCs, based on the

observed df/dt rates in the regions, if it feels so. The quantum indicated in above df/dt Table 10.2 is for reference only.

Testing of AUFLS and df/dt :

- 1) Wherever relays are installed at 110 / 132 kV level and above S/s: The periodicity of testing shall be **Twice in a year**.
- 2) Wherever relays are installed at 66 kV level and below S/s: The periodicity of testing shall be **Once in a year**.
- 3) SLDCs shall in consultation with the Utilities responsible for testing should chalk out a plan of relays testing schedule before 1st of December and submit the same to RPC/RLDC.
- 4) Test shall be carried out by the State testing teams and report of the test carried out should be submitted to SLDC. SLDC shall submit a compiled progressive report of the same to RPC/RLDC every month. The format for testing of AUFLS is enclosed at Annexure-IV
- 5) SLDC should monitor the periodicity of test and ensure that the relays are tested as per the schedule. Deviation if any shall be intimated to RPC/RLDC with proper justification.
- 6) If possible, relays through test up to breakers may be carried out. If this is not possible the continuity of trip circuit of UFR up to the trip coil of breaker should be checked during the testing.
- 7) SLDC's shall ensure that at least 10% of the total relay testing be witnessed/carried out by other Circle Testing Engineer/RLDC/RPC.



भारत सरकार/Government of India

विद्युत मंत्रालय/Ministry of Power

केन्द्रीय विद्युत प्राधिकरण/Central Electricity Authority

एन.पी.सी. प्रभाग/National Power Committee Division

1st Floor, Wing-5, West Block-II, RK Puram, New Delhi-66, e-mail:cenpc-cea@gov.in

No. 4/MTGS/NPC/CEA/2020/

Date: 19th January 2021

To,
(As per distribution list)

Subject: Constitution of "Sub-Committee to study AUFLS Scheme and to work out on a uniform approach for df/dt settings"- reg.

In the 9th meeting of NPC, it was decided that a Sub-Committee may be formed under the Chairmanship of Member Secretary, WRPC, with representatives from POSOCO and all the RPCs to study the AUFLS Scheme. NPC Secretariat vide letter No. 4/MTGS/NPC/CEA/2020/01-06 dated 01.01.2021 had asked for nominations from all the RPCs. Based on the receipt of nominations from all the RPCs, the composition of the **Sub-Committee** has been formed as follow:

Designation & Organisation	Name	Constitution of the Committee
Member Secretary, WRPC	Sh. Satyanarayan S.	Chairman
Member Secretary, NPC	Smt. Rishika Sharan	Member
Superintending Engineer (P), WRPC	Sh. J. K Rathod	Member Convener
Superintending Engineer, NERPC	Sh. B. Lyngkhoi	Member
Executive Engineer, SRPC	Ms. N S Malini	Member
Executive Engineer, ERPC	Sh. Pranaya Piyusha Jena	Member
Executive Engineer, NRPC	Sh. Ratnesh Kumar,	Member
General Manager, NLDC	Sh. Rajiv Porwal,	Member

Term of Reference (TOR) of the Sub-Committee:

1. To examine the AUFLS scheme for all Indian Grid currently deployed and suggest any revision for the same.
2. To examine the df/dt setting in different Regions for all India grid and suggest a suitable approach for effective working of the same.

The Sub- Committee may Co-opt/ associate any other expert in the field as they feel necessary.
The Sub-Committee may submit the report in 3 months time.

Yours faithfully,

(ऋषिका शरण/Rishika Sharan)

मुख्य अभियन्ता एवं सदस्य सचिव, रा.वि.स /
Chief Engineer & Member Secretary, NPC

Distribution list:

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2. Member secretary, NRPC
3. Member secretary, ERPC
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FRC and Power number Calculations																
S.No.	Date	Description	Prior Frequency(A)	Time (A)	Stabilised Frequency Point (B)	Time (B)	A-B (HZ)	Nadir Frequency Point (c)	Time (C)	A-C (HZ)	Load Generation Loss (MW)	FRC	Power Number(MW/HZ)	Time(B-A)	Time(C-A)	Time (B-C)
1	10-Jan-18	Due to Loss of Evacuation path 1050 MW Generation loss occurred at Teesta-III, Dikchu,Tashding.	50.02	17:34:03.000	49.96	17:34:42.760	0.06	49.92	17:34:15.720	0.11	1050	16935	10000	00:00:39.760	00:00:12.720	00:00:27.040
2	30-Jan-18	Due to Fault at Korderma S/s , Generation loss of 1250 Mw & Load Loss of 350 Mw occurred at Koderma & Bokaro S/S.	49.90	10:46:11.120	49.84	10:46:54.640	0.06	49.81	10:46:29.840	0.09	1250	19231	13298	00:00:43.520	00:00:18.720	00:00:24.800
3	07-Mar-18	HVDC Talchar Kolar Pole-1 Tripped due to external trip command at Talchar end , consequently SR Demand of Reduced by 1043MW.	49.97	09:38:24.600	50.05	09:39:02.640	-0.08	50.08	09:38:38.680	0.11	-1043	13545	9657	00:00:38.040	00:00:14.080	00:00:23.960
4	23-Apr-18	Multiple tripping from Kotra PG due to DC earth fault reported in 765kV Kotra S/S, consequently Generation loss of 3090MW occurred.	50.02	10:42:10.640	49.73	10:42:49.720	0.29	49.71	10:42:29.120	0.30	3090	10767	10198	00:00:39.080	00:00:18.480	00:00:20.600
5	06-May-18	There was generation loss of 1100 MW on account of tripping of Lalitpur Unit-I, II& III due to loss of evacuation path.	49.89	16:50:04.000	49.84	16:50:35.080	0.05	49.81	16:50:17.520	0.08	1100	22449	13415	00:00:31.080	00:00:13.520	00:00:17.560
6	10-May-18	There was generation loss of 900 MW on account of tripping of DSTPS unit I & II due to loss of evacuation path	49.93	06:11:36.000	49.88	06:12:10.280	0.05	49.84	06:11:46.120	0.09	900	16756	10500	00:00:34.280	00:00:10.120	00:00:24.160
7	10-Jul-18	400 KV Rangpo – Binaguri I tripped on R-B phase fault and SPS –I & SPS -II operated, due to loss of evacuation path Total generation loss of 1025 MW took place at Teesta generation complex.	50.03	08:14:34.400	49.97	08:14:57.560	0.06	49.95	08:14:45.360	0.09	1025	16532	11648	00:00:23.160	00:00:10.960	00:00:12.200
8	30-Jul-18	400 KV Binaguri-Rangpo-2 tripped due to Y-B phase fault and SPS –I & SPS -II operated, due to loss of evacuation path Total generation loss of 1024 MW took place at Teesta generation complex.	49.92	20:48:33.880	49.85	20:49:12.600	0.07	49.82	20:48:48.600	0.11	1024	14423	9660	00:00:38.720	00:00:14.720	00:00:24.000
9	06-Aug-18	400kV Chakan & 400kV Lonikhand S/S tripped due to operation of busbar protection,Load loss of around 1000 MW	50.08	13:06:27.280	50.14	13:07:05.000	-0.05	50.21	13:06:39.200	0.13	-1000	18618	7752	00:00:37.720	00:00:11.920	00:00:25.800
10	07-Aug-18	On 07th August 2018 at 14:17Hrs KSK unit #2 & unit #4 tripped on operation of reverse power relay as reported by WRDLC. Total Generation loss is around 890 MW .	49.88	14:17:05.680	49.85	14:17:33.000	0.04	49.79	14:17:15.320	0.09	890	25429	9468	00:00:27.320	00:00:09.640	00:00:17.680
11	12-Aug-18	400 KV Rangpo – Binaguri II tripped on B-N phase fault and SPS –I & SPS -II operated, due to loss of evacuation path Total generation loss of 852 MW took place at Teesta generation complex.	50.04	05:30:58.120	50.01	05:31:32.640	0.02	49.96	05:31:10.200	0.08	852	34080	10265	00:00:34.520	00:00:12.080	00:00:22.440
12	29-Aug-18	400kV Rampur-Nalagarh Ckt-1 Auto Reclosed Successfully and 400kV Rampur-Nalagarh Ckt-2 tripped on B-N fault, consequently SPS operated at NJPC and Rampur Hydro stations and resulted in Generation Loss of around 1200 MW .	50.02	04:02:15.000	49.96	04:02:58.000	0.06	49.92	04:02:26.000	0.10	1200	21429	11650	00:00:43.000	00:00:11.000	00:00:32.000

S.No.	Date	Description	Prior Frequency(A)	Time (A)	Stabilised Frequency Point (B)	Time (B)	A-B (HZ)	Nadir Frequency Point (c)	Time (C)	A-C (HZ)	Load Generation Loss (MW)	FRC	Power Number(MW/HZ)	Time(B-A)	Time(C-A)	Time (B-C)
13	30-Oct-18	Unit # 30,40 and 50 (830 MW each) of CGPL Mundra UMPP tripped due to generator Class-A2 Protection operation. Total generation loss as per SCADA data was 2240 MW.	49.94	19:22:30.720	49.79	19:23:28.600	0.15	49.73	19:22:43.480	0.21	2240	14737	10516	00:00:57.880	00:00:12.760	00:00:45.120
14	16-Jan-19	There was a dropper flashover at 220kV GIS Bhadla substation. There was also tripping of 400kV Jodhpur-Bhadla,400kV Merta-Bhadla,400kV Bhadla-Bikaner 1&2. Solar Generation loss around 1400MW as reported by NRLDC.	49.97	12:26:04.680	49.92	12:26:53.000	0.047	49.86	12:26:13.360	0.11	1400	29787	12963	00:00:48.320	00:00:08.680	00:00:39.640
15	23-Jan-19	On 23rd Januray 2019, at 06:37 Hrs 400KV Jhakri-Panchakula 1, 400KV Jhakri-Rampur 1 tripped due to bus bar protection operated at NJPC during charging of 400KV Jhakri-Karcham 1. Consequently, 961 MW generation loss occurred at both Jhakri and Rampur.	49.96	06:37:26.400	49.92	06:38:00.520	0.04	49.876	06:37:36.040	0.08	961	24641	11440	00:00:34.120	00:00:09.640	00:00:24.480
16	05-Feb-19	On 05th Feb 2019, at 11:57 Hrs load loss of approx. 869 MW occurred in Northern Region as per SCADA data(Delhi-226 MW, Haryana 152 MW, Rajasthan 400 MW, UP 91 MW) . Only Delhi SLDC has reported that load loss occurred due to outage of 220 kV Sarita Vihar-Badarpur D/C and 220 kV Sarita Vihar-Maharanibagh. Report is still pending from other SLDC's.After 8 seconds of incident, all Northern region PMU's data was not available and data came back after almost 3 minutes.	50.119	11:57:28.000	50.146	11:58:27.480	-0.03	50.20	11:57:38.000	0.083	-869	32185	10432	00:00:59.480	00:00:10.000	00:00:49.480
17	12-Mar-19	On 12-March-2019 at 13:03 Hrs, HVDC talcher-Kolar pole 2 tripped due to DC earth fault . Prior to incident, power flow on bipole was 2000 MW and after tripping of pole-II, power flow on pole-I jumped to 1250 MW. Then after 1.5 minutes flow on pole-I came down to 150 MW. The SPS associated with HVDC Talcher-kolar pole tripping operated at 13:03 Hrs and led to load relief of approx 1219 MW(as per SCADA data) in southern region. The SPS operation in ER region at 13:04:30, led to generation relief of aprox 734 MW (Talcher stg 2 - 641 MW, GMR-147 MW & JITPL-100 MW). The FRC has been calculated for the incident at 13:03 Hrs as frequency change is more than 0.10 Hz.	50.159	13:02:37.240	50.21	13:03:08.800	-0.05	50.2746	13:02:46.000	0.116	-1219	22574	10545	00:00:31.560	00:00:08.760	00:00:22.800
18	12-Mar-19	On 12-March-2019 at 17:03 Hrs, two running units at Singareni generating 1170 MW tripped due to Bus-Bar protection operation at 400kV Ramadugu substation.	50.049	17:02:57.640	49.98	17:03:36.720	0.07	49.9580	17:03:12.080	0.091	1170	16957	12857	00:00:39.080	00:00:14.440	00:00:24.640
19	11-Apr-19	On 11 April 2019, at 13:00 hrs HVDC Talcher-Kolar pole-I got blocked due to emergency switch off signal from Kolar end. Prior to incident flow on bipole was 2000 MW and in post incident flow on Pole-2 was 1000 MW. The net change in flow on bipole satisfied the SPS criteria and due to SPS operation, load loss of 1123 MW took place in southm region and generation loss of 225 MW in eastern region as per SCADA data.The generation relief in aforesaid units was on account of ramp down which took place in span of minutes, so delta P considered in FRC calculation is of load relief quantum in southern region.	50.068	13:00:57.720	50.12	13:01:35.440	-0.05	50.1610	13:01:10.080	-0.093	1123	22238	12101	00:00:37.720	00:00:12.360	00:00:25.360

S.No.	Date	Description	Prior Frequency(A)	Time (A)	Stabilised Frequency Point (B)	Time (B)	A-B (HZ)	Nadir Frequency Point (c)	Time (C)	A-C (HZ)	Load Generation Loss (MW)	FRC	Power Number(MW/HZ)	Time(B-A)	Time(C-A)	Time (B-C)
20	12-Apr-19	At 23:55 hrs, 12/04/19 400 KV Teesta III-Kishanganj tripped on R-Y-N Fault. As a result around 1865 MW generation of the entire complex started to flow through 400 KV Rangpo-Kishanganj S/C which tripped on overload (Back –up overcurrent with each phase current of 4000 amps) and resulted in loss of generation of around 1865 MW.	50.029	23:55:11.720	49.93	23:55:48.520	0.10	49.8590	23:55:23.360	0.170	1865	18502	10990	00:00:36.800	00:00:11.640	00:00:25.160
21	16-Apr-19	400 KV Rangpoh – Kishanganj line tripped at 23:37 Hrs and five out of six units at Teesta – 3 tripped following SPS operation. Generation Loss of around 1000 MW reported by ERLDC.	50.023	23:37:27.960	49.98	23:38:04.200	0.04	49.9400	23:37:38.640	0.083	1000	25000	12048	00:00:36.240	00:00:10.680	00:00:25.560
22	16-May-19	On 16th May 2019, at 19:10 hrs smelter load of Vedanta plant that is coming through Sterlite sub-station became nil as reported. The reason of the incident is still not being intimated by SLDC. Also in the incident, SCADA data of Sterlite station was suspected. The net change in power is calculated from remote end data of 400 kV lines connected to Sterlite station and that change is 1337 MW.	49.976	19:10:26.160	50.04	19:10:59.680	-0.06	50.1000	19:10:37.680	-0.124	1337	22283	10782	00:00:33.520	00:00:11.520	00:00:22.000
23	19-May-19	On dated 19-May-2019 at 10:35 hrs ,all units in operation i.e. unit 1- 4 & 6 of 210 MW each (Unit -5 was already under planned shutdown for annual Maintenance) and Unit 7-10 of 500MW each at Vindhyachal STPS Stage-1, Stage-2 and Stage-3 tripped along with all 400kV Buses and emanating lines connected to VSTPS Stage-1, Stage-2 and Stage-3. As reported by NTPC, incident started due to R-phase bushing failure of generator transformer of Unit-7 and subsequent tripping of other units on impedance protection and turbine over speed. Around 2975 MW of generation loss occurred as per NLDC SCADA Data.	50.012	10:35:32.440	49.80	10:36:02.400	0.21	49.7400	10:35:45.360	0.272	2975	14234	10978	00:00:29.960	00:00:12.920	00:00:17.040

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24	05-Jul-19	On 05th June 2019, at 03:56:20 hrs C phase jumper of 220 KV Akal-Bhu Line-I snapped and fallen on 220 KV Bus-I at Akal station as reported by Rajasthan SLDC. It led to the tripping of 220 KV Akal-Bhu Line-I & II, 220 KV Akal- Dangri-I and 400/220 KV ICT-I & II at Akal station. The fault clearing time as per PMU was 680 ms and Wind generation loss in Akal station as per SCADA data is 1500 MW. After 2 minutes of incident, 400 KV Akal-Kankani-I & Akal - Ramgarh-II tripped on over voltage as reported and Wind generation loss at Akal station at this second incident was 300 MW as per SCADA data. The FRC has been calculated for the first incident when generation loss was 1500 MW.	49.896	03:56:18.360	49.82	03:56:48.400	0.08	49.7650	03:56:28.040	0.131	1500	18987	11450	00:00:30.040	00:00:09.680	00:00:20.360
25	21-Aug-19	At 00:02 hrs on 21-Aug-2019, 400 KV Dikchu -Rangpo tripped from Rangpo end only, consequently 400 KV Teesta III- Dikchu also tripped resulting in total black out at 400 KV Dikchu and 400 KV Teesta III, generation loss of 1364 MW of Teesta III-1260MW and Dikchu-104 MW.	49.923	00:02:43.120	49.83	00:03:09.880	0.09	49.8050	00:02:54.560	0.118	1364	14667	11559	00:00:26.760	00:00:11.440	00:00:15.320
26	01-Nov-19	at 11:16hrs R-phase jumper of 220kv Giral line at Akal station snapped & dropped at 220kv structure leading to tripping of all 220 kV lines emanating from Akal S/S. Due to this tripping, approx.1644 MW generation loss was observed as per SCADA data. This value is calculated by summing the net delta P on all the lines emanating from Akal-Ramgarh generation complex. In this complex only Akal station have reported a Wind outage of 1200MW. Mada Suz and Ramgarh SCADA data was suspected in the entire incident. 400KV Akal-Ramgarh ckt-2 has also got tripped in the incident. The outage of elements have not been captured in the SOE available at NLDC. The fault clearing time as per Jodhpur PMU was almost 1 second.	50.034	11:16:46.720	49.91	11:17:33.160	0.12	49.8430	11:16:58.160	0.191	1644	13700	8886	00:00:46.440	00:00:11.440	00:00:35.000
27	18-Jan-20	On 20th january 2020, at 12:36hrs all the elements at Chandrapur station tripped due to operation of Bus bar protection as reported. In the event, the four running units of chandrapur station also have tripped. The total generation loss as per SCADA is 1085 MW.	49.969	12:36:46.280	49.94	12:37:15.000	0.03	49.8810	12:36:54.920	0.088	1085	32485	12386	00:00:28.720	00:00:08.640	00:00:20.080

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28	17-Feb-20	HVDC Talcher - Kolar pole-II got tripped due to persistent DC line fault. At this time TS1 and TS2 signal generated at Kolar end and load relief of 1415 MW obtained in southern region as per SCADA data. It led to the frequency rise to 50.099 Hz from 49.930 Hz. Due to primary response, the frequency gone down to 50.025 Hz. Then at 17:39:58.400 hrs, Pole-I went into ground return mode and at Talcher end, signal 3 is generated. On this signal, instantaneous backdown of 666 MW occurred in Talcher stg II. Consequently the frequency dipped to 49.96 Hz from 50.07 Hz and finally settled to a higher value of 50.04 Hz. The FRC has been calculated for the load relief of 1415 MW obtained in southern region.	49.930	17:38:32.880	50.03	17:39:31.840	-0.09	50.10	17:38:46.320	-0.169	-1415	19700	8373	00:00:58.960	00:00:13.440	00:00:45.520
29	22-Feb-20	Unit-II and Unit III at Bara station tripped. The reason of unit outage was differential protection as reported. As per Kanpur 3 phase voltage PMU, there was only single voltage dip and maximum dip is in Y-Phase. The total generation loss in the event was 1134 MW. In the event, Unit-I at Bara station remained connected and no generation was affected in it.	49.968	18:23:18.600	49.91	18:24:06.160	0.06	49.87	18:23:29.840	0.099	1134	18000	11455	00:00:47.560	00:00:11.240	00:00:36.320
30	01-Mar-20	400 kV Bus Bar protection operated at 400KV Naptha Jhakri Sub-Station.400kV buses 1,2,3&4 tripped along with 6 nos. 400kV lines at Naptha Jhakri Substation. Total Generation loss was around 1340 MW at NJPC (810MW), Rampur (230MW) & Karcham (300MW).	50.012	06:09:25.680	49.97	06:10:03.000	0.04	49.89	06:09:37.320	0.124	1340	31163	10806	00:00:37.320	00:00:11.640	00:00:25.680
31	19-Mar-20	At the time of fault in 400 kV Tamarnar - JPL stg-II ckt II, unit 3 and 4 at JPL stage -II station(capacity 4x600 MW) got tripped (other units were off bar) due to operation of class A & B protection as reported. As per Tamarnar PMU, the fault seems to be in B phase and the fault clearing time was 280 ms.The generation loss in the event was 1139 MW as per SCADA data. The CB opening status of the JPL stg II station is not captured in SOE available at NLDC. Also SCADA data of JPL-stg-II became suspected in post incident.	50.051	14:36:52.440	49.98	14:37:22.080	0.08	49.94	14:37:03.880	0.110	1139	15126	10326	00:00:29.640	00:00:11.440	00:00:18.200
32	28-May-20	On 28th May 2020, at 17:27 Hrs Complete outage in 765 kV level at Vindhyachal PS, Sasan and black out at 400 kV Vindhyachal IV, 400 kV Vindhyachal V and 400 kV Rihand stg III generating stations occurred due to inclement weather reported in western region. Consequently generation loss of 5346 MW observed (Sasan-3103 MW, VSTPS-V- 459 MW, VSTPS-IV-744 MW, VSTPS NTPC 100 MW and Rihand Stg-3-940 MW). SLDC MP reported load loss of around 950 MW in Madhya Pradesh due to tripping of 220/132kV lines during the inclement weather, at 17:27 hrs as per NLDC SCADA data 150 MW load loss is observed and the same figure has been considered in the FRC calculation	50.021	17:26:50.760	49.65	17:27:28.360	0.37	49.55	17:27:04.360	0.472	5196	13968	11008	00:00:37.600	00:00:13.600	00:00:24.000
33	11-Jun-20	On 11th June 2020, at 11:59 Hrs R-phase jumper connecting CT to wavetrap broken at Saurya urja (Rajasthan end). Fault was in 220kV Bhadla(Raj) – 220kV Saurya Urja ckt-2,220 KV Bhadla(PG)-Saurya Urja(SU) (UNDEF) Ckt-1 & 2 also got tripped. As per PMU,Y-N fault is observed in the system.Generation loss of around 1126MW & 1000MW (as per NLDC SCADA data) observed in solar connected to Bhadla(PG) & Bhadla(Raj) respectively and the same figure has been considered in the FRC calculation	50.060	11:59:28.840	49.93	12:00:21.800	0.13	49.80	11:59:45.880	0.260	2126	16354	8133	00:00:52.960	00:00:17.040	00:00:35.920
34	14-Jul-20	On 14th July 2020, at 14:11 Hrs Units 1,2,3 and 4 tripped at Koyna Hydro power plant due to DC supply fail resulting Generation loss of around 975MW (as per NLDC SCADA data)	50.000	14:10:51.560	49.96	14:11:30.680	0.04	49.90	14:11:09.920	0.100	975	23214	9750	00:00:39.120	00:00:18.360	00:00:20.760

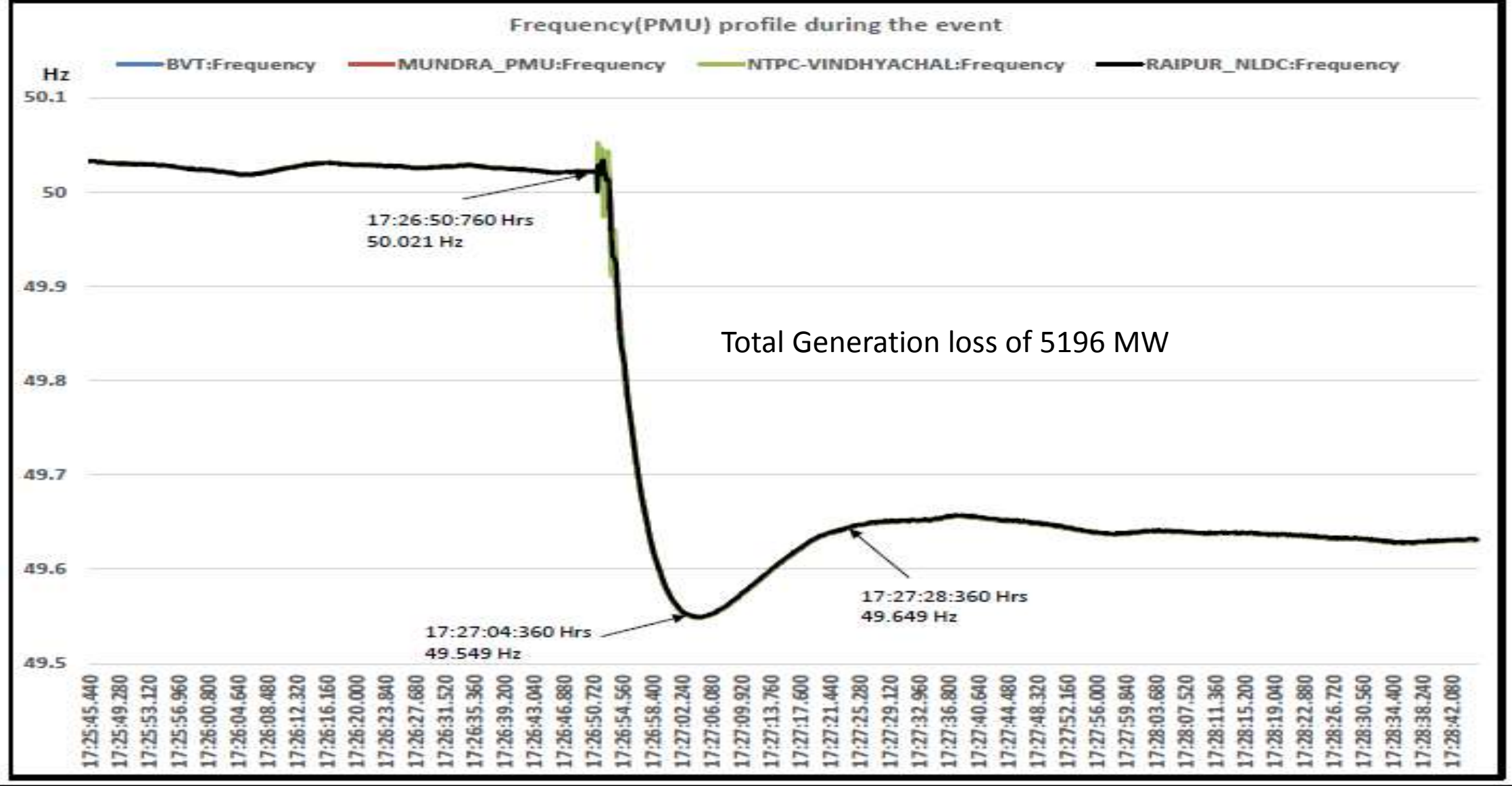
S.No.	Date	Description	Prior Frequency(A)	Time (A)	Stabilised Frequency Point (B)	Time (B)	A-B (HZ)	Nadir Frequency Point (c)	Time (C)	A-C (HZ)	Load Generation Loss (MW)	FRC	Power Number(MW/HZ)	Time(B-A)	Time(C-A)	Time (B-C)
35	20-Jul-20	On 20th July 2020,As reported 220kV Amarsagar-Dechu, 220kV Amarsagar-Mada and 220kV Amarsagar-Akal tripped at 20:50 Hrs due to snapping of Main bus jumper at 220kV Amarsagar.Wind generation loss of around 1213 MW occurred (as observed from NLDC SCADA data).	50.100	20:50:21.800	50.02	20:51:03.160	0.08	49.97	20:50:34.040	0.130	1213	15163	9331	00:00:41.360	00:00:12.240	00:00:29.120
36	22-Jul-20	On 22nd of July 2020 at 12:49 hrs, As reported 400/220 KV 500MVA ICT-1 & ICT-3 at Bhadla Rajasthan tripped due on overcurrent. 400/220 KV 500MVA ICT-2 was already under outage due to PRD operation. During the event Solar generation loss at Bhadla Rajasthan 1402 MW (as observed from NLDC SCADA data).	50.030	12:49:18.800	49.95	12:50:01.640	0.08	49.86	12:49:34.160	0.170	1402	17525	8247	00:00:42.840	00:00:15.360	00:00:27.480
37	16-Jul-20	On 16th July 2020, 400 KV Teesta III-Kishanganj was under emergency outage availed at 15:49 Hrs, to replace gas density monitor. At 16:27 Hrs 400 KV Rangpo-Kishanganj tripped on directional earth fault in B phase at Rangpo end and DT receipt at Kishanganj. At the same time, 400kV Rangpo-Dikchu and 400 kV Dikchu-Teesta III also tripped. As per NLDC SCADA data generation loss during the event comes out to be 1394 MW (1285 MW and 109 MW at Teesta III and Dikchu respectively).	49.990	16:27:21.480	49.91	16:27:57.560	0.08	49.86	16:27:37.370	0.130	1394	16400	10029	00:00:36.080	00:00:15.890	00:00:20.190
38	06-Aug-20	On 06th August 2020,As reported at 13:50 Hrs 400 KV Akal-Jodhpur (RS) Ckt-1 tripped due to DT received at Jodhpur end. At the same time, 400/220 kV 315 MVA ICT 1 & 315 MVA ICT 2 at Barmer(RS) also tripped.Wind generation loss of around 1348 MW occurred (as observed from NLDC SCADA data).	50.070	13:50:17.640	50.03	13:50:46.360	0.04	49.96	13:50:27.680	0.110	1348	33700	12255	00:00:28.720	00:00:10.040	00:00:18.680

S.No.	Date	Description	Prior Frequency(A)	Time (A)	Stabilised Frequency Point (B)	Time (B)	A-B (HZ)	Nadir Frequency Point (c)	Time (C)	A-C (HZ)	Load Generation Loss (MW)	FRC	Power Number(MW/HZ)	Time(B-A)	Time(C-A)	Time (B-C)
39	13-Aug-20	On 13th of August 2020 at 07:03 hrs, As reported, 400kV Jhakri-Panchakula ckt- 1 and 2 tripped due to sparking of Y-ph isolator for ckt1 at Panchakula end and the second ckt tripped at Jhakri end. In this connection, SPS operated at Jhakri, Karcham and Rampur. Consequently, 02 Nos Units of Karcham (Unit-2 &4), 02 Nos units of Jhakri (Unit-3 & 5) and 02 Nos Units of Rampur (Unit – 3 & 4) tripped.As per NLDC SCADA data generation loss 1200 MW occurred during the event. 1210 MW generation loss has been considered in the calculation as per the reported region	49.93	07:03:05.480	49.88	07:03:43.120	0.05	49.82	07:03:17.560	0.11	1210	24200	11000	00:00:37.640	00:00:12.080	00:00:25.560
40	12-Oct-20	On 12th of October 2020, As reported, At 09:58hrs, 400kV Kalwa-Padghe line-2 tripped on R-ph fault. At 10:05hrs, 400kV Pune-Kharghar line emergency hand tripped (due to heavy sparking on isolator) and 400 KV Kalwa – Kharghar line also hand tripped due to CT jumper hot spot leading to Mumbai system blackout . Trombay Unit-5(500MW), Trombay Unit-7(A) & 7(B), Uran-5(108MW) and Uran-6(108MW) Uran(A0) tripped at 10:05hrs during Mumbai blackout. Adani system got islanded and survived with a total load of 400MW (feeding through Dahanu Unit-1 and Unit2). It is reported that loads at Bhiwandi area feeding from Padghe also tripped. Total load loss was observed to be 2600MW (2200MW of Mumbai, 400MW of Kharghar, Navi Mumbai, Bhiwandi and Thane). Total Generation loss was around 840MW at TATA and 220MW at Uran.FRC has been calculated for load relief of 1540 MW.	50.054	10:05:04.280	50.155	10:05:50.680	-0.101	50.277	10:05:16.520	-0.223	-1540	15248	6906	00:00:46.400	00:00:12.240	00:00:34.160
41	26-Dec-20	As reported On 26th December 2020, At 10:18hrs B-Phase CT of Unit-5 main bay in Wanakbori substation bursted which resulted in tripping of Bus-2 at Wanakbori S/S . Unit-8 at Wanakbori(GIS) station tripped due to operation of Surge Protection Relay at the same time. Generation loss of 1000MW observed(Unit-8:802MW and Unit 5-210MW). In PMU Frequency, It is observed that maximum change in the frequency was around 0.078 Hz and Generation of Unit 5 & 8 was 208 MW & 803 MW respectively .Accordingly FRC has been calculated for total generation loss of 1011 MW at Wanakbori generating station.	50.042	10:18:09.560	50.019	10:18:39.760	0.023	49.962	10:18:19.120	0.08	1011	43957	12797	00:00:30.200	00:00:09.560	00:00:20.640

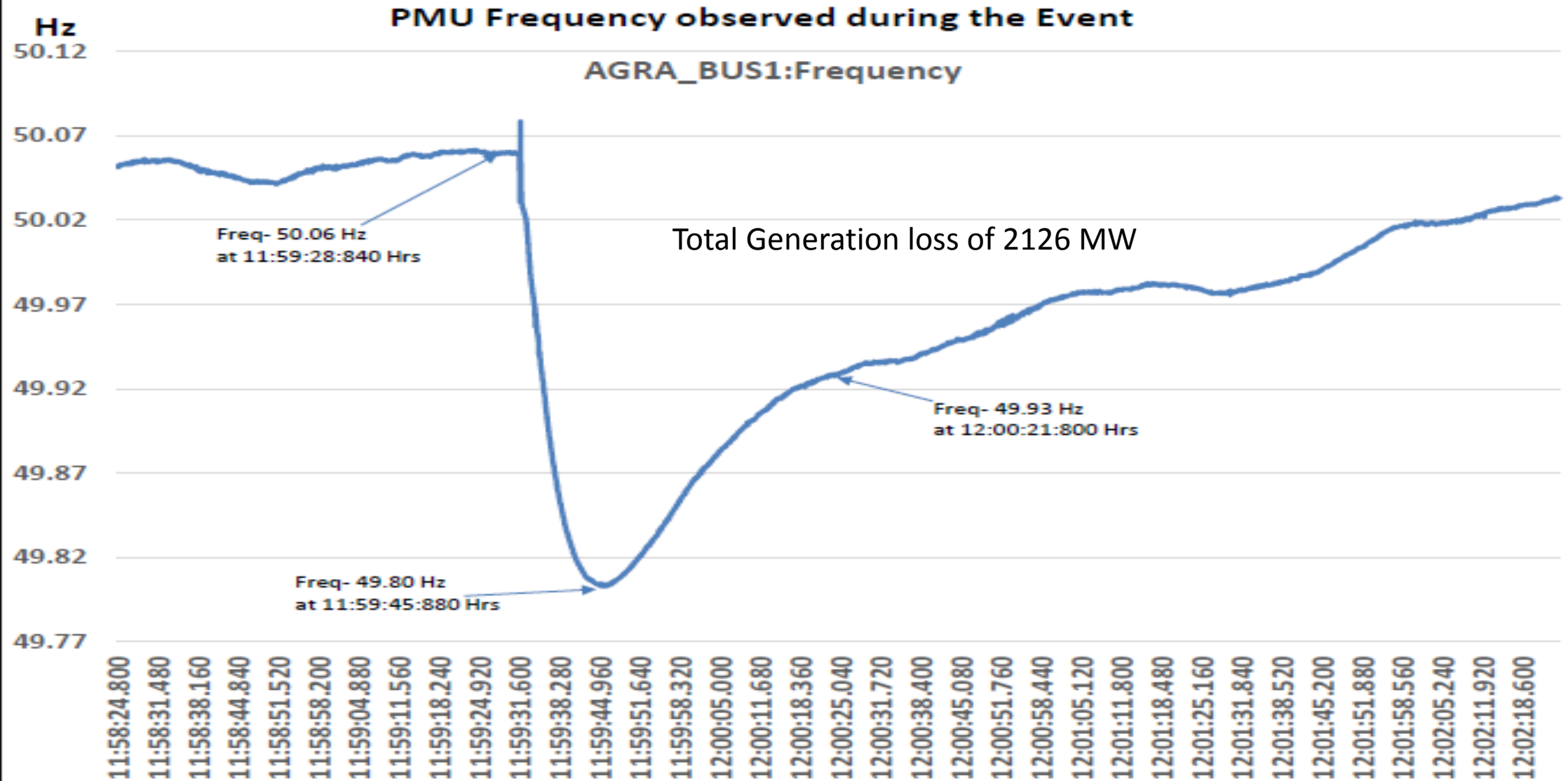
S.No.	Date	Description	Prior Frequency(A)	Time (A)	Stabilised Frequency Point (B)	Time (B)	A-B (HZ)	Nadir Frequency Point (c)	Time (C)	A-C (HZ)	Load Generation Loss (MW)	FRC	Power Number(MW/HZ)	Time(B-A)	Time(C-A)	Time (B-C)
42	19-Feb-21	On 19th Feburaury 2021, at 15:26 hrs multiple trippings occurred at Bhadla(PG) station. It has been reported that while availing planned shutdown of 220kV Bus-II at Bhadla(PG), multiple 220kV solar generation evacuation lines also tripped. As per SCADA data the total generation loss in the event was 1300MW	49.985	15:26:52.160	49.938	15:27:37.320	0.047	49.854	15:27:02.720	0.131	1300	27660	9924	00:00:45.160	00:00:10.560	00:00:34.600
43	10-Mar-21	As reported, on dated 10th-March-2021 at 19:35 400kV Rango-Kishanganj & 400kV Teesta III - Kishanganj tripped due to R-B-N Fault and resulted in Complete outages of Stations at 400kV(Rango, Teesta III, Dikchu) ,220kV (Jorethang,Tashiding,New Melli) and 132kV (Chuzachen,Gangtok) level. Consequently Generation loss of 1561 MW due to loss of evacuation path and Load loss of 54 MW occurred in Sikkim . Accordingly FRC has been calculated for total generation loss of 1507 MW in Teesta Generation Complex.	50.01	19:35:34.200	49.94	19:36:10.000	0.07	49.87	19:35:45.600	0.14	1507	20365	10764	00:00:35.800	00:00:11.400	00:00:24.400
44	24-Mar-21	As reported,On 24th March 2021 at 12:16 hrs, Due to Multiple tripping at 400kV Bikaner (RS) station & 220kV side at Bhadla(PG),Solar generation loss of around 2000 MW and Load loss of around 450 MW observed during the event.As per NLDC SCADA Solar Generation loss of 2036 MW is observed, accordingly 1586 MW figure has been considered for FRC calculation.	50.022	12:16:19.360	49.907	12:17:00.680	0.115	49.856	12:16:32.400	0.166	1586	13791	9554	00:00:41.320	00:00:13.040	00:00:28.280

FRC plots of events
occurred during
April 2020 to March 2021

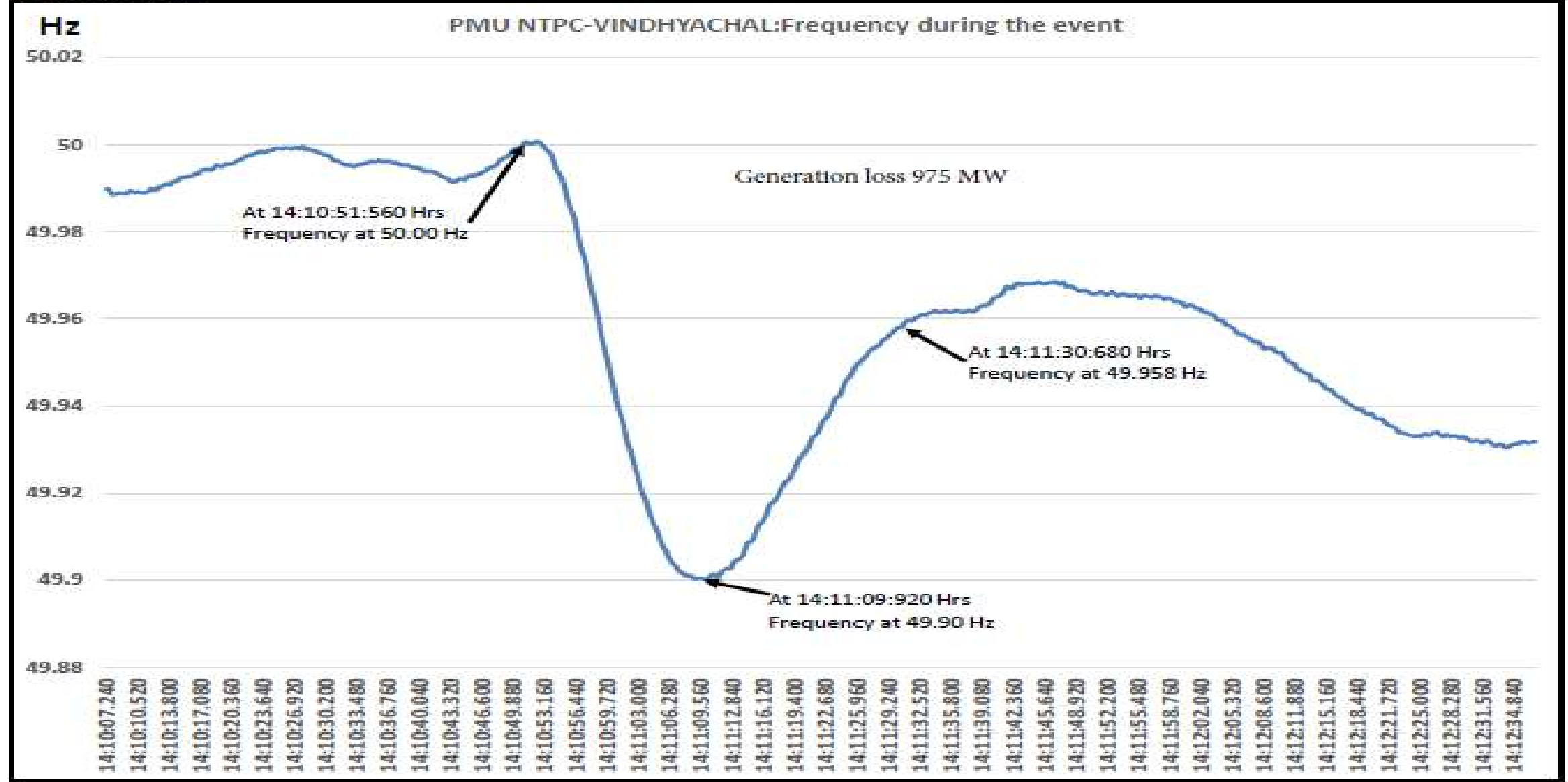
On 28th May 2020, at 17:27 Hrs Complete outage in 765 kV level at Vindhyachal PS, Sasan and black out at 400 kV Vindhyachal IV, 400 kV Vindhyachal V and 400 kV Rihand stg III generating stations.



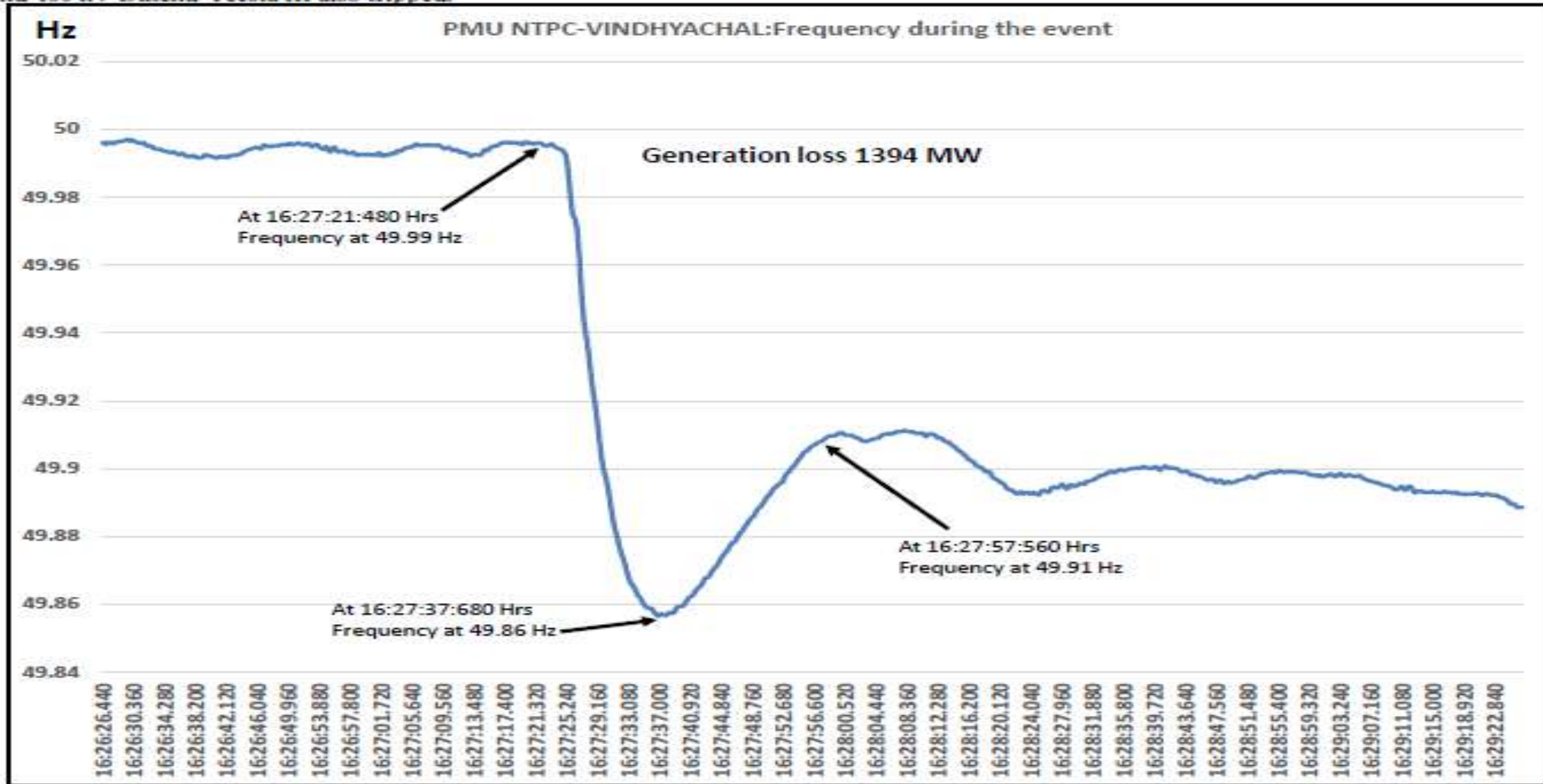
On 11th June 2020, at 11:59 Hrs R-phase jumper connecting CT to wavetrap broken at Saurya urja (Rajasthan end). Fault was in 220kV Bhadla(Raj) – 220kV Saurya Urja ckt-2, 220 KV Bhadla(PG)-Saurya Urja(SU) (UNDEF) Ckt-1 & 2 also got tripped.



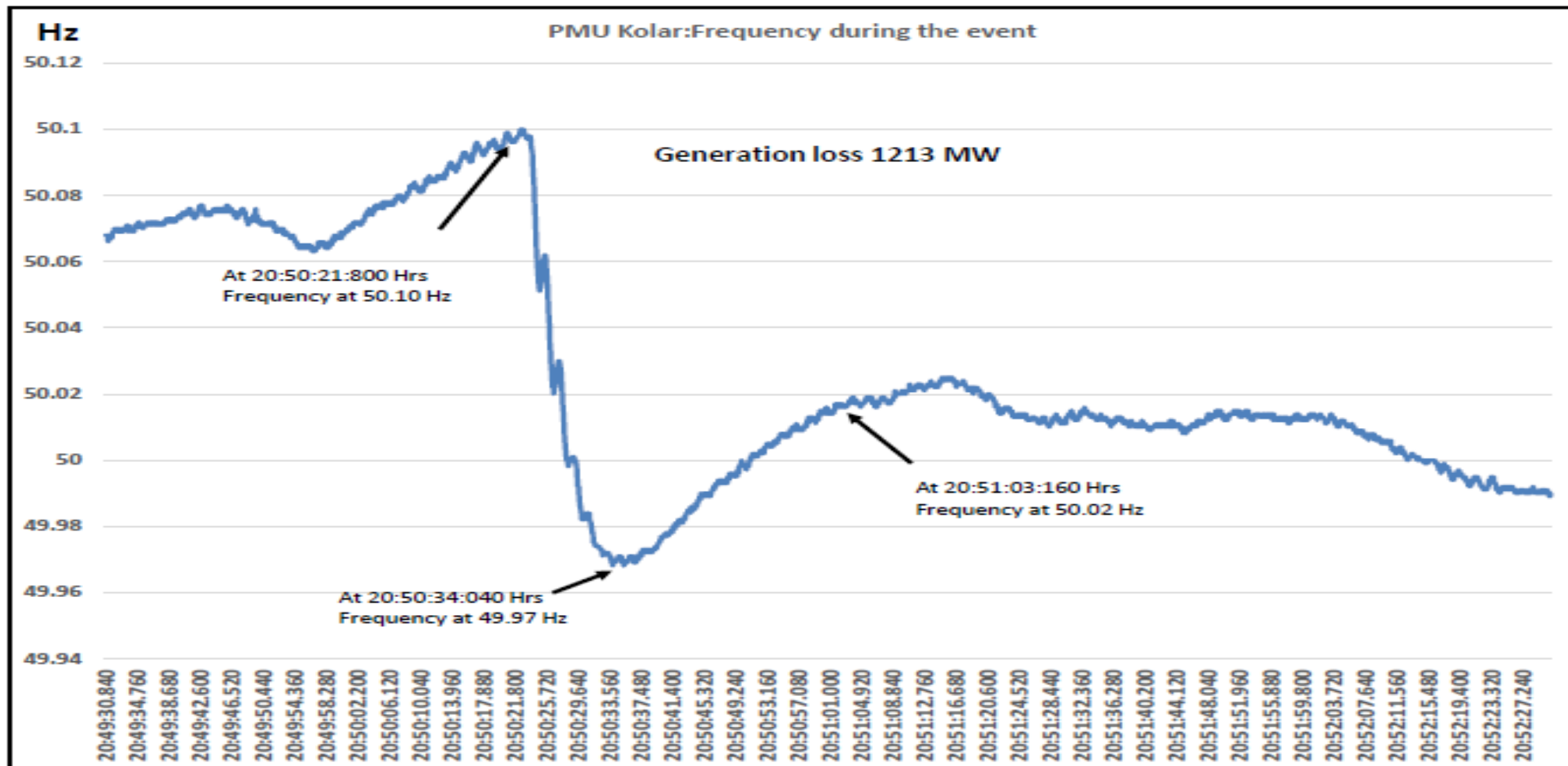
On 14th July 2020, at 14:11 Hrs Units 1,2,3 and 4 tripped at Koyna Hydro power plant due to DC supply fail resulting Generation loss of around 975MW .



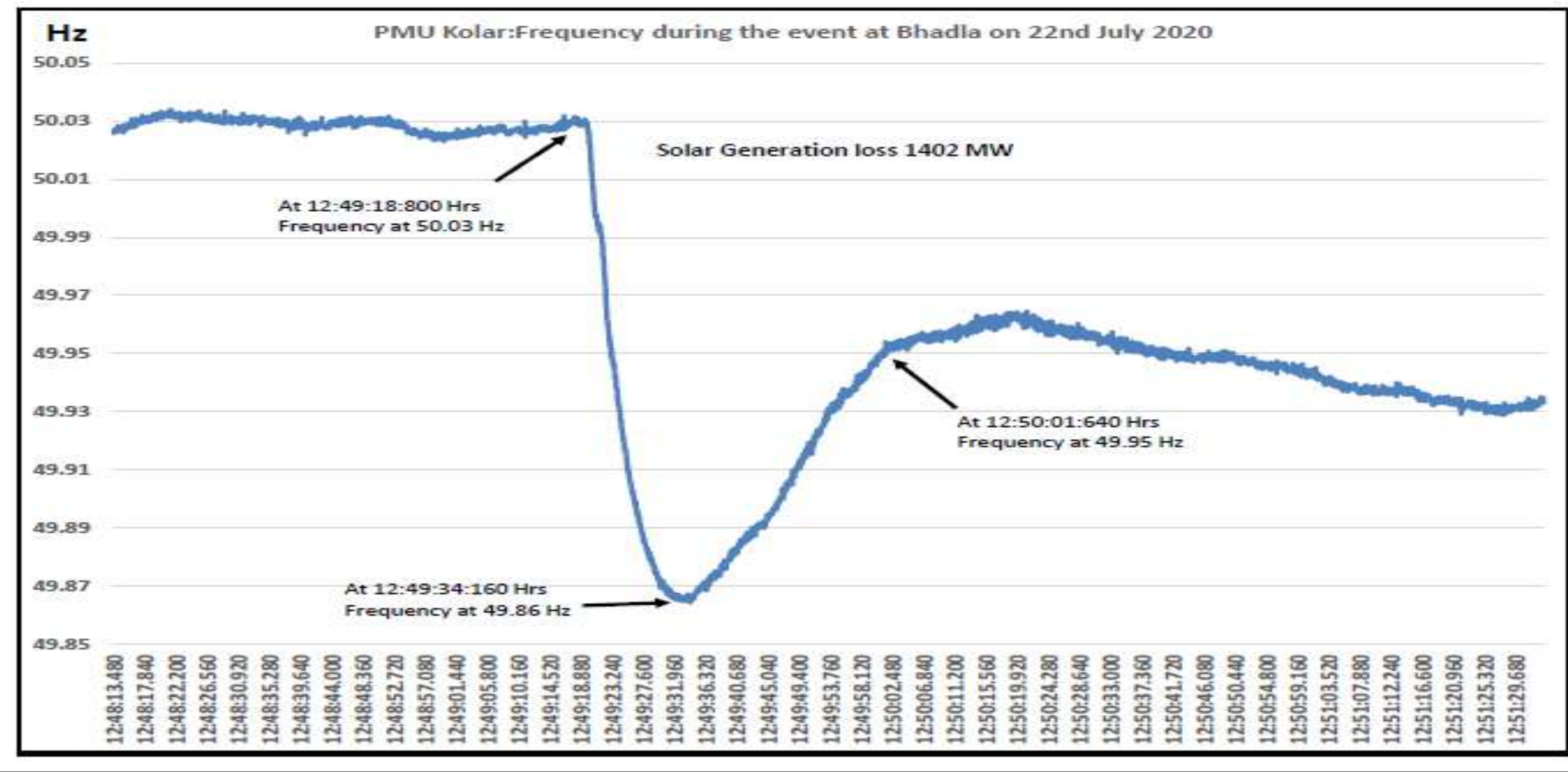
On 16th July 2020, 400 KV Teesta III-Kishanganj was under emergency outage availed at 15:49 Hrs, to replace gas density monitor. At 16:27 Hrs 400 KV Rangpo-Kishanganj tripped on directional earth fault in B phase at Rangpo end and DT receipt at Kishanganj. At the same time, 400kV Rangpo-Dikchu and 400 kV Dikchu-Teesta III also tripped.



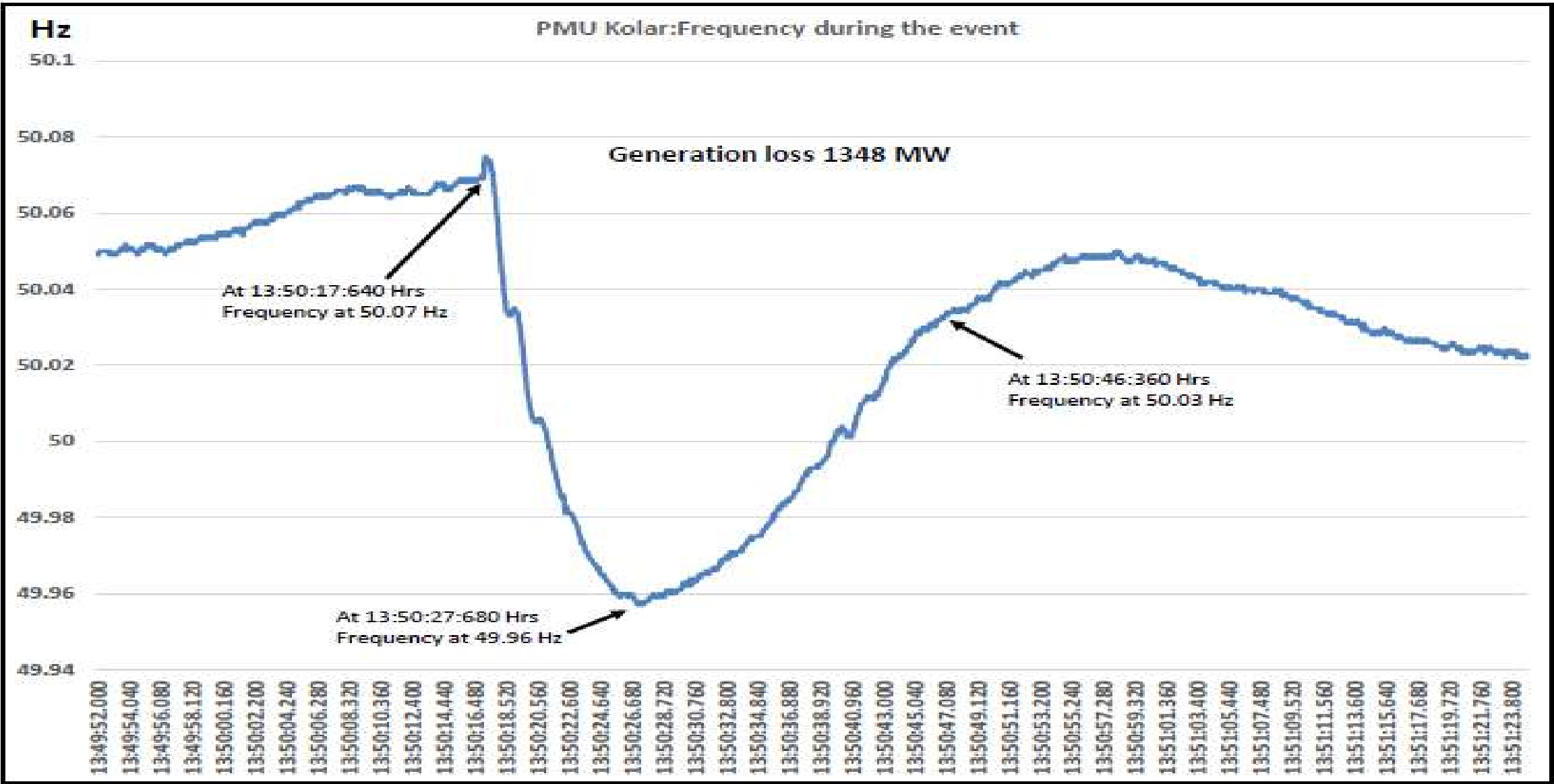
On 20th July 2020, As reported 220kV Amarsagar-Dechu, 220kV Amarsagar-Mada and 220kV Amarsagar-Akal tripped at 20:50 Hrs due to snapping of Main bus jumper at 220kV Amarsagar. Wind generation loss of around 1213 MW occurred .



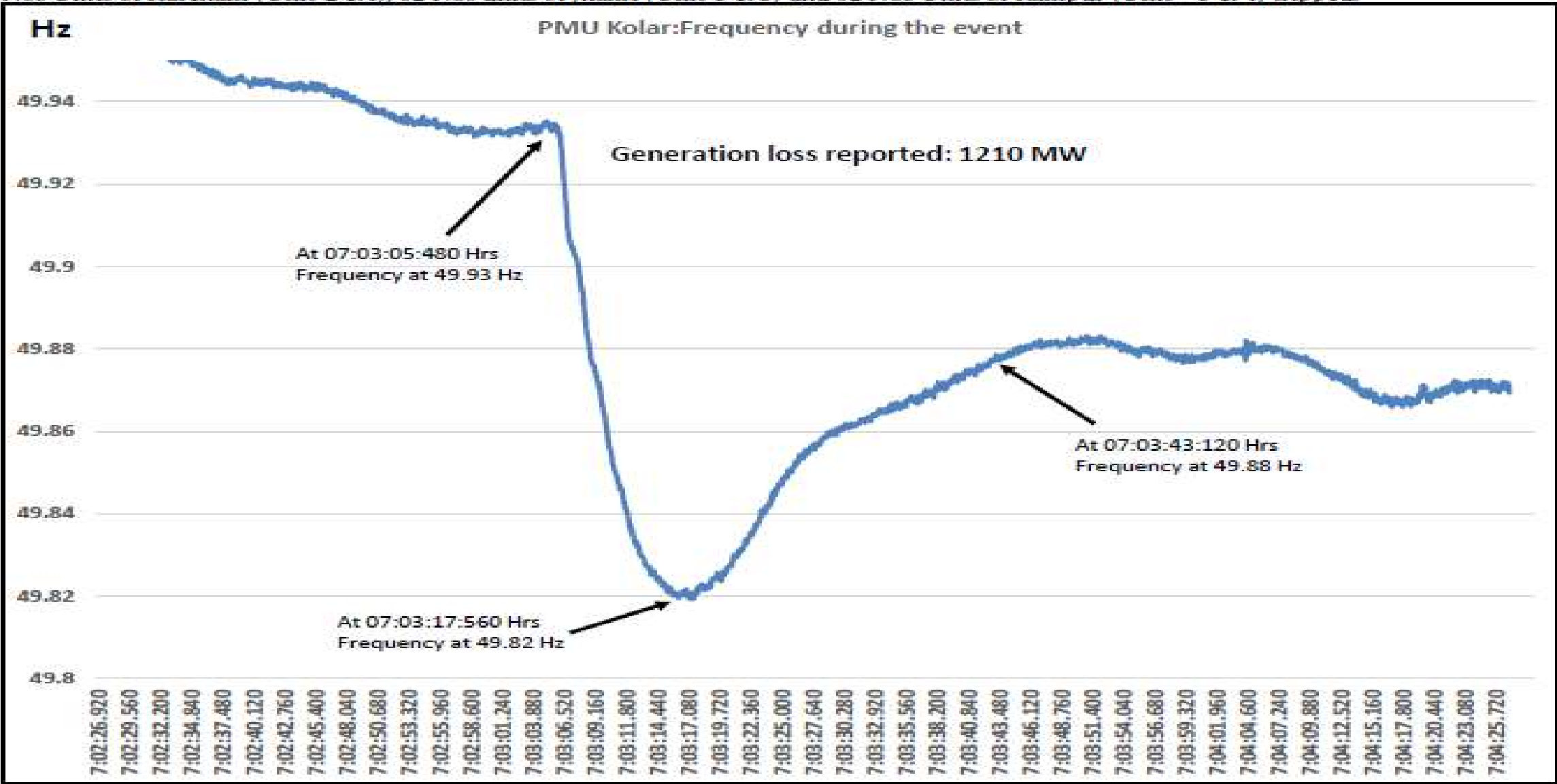
On 22nd of July 2020 at 12:49 hrs, As reported 400/220 KV 500MVA ICT-1 & ICT-3 at Bhadla Rajasthan tripped due on overcurrent, 400/220 KV 500MVA ICT-2 was already under outage due to PRD operation. During the event Solar generation loss at Bhadla Rajasthan 1402 MW.



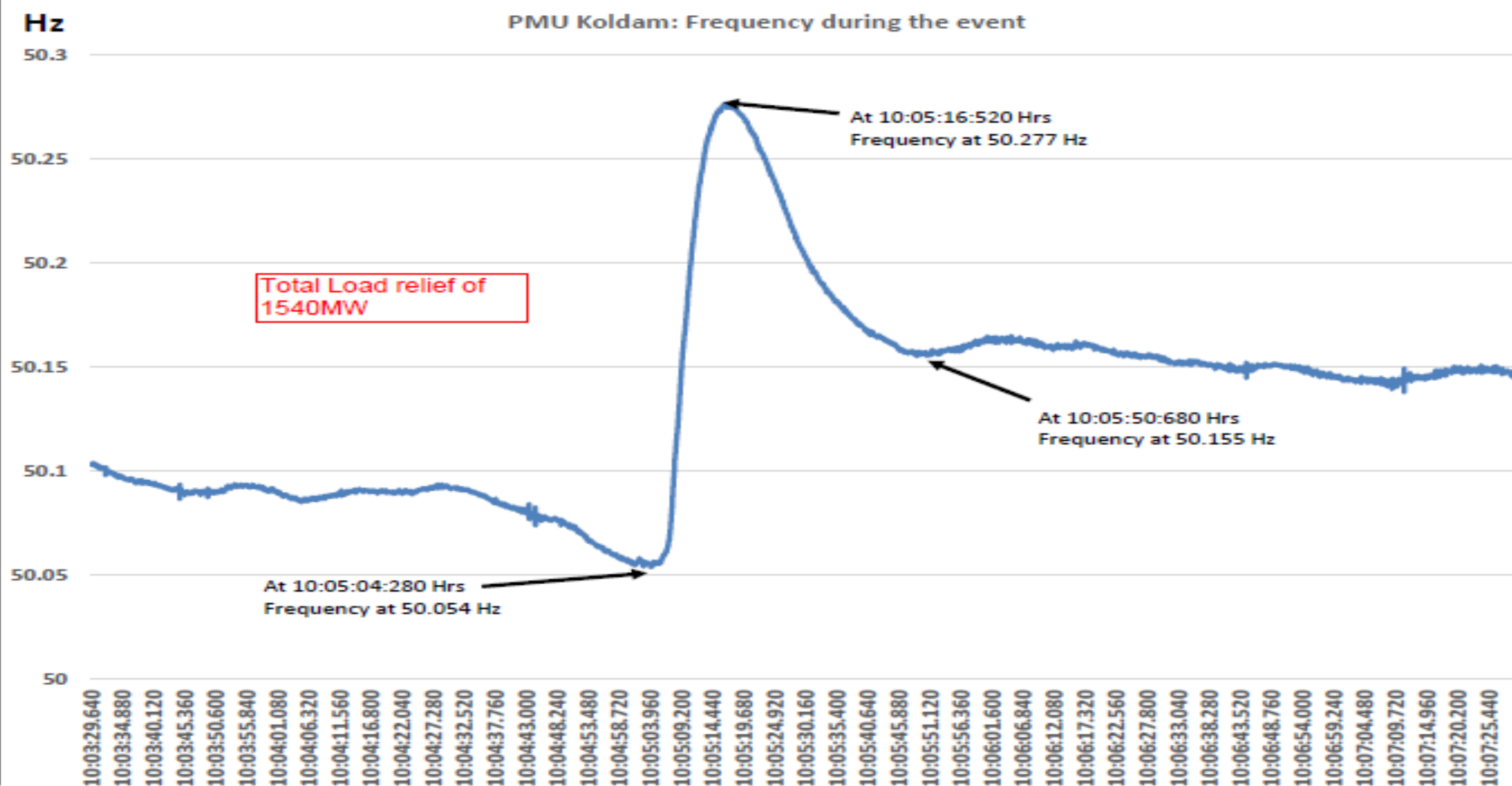
On 06th August 2020,As reported at 13:50 Hrs 400 KV Akal-Jodhpur (RS) Ckt-1 tripped due to DT received at Jodhpur end. At the same time, 400/220 kV 315 MVA ICT 1 & 315 MVA ICT 2 at Barmer(RS) also tripped.Wind generation loss of around 1348 MW occurred.



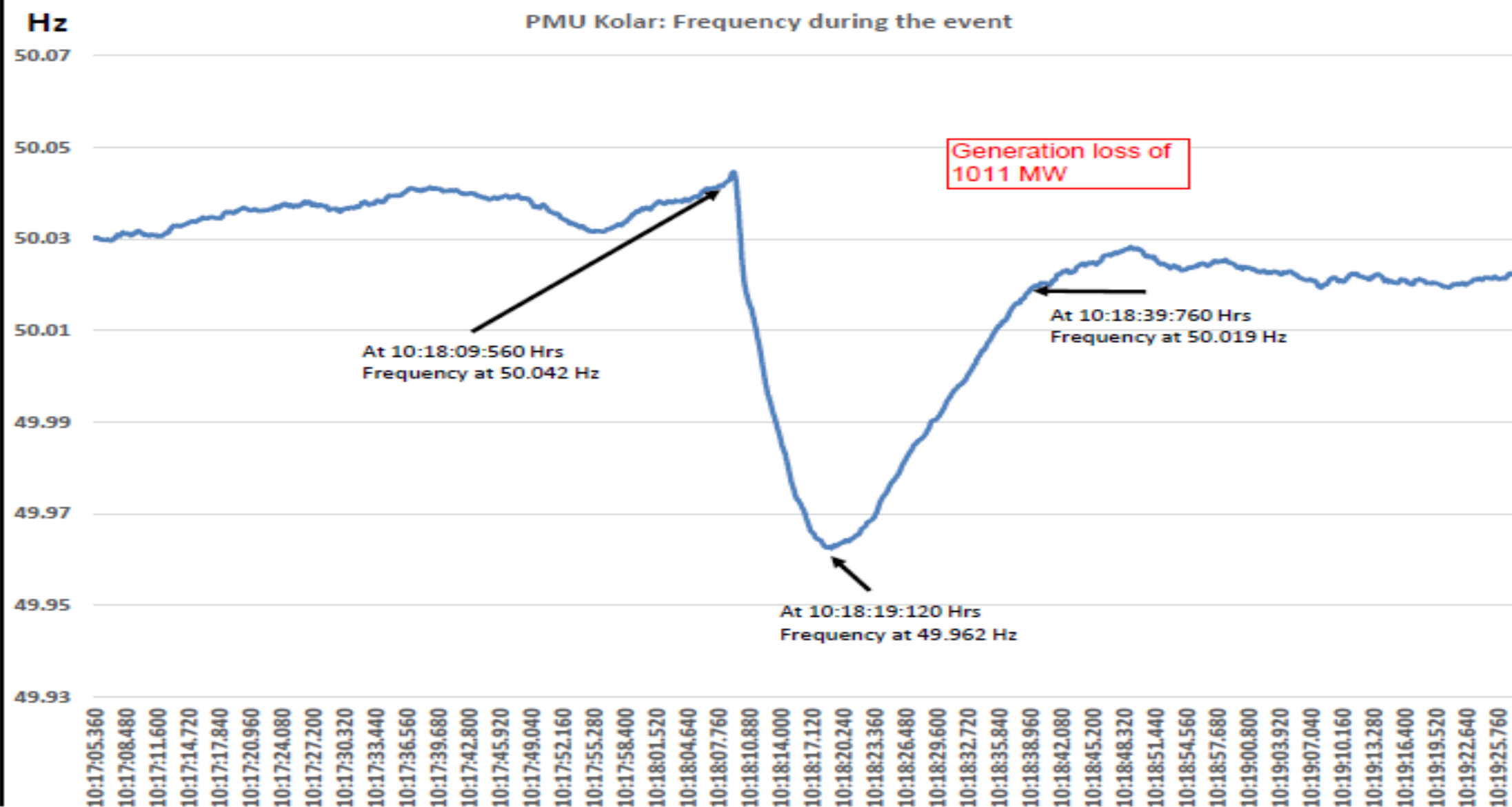
On 13th of August 2020 at 07:03 hrs, As reported, 400kV Jhakri-Panchakula ckt- 1 and 2 tripped due to sparking of Y-Ph Isolator for ckt1 at Panchakula end and the second ckt tripped at Jhakri end. In this connection, SPS operated at Jhakri, Karcham and Rampur. Consequently, 02 Nos Units of Karcham (Unit-2 &4), 02 Nos units of Jhakri (Unit-3 & 5) and 02 Nos Units of Rampur (Unit – 3 & 4) tripped.



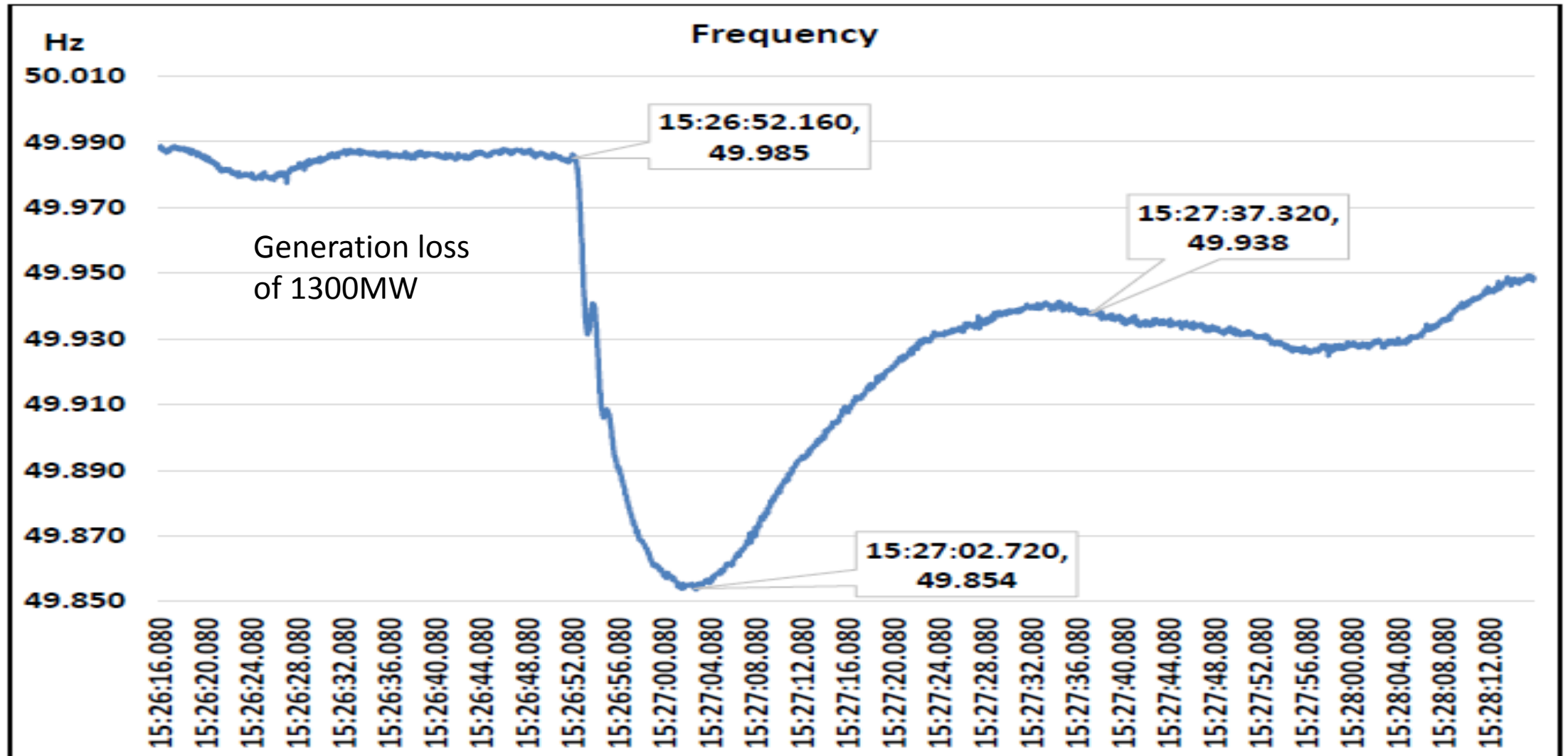
Event: 12th of October 2020 at 10:05 Hrs, Total Load relief of 1540 MW in Mumbai area.



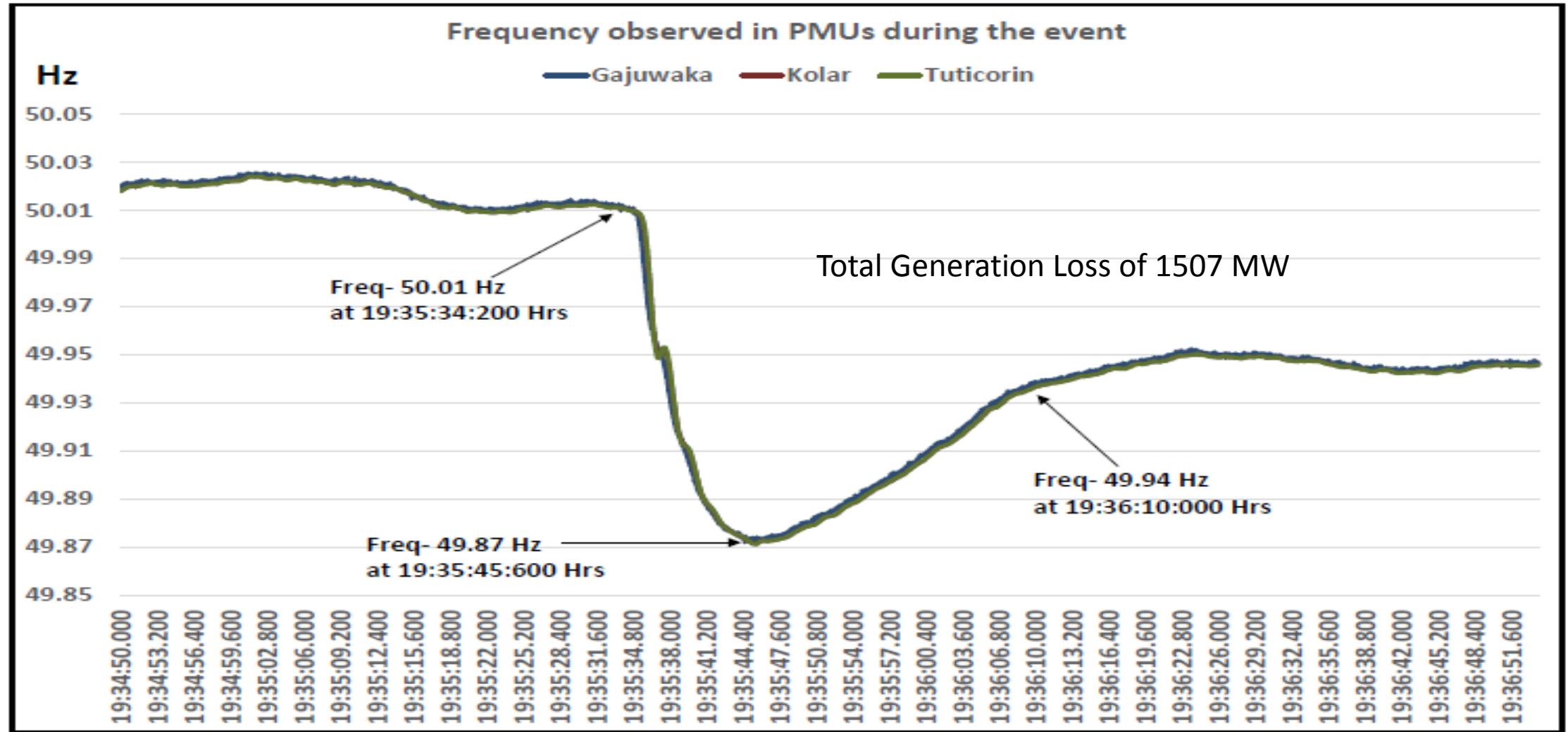
Event: 26th December 2020, At 10:18hrs, Generation loss of 1011 MW at Wanakbori Generating station.



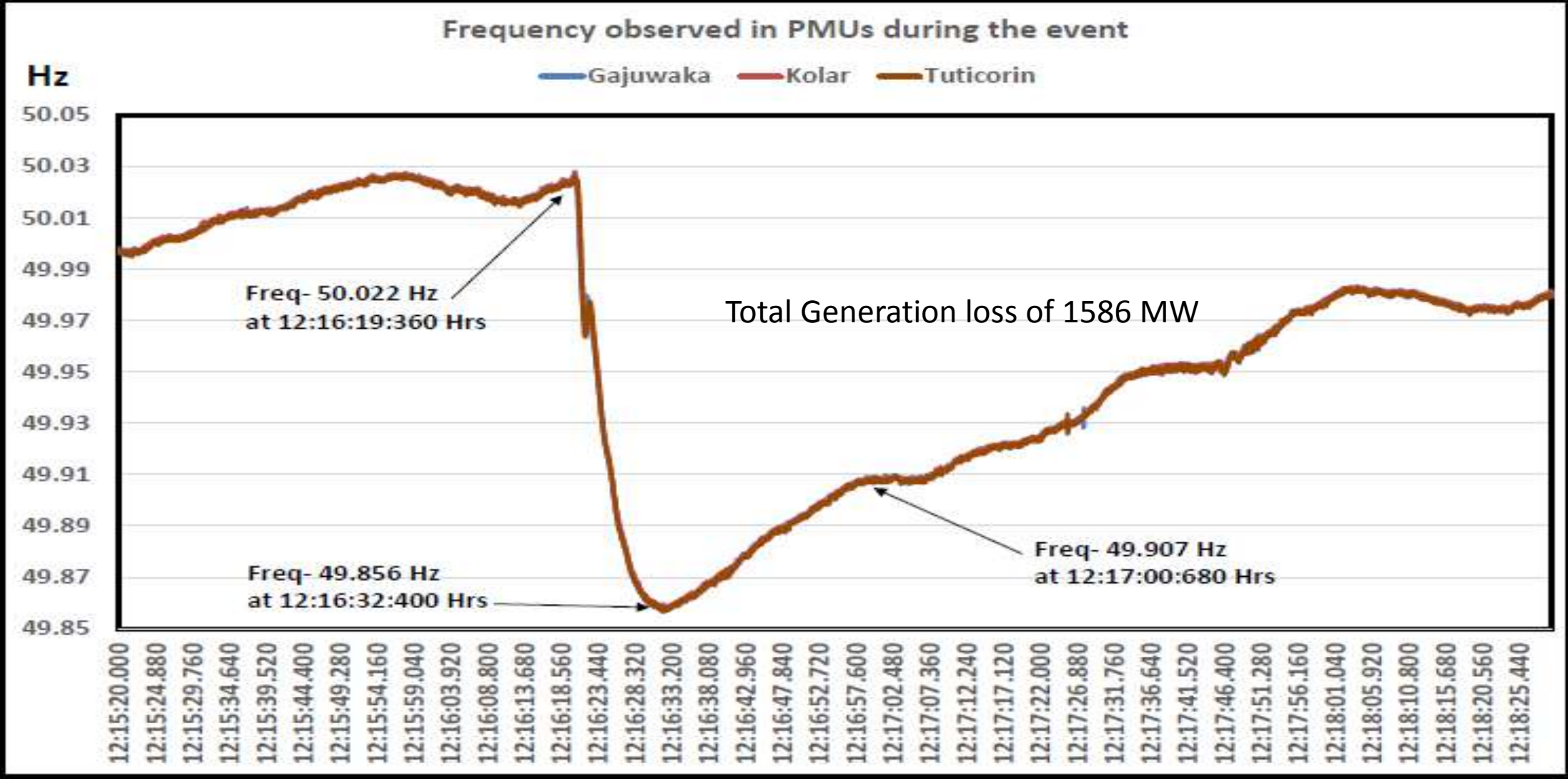
On 19th Feburaury 2021, at 15:26 hrs multiple trippings occurred at Bhadla(PG) station. It has been reported that while availing planned shutdown of 220kV Bus-II at Bhadla(PG), multiple 220kV solar generation evacuationlines also tripped.



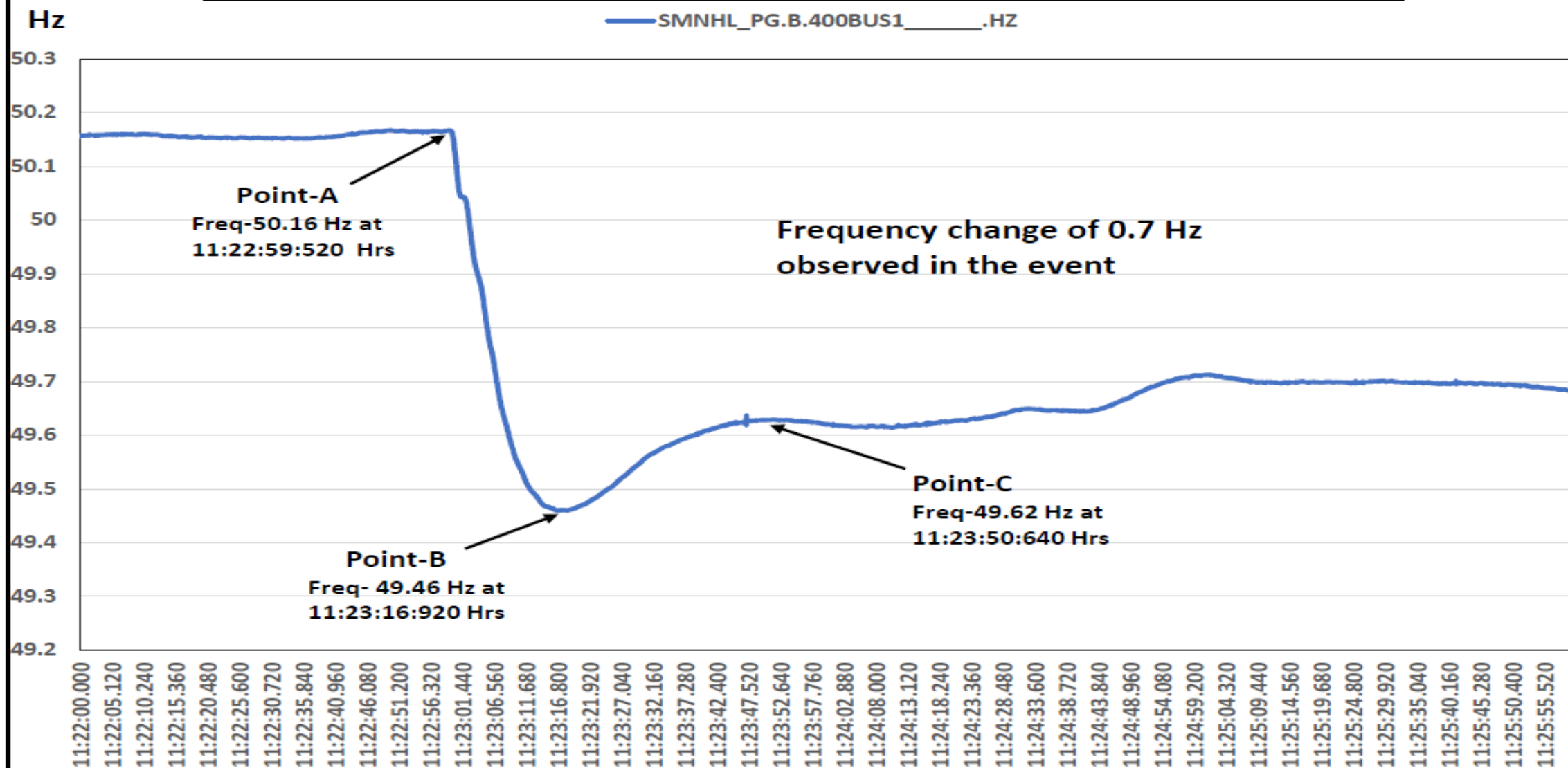
As reported, on dated 10th-March-2021 at 19:35 400kV Rango-Kishanganj & 400kV Teesta III - Kishanganj tripped due to R-B-N Fault and resulted in Complete outages of Stations at 400kV(Rangpo, Teesta III, Dikchu) ,220kV (Jorethang,Tashiding,New Melli) and 132kV (Chuzachen,Gangtok) level.



As reported, At 12:16 hrs, Due to Multiple tripping at 400kV Bikaner (RS) station & 220kV side at Bhadla(PG).



Frequency profile observed in PMUs during Solar Generation loss of around 6000MW in Northern region on 11th-August-2022



Best Practices in Major power systems -AUFLS

- 1. Continental Europe:** The quantum of load shedding at each stage of under frequency may be designed in terms of percentage of total load at national level. The similar practice is being followed in Continental Europe as brought out in “*Commission Regulation on establishing a network code on emergency and restoration.*” The table used as reference for automatic low frequency demand disconnection scheme is given below. It can be observed that cumulative demand disconnected is 45 % of total load at Continental Europe level. In Great Britain system, the value is 50% of national load. The regulation available at <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R2196&rid=5> mentions that “*Each TSO shall design the scheme for the automatic low frequency demand disconnection in accordance with the parameters for shedding load in real-time laid down in the Annex. The scheme shall include the disconnection of demand at different frequencies, from a ‘starting mandatory level’ to a ‘final mandatory level’, within an implementation range whilst respecting a minimum number and maximum size of steps. The implementation range shall define the maximum admissible deviation of netted demand to be disconnected from the target netted demand to be disconnected at a given frequency, calculated through a linear interpolation between starting and final mandatory levels. The implementation range shall not allow the disconnection of less netted demand than the amount of netted demand to be disconnected at the starting mandatory level. A step cannot be considered as such if no netted demand is disconnected when this step is reached.*”

Automatic low frequency demand disconnection scheme characteristics:					
Parameter	Values SA Continental Europe	Values SA Nordic	Values SA Great Britain	Values SA Ireland	Measuring Unit
Demand disconnection starting mandatory level: Frequency	49	48,7 – 48,8	48,8	48,85	Hz
Demand disconnection starting mandatory level: Demand to be disconnected	5	5	5	6	% of the Total Load at national level
Demand disconnection final mandatory level: Frequency	48	48	48	48,5	Hz
Demand disconnection final mandatory level: Cumulative Demand to be disconnected	45	30	50	60	% of the Total Load at national level
Implementation range	± 7	± 10	± 10	± 7	% of the Total Load at national level, for a given Frequency
Minimum number of steps to reach the final mandatory level	6	2	4	6	Number of steps
Maximum Demand disconnection for each step	10	15	10	12	% of the Total Load at national level, for a given step

2. **North America:** *North American Electric Reliability Corporation (NERC) standard PRC-006-2* — Automatic Underfrequency Load Shedding mentions that “Each Planning Coordinator shall develop a UFLS program, including notification of and a schedule for implementation by UFLS entities within its area, that meets the following performance characteristics in simulations of underfrequency conditions resulting from an imbalance scenario, where an imbalance = [(load — actual generation output) / (load)], of up to 25 percent within the identified island(s).”

3. **Australian Energy Market Operator**

The Network Operator must ensure that its UFLS scheme: (a) in aggregate, targets 75% of the system load available at any time for interruption, where system load is the sum of generation injection into the SWIS, measured at the generator terminals; (b) has five stages, each targeting 15% of the system load; and (c) has a relay time delay setting of 0.4 second for each stage with the maximum clearance time minimised. Load allocated to the UFLS scheme for shedding may also include large individual load connections, where it is possible to do so, provided that the Network Operator has considered the associated impacts of losing that individual load.

The Network Operator must ensure that each stage of the UFLS scheme initiates shedding at the frequencies listed in Table 1, where the frequency is measured by the

UFLS scheme at a point on the Network Operator's Network that is electrically close to where the scheme initiates the load shedding.

Stage	Initiation Threshold (Hz)	Load Shed Quantity (%)
1	48.75	15
2	48.50	15
3	48.25	15
4	48.00	15
5	47.75	15

The UFLS scheme must be designed such that, where possible, the Network Operator is able to monitor when critical elements of the scheme are unavailable (e.g. a particular relay in a particular substation). The Network Operator must be able to reasonably establish whether the scheme operated correctly, including where possible, measuring or estimating: (a) the frequency that initiated the scheme at each applicable location; (b) the timing of actual load shedding at each applicable location, including measurements as applicable:

- activation of the scheme;
- relay pickup times;
- communication times; and
- circuit breaker operation times;

4. National Grid –UK

Low Frequency Demand Disconnection (LFDD) is triggered if frequency on the transmission system drops below 48.8 Hz. It aims to preserve the integrity of the system by holding the frequency above 47.5 Hz.

When prompted, DNOs open circuit breakers on portions of the distribution network to disconnect demand in a controlled fashion by as much as 5-60% of total national demand. The volume of demand cut off is staged in nine blocks (5%, 7.5% and 10%) so that the amount increases if frequency continues to drop. In stage one there's a 5% reduction in demand across England and Wales. This is divided between the DNOs as evenly as possible.

Frequency (Hz)	% of Demand Disconnection
48.8	5
48.75	5
48.7	10
48.6	7.5
48.5	7.5
48.4	7.5
48.2	7.5
48.0	5
47.8	5
Total % Demand	60

LFDD schemes are fitted at 132kV substations and are designed to trip the lower voltage side of the incoming 132kV transformers or some or all of the outgoing feeders. The operating time of an LFDD scheme is as far as reasonably practicable be less than 200 mS.

5. New Zealand

AUFLS technical requirements report on Automatic Under-Frequency Load Shedding Systems 2021 (available at <https://www.transpower.co.nz/sites/default/files/bulk-upload/documents/AUFLS-Technical-Requirements-Report.pdf>) mentions that “The AUFLS system must electrically disconnect demand: (a) for the primary under-frequency settings: (i) within 0.3 seconds of the instantaneous frequency falling below the frequency set point; or (ii) with the rate of change of frequency reaching the set point whilst below the guard frequency, as shown in A to E in figure 1; (b) for the secondary under-frequency settings within 15 seconds of the instantaneous frequency reaching the set point as shown in A to E in figure 1; and (c) in accordance with the relay setting requirements set out in clause 2.5, and using logic set out in figure 2, of this report.”

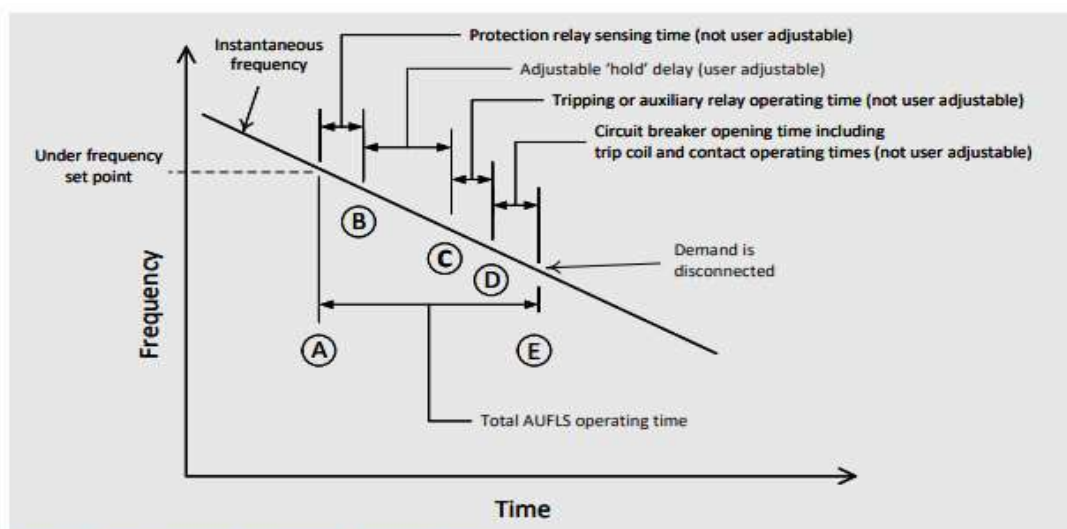
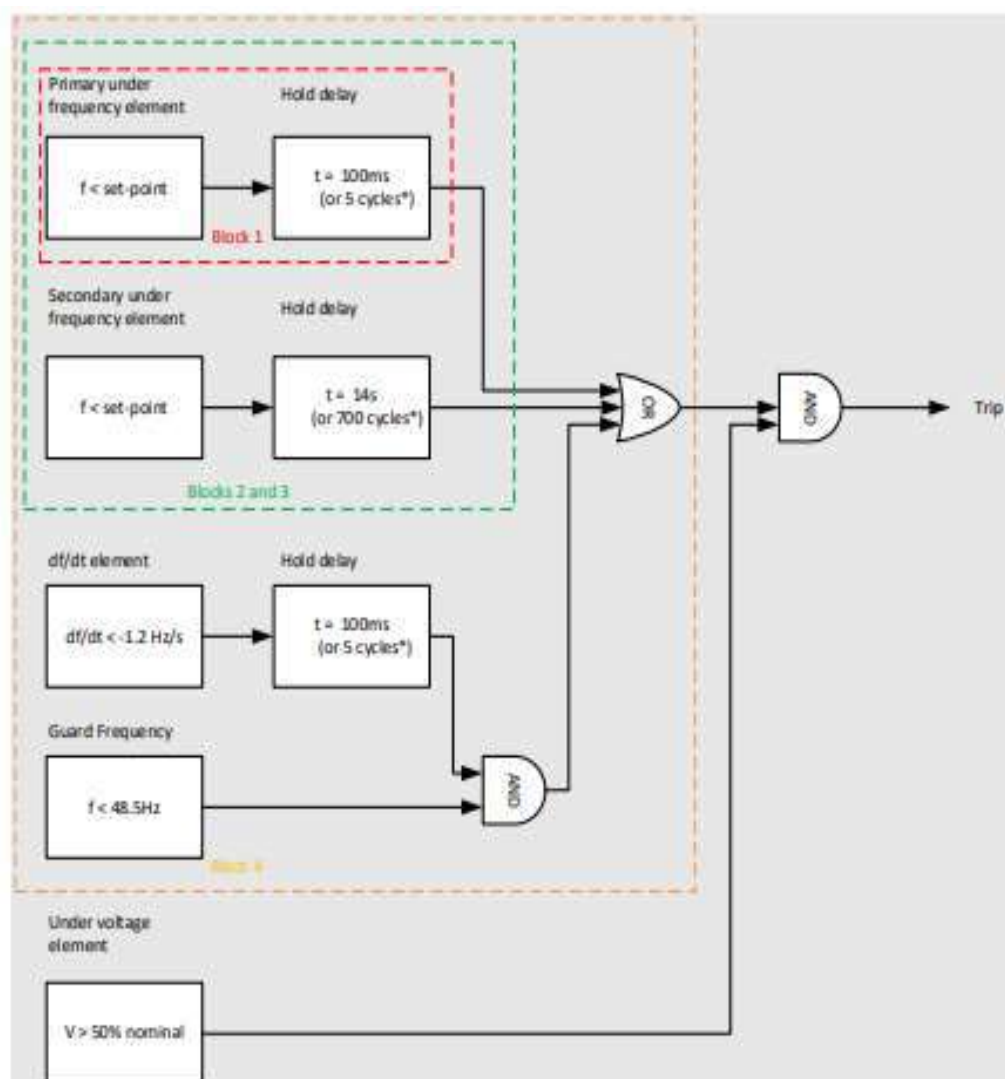


Figure 1. Under-frequency trip timing diagram (typical)



* This is included for relays that use 'cycles' instead of seconds for their timers.

Figure 2. Logic diagram for AUFLS Blocks.

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Approach-B:

Automatic under frequency load shedding scheme is designed considering the adverse condition in the grid i.e. when the grid is operating at its peak load and largest generation complex is lost.

The peak demand observed in the year 2021-22 was of the order of 2,10,000 MW. The largest sudden generation complex loss could be a loss of UMPP station of CGPL capacity or generation complex of Vindhyachal. The capacity loss can fairly be assumed to be around 5000 MW. This can be treated as a credible contingency and to mitigate the situation, the system operator has to maintain adequate reserves. The reserves are generally maintained to address the credible contingencies. It is therefore necessary to ascertain that the defense mechanism should not come into play when there is a credible contingency of loss of generation. The loss of generation of @5000MW will result in frequency settling to 49.52Hz, without any response from the reserves. However the situation can worsen if there is a further sudden loss of other smaller complex of around 1000-2000MW. Therefore, under this situation, the total sudden generation loss of around 8000-10000MW can be assumed as a stressed scenario and under these scenario; the defense mechanism should come into action. The sample estimation shows that for a system size of 210000MW, a generation loss of 8400MW will result the frequency settling to 49.2Hz, without any response of the reserves. In the worst case scenario a generation loss/load increase of 11850 MW, the frequency would settle around 48.7Hz without any response of the reserves.

The estimation of the above quantum's have been done by considering the combined effect of frequency dependence of load factor "D" and the regulation response of the generators "R" (only 40% of generation is assumed to provide only 5% regulation), to see the frequency settling point and load required to shed;

- a) For simplicity assume a loss less system i.e. generation = load. This can be fairly a good assumption, since the system prior to disturbance is in steady state and system losses are approximately proportional to the loads. Further a Generation Loss has been considered which is similar to Load increase in $\Delta "G"$
- b) Empirically the "frequency dependence of load" can be seen in the range of 1.5%. As has been seen in the previous sections 'D' in worst case scenario has little influence in the final settling frequency. So it is fair to assume the "frequency dependence of load" as 1.5% in the peak period. Therefore, at a peak demand of 210000MW, the "frequency dependence of load" factor D if assumed to 1.5% the fall/decrease in load would be 6300MW/Hz for 1 Hz fall of frequency.

The generators are assumed to be running to their full capacity and therefore can provide 5% governor response through RGMO/FGMO as stipulated in IEGC. There could be some generators which may be running below the full load capacity and can provide more response also. However, on bar generators can provide 5% governor response through RGMO/FGMO during the above load scenario. This is a very conservative approach. For example, this translates to a regulation factor “R” of 50 Hz/pu MW on the new MW base of 10500MW (Old MW base being 210000MW) for the Stage-I-A.

- c) In the calculations, it has been tried to establish, at what generation drop/load increase the frequency would settle to 49.2, 49.0, 48.8, 48.7 & 48.6 Hz respectively, as these being the Stages for Stage-I, identified for load shedding.
- d) The initial frequency is assumed to be at 50 Hz. If the frequency falls to 49.2 Hz due to either generation loss or demand rise, even after primary reserves respond, the AUFLS 1st stage (i.e Stage-I-A) will give relief. To estimate the Generation Loss/Demand Increase quantum (Generation loss has been estimated for estimating LS), with the Load dependence of frequency (D) and regulation factor (R), the system frequency settling at 49.2Hz what would be the “generation loss quantum” that would settle the frequency to 49.2 Hz. There will be a generator RGMO/FGMO response and load loss (due to frequency dependence) due to fall of frequency from 50Hz to 49.2 Hz. Now after the Stage-I A load shedding is triggered and gives load relief, the frequency will rise above 49.2Hz but will not reach 50Hz, since with the increase of frequency again the Loads will increase due to “D”. This increase in load is also required to be shed so that the frequency is restored to 50Hz. The steps involved are as given below;
 - (i) Generation and loads assumed to be 210000MW
 - (ii) Frequency drops to 49.2Hz from 50Hz
 - (iii) Calculate D in puMW/Hz,
 - (iv) Calculate R in Hz/pu MW
 - (v) Calculate change(drop) in load due to fall of freq from 50Hz to 49.2Hz (0.8Hz)
 - (vi) Calculate β (FRC)= $D + 1/R$
 - (vii) Find $f_0 = (\text{loss of gen}) / \beta$
 - (viii) Find the settling freq. by adjusting the generation loss till f_0 become 49.2Hz.
 - (ix) The new load and generation due to freq drop is calculated as follows;

New Load (NL_1)=Initial Load (NL_0)- Load Drop (LD_0) due to freq. fall. ----- (1)

New Generation (NG_1) = Initial Gen. (NG_0)-Gen Loss+RGMO/FGMO.----- (2)

RGMO/FGMO response has been assumed to be very low.

Now to establish the Load generation balance (LGB) (so that frequency can be raised to 50 Hz), the Load Shedding (LS_1) quantum required can be estimated by comparing the new loads with the new generation. The difference between New load and New generation would be the load shedding quantum to raise the frequency above 49.2 Hz.

$$(LS_{11})=(NL_1) - (NG_1)----- (3)$$

- (x) With the LS_1 Load is shed, the Load-Generation balance is established, so the frequency will try to reach 50Hz. However again due to frequency rise from 49.2Hz to 50Hz, the load will increase because of load dependence on the frequency. With the assumed D and NL, the rise in load say NL_{11} is estimated. Now if this Load is added to LS_{12} , a perfect load generation balance will be achieved. Therefore the load shedding quantum for Stage IA will be

$$\text{Load Shedding quantum in Stage-A } (LS_1) = LS_{11} + LS_{12}.----- (4)$$

- (xi) The LS quantum arrived at to raise the frequency to 50Hz from 49.2Hz was estimated for Stage-I-A. Even after Load Shedding (LS_1) under Stage-A as above, if suppose the frequency does not improve and keeps falling further to 49 Hz, the Stage-B of AUFLS would triggered.

Now for Stage-B, the Initial frequency assumed to be at 50Hz with a NL_2 & NG_2 to be same.

$$NL_2 = NL_1 - LS_1 \text{ and } NG_2 = NL_2$$

Now the steps (1) to (4) are repeated.

- (xii) The above steps are followed to arrive the LS quantum for each stage. It is assumed that at the start of every stage the initial frequency is 50Hz. The quantum of load increase/ Generation loss is iteratively achieved so that the new system frequency settles at 49.2 Hz. The load shedding quantum required to establish load and generation balance is computed by carrying out load loss (due to 'D') due to frequency falling to 49.2 Hz and this increase due to raising the frequency to 50 Hz, the very negligible governor action and load

loss due to AUFLS at 49.2 Hz. This approach has been extended to see where this frequency settles at 49.0, 48.8, 48.6 and 48.5 Hz and the adjusted load shedding quantum required to be wired up for AUFLS. Therefore even if Stage-I A, B, C & D does not raise the frequency to 50Hz, the last Stage-E is capable to increase the frequency from 48.5Hz to 50 Hz, if the loads are shed as estimated for Stage-IE. This is even true for all the Stages-I B,C &D. So each stage, independently, is capable to raise the frequency from the stage trigger frequency to 50Hz.

The calculations were done with the above assumptions and it is observed that during the peak demand scenario (210000MW), a sudden 3% of demand rise or 3% generation loss of (6300MW) will lead to frequency falling to 49.43 Hz.

The frequency setting and load shedding quantum needs to align so that the above dangerous situation can be averted. Following frequency settings with Load shedding philosophy could be adopted;

Stage-A (49.2 Hz) : Assume that All India grid is running in synchronism. At peak load a sudden demand rise/generation loss of 8400MW will lead to frequency settling at 49.20 Hz. The contribution through the governor action would be around 210MW and the released load (load drop due to frequency dependence) of around 5040 MW on account of frequency falling to 49.20 Hz. These two components add to 5250 MW. A 20% safety margin in the Load shedding quantum estimated is added for stage-A to C and 40% safety margin for Stage-D & E. The load shedding quantum required under stage-A works out to be 4681MW without safety margin and 5617MW with a 20% safety margin.

To avoid frequency fall to 49.2 Hz, following philosophy of LS could be adopted;

- (i) 3370 MW (60%) of the load shedding quantum be done in the importing regions at 49.2Hz. To identify the regions, last year peak demand period import by the each region during the All India peak could be obtained and Load Shedding (LS) quantum of 3370 MW be assigned to the States of this region in proportion to their import/peak demand during the all India peak of last year. An all India peak demand scenario can be considered to find out the importing regions and exporting regions.
- (ii) 2247 MW (40%) of the load shedding quantum can be done in the exporting regions based on the above philosophy.

- (iii) Once the regional LS quantum of all regions is known, the distribution of this quantum amongst the States of the regions can be done in proportion to the peak demand of the States or as decided by respective RPCs.

Stage-B (49 Hz) : 6660 MW LS required to raise the frequency to 50Hz.

Similar approach for the 6660 MW LS quantum sharing in 60:40 ratio by importing and exporting regions as given for Stage-A.

Stage-C (48.8 Hz) : 7510 MW LS required to raise the frequency to 50Hz.

Similar approach for the 7510 MW LS quantum sharing in 60:40 ratio by importing and exporting regions as given for Stage-A.

Stage-D (48.7 Hz) : In proportion to the peak demand LS required to raise the frequency to 50Hz

Under this Stage a safety margin of 40% has been considered, since it is assumed that something has gone wrong with the LS scheme (Not adequate relief obtained in Stage-A, B & C or system is under stress).

The LS quantum of 9037 MW be assigned to all the States in proportion to their peak demand, since credible LS relief is required under this scenario.

Stage-A (48.6 Hz): In proportion to the peak demand LS required to raise the frequency to 50Hz.

9078 MW LS quantum be assigned to all the States in proportion to their peak demand.

Table of AUFLS:

Sl No	Stage	Freq.	Load Shedding quantum for FY 2022-23	Importing region	Exporting region
1	A	49.2 Hz	5617 MW	3370 MW	2247 MW
2	B	49.0 Hz	6660 MW	3996 MW	2664 MW
3	C	48.8 Hz	7590 MW	5313 MW	2277 MW

4	D	48.7 Hz	9037 MW	In proportion to peaks of the States	
5	E	48.6 Hz	9078 MW		
Sub Total A, B, C			19867 MW	11920 MW	7947 MW
Sub Total D.E			18114 MW		
Grand Total			37981 MW		

Calculation Table by considering combined effect of “R” & “D” :

													Effect of both D & R									Load Shedding apportionment				
Stage	freq	Gen	Load	Change in load/Gen Δ "G/L" ***	Pu Δ "G/L"	D in %	D freq dependance	D MW/Hz	D Pu MW/Hz	Gen (reg) 5%gen respon d	R reg	R Hz/pu MW	FRC β	Δ fo	Final Settling freq f	Gen increa se through Gov	Load drop due to freq depende	LS reqd.= Load-Gen	With 20% safety margin for stage-A to C LS reqd & 40% for Stage- D & E	New Gen after gen loss+ regulation	New load after loss of load due to freq dependence	With 20% safety margin for stage-A to C LS reqd & 40% for Stage- D & E	% of total load	Importing Region	Exporting Region	Ratio of LS sharing
		C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
					E6/D6			H6*D6/(0.01*B6)	((15/100)*D6/(50/100))/C6	C6*S/100		2.5*C6/K6	J6+I/106	F6/N6	B6-O6	K6/M6	I6*O6	V6-U6+A/O6	S6*12	C6-E6+O6	D6-R6	T6	W6/D6	W6*0.6	W6*0.4	
A	50.00	210000	210000	8400	0.04	1.5%	0.015	6300	0.03	10500	5%	50	0.05	0.80	49.20	210	5040	4681	5617	201810	204960	5617	3%	3370	2247	60:40
B	49.20	201810	201810	10100	0.05	1.5%	0.015	6153	0.03	10091	5%	50	0.05	1.00	49.00	202	6159	5550	6660	191912	195651	6660	3%	3996	2664	60:40
C	49.00	191912	191912	11500	0.0599	1.5%	0.015	5875	0.03	9596	5%	50	0.05	1.20	48.80	192	7041	6325	7590	180604	184871	7590	4%	5313	2277	70:30
D	48.80	180604	180604	11780	0.0652	1.5%	0.015	5551	0.03	9030	5%	50	0.05	1.30	48.70	181	7242	6455	9037	169004	173362	9037	4%	proportional to the peak demands		
E	48.70	169004	169004	11850	0.0701	1.5%	0.015	5206	0.03	8450	5%	50	0.05	1.40	48.60	169	7300	6484	9078	157323	161704	9078	4%	proportional to the peak demands		
																Stage A-C	16555					19867	9%			
																Stage D-E	12939					18114	9%			
																Grand Total	29494					37981	18%			

New Gen	New Load	Change in load $\Delta "L"$ due to freq rise from 49.2Hz to 50Hz	Pu $\Delta "L"$	D in %	D freq dependence	D MW/Hz	D Pu MW/Hz	Gen (reg) 5% gen respond	R reg	R Hz/pu MW	FRC β	Δ fo	Δ Increase in load due to increase in freq	New Gen after freq increase	New Load after freq increase
AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ
U6	V6	AC6-AB6	AD6/AC6			$AG6*AC6/(0.01*B6)$	$((15/100)*AC6/(50/100))/AB6$	$AB6*5/(100*M6)$		$2.5*AB6/AJ6$	$AI6+1/AL6$	AE6/AM6	$AC6*AG6*0.8$	AB6	AC6+AO6
201810	204960	3150	0.0154	1.5%	0.015	6149	0.030468	202	5%	2500	0.031	0.498	1531	201810	206491
191912	195651	3740	0.0191	1.5%	0.015	5965	0.030585	192	5%	2500	0.031	0.617	1810		
180604	184871	4267	0.0231	1.5%	0.015	5659	0.030709	181	5%	2500	0.031	0.742	2058		
169004	173362	4358	0.0251	1.5%	0.015	5329	0.030774	169	5%	2500	0.031	0.806	2097		
157323	161704	4381	0.0271	1.5%	0.015	4981	0.030835	157	5%	2500	0.031	0.867	2104		

Annexure IV

REGION:

Inspection of AUFLS Relays at Site:

Date & Time:

Details of Relay:

System frequency:

Make of Relay	Serial no.	Stage	Date of Inspection

State/Name of Power Utilities:

Name of Sub-station:

[illegible]

Name, Designation & Signature of the Site
Engineer present at that time of inspection

Name & designation & sign of 3rd party inspecting officer

Note: 1. The functional testing has to be carried out by readjusting the relay setting to the present grid frequency.
2. Details of UFR operational & load relief obtained may be furnished in separate annexures.



भारत सरकार
Government of India
 केन्द्रीय विद्युत प्राधिकरण
 Central Electricity Authority
 पश्चिम क्षेत्रीय विद्युत समिति



आई एस ओ : 9001 2008
 ISO : 9001-2008

Western Regional Power Committee

एफ -3, एमआयडीसी क्षेत्र, अंधेरी (पूर्व), मुंबई - 400093

F-3, MIDC Area, Andheri (East), Mumbai - 400093

दूरभाष Phone: 022- 28221636; 28200195; 28200194 ; फैक्स Fax : 022 -28370193

Website : www.wrpc.gov.in

E-mail : ms-wrpc@nic.in

NO.WRPC/PROTECTION/2012- 9507

Date: 26.09.2012

To,

As per List

Subject:- Report on Review of Defense Mechanism, RGMO & Blackstart facilities in Western Region.

Sir,

During the meeting Chaired by Chairman, WRPC on 7th August, 2012 regarding Grid Disturbances of 30th & 31st July, 2012 in NR, a group comprising of TCC Chairman & Director (O), MSETCL, Member Secretary I/C and GM, WRLDC was formulated to study (1) Review of UFR scheme & its performance and Generation control through governor mode of operation (RGMO), (2) Identification of Black start facilities and scheduling of mock drills on these stations and (3) Prioritization/Review of communication channels between RLDC/SLDC/power stations/sub-stations in case of eventualities.

The said group discussed the above issues in a special meeting held at Pune on 7th September, 2012. A copy of report covering above issues and recommendations evolved is enclosed herewith for your information and further necessary action.

Thanking you,

Yours faithfully,

Encl:- As above.

(S.D.TAKSANDE)
 Member Secretary I/C.

MAILING LIST

01	CMD,MSEDCL& Chairman, WRPC	28	Director(Operation),MSETCL & Chairman, TCC
02	Member (GO&D), CEA, New Delhi	29	Chief Engineer (GM), CEA, New Delhi
03	Managing Director, CSPTCL,Raipur	30	Managing Director,CSPTCL,Raipur
04	Managing Director, CSPDCL, Raipur	31	Executive Director (O & M), CSPDCL, Raipur
05	Managing Director, CSPGCL, Raipur.	32	Chief Engineer(O&M:Gen), CSPGCL, Raipur
06	Chairman, GSECL, Vadodara	33	Executive Director(Gen.), GSECL, Vadodara
07	Managin Director, GSECL, Vadodara	34	Executive Director (O&M-Gen), MPPGCL, Jabalpur
08	Managing Director, GETCO, Vadodara.	35	Director (Operation), MSEGCL, Mumbai
09	Managing Director UGVCL, Mehsana (Gujarat)	36	Director (Operation), MSEDCL, Mumbai
10	Managing Director, MPPTCL, Jabalpur	37	Executive Engineer, DD, Nani Daman
11	Chairman & Managing Director, MPPGCL,Jabalpur.	38	Executive Engineer, DNH, Silvassa
12	Chairman & Managing Director, MSETCL, Mumbai.	39	Regional ED, NTPC Ltd., WRHQ-I, Mumbai.
13	Chairman & Managing Director, MSEGCL, Mumbai.	40	Regional ED, NTPC Ltd., WRHQ-II, Raipur
14	Chairman & Managing Director, MSEDCL, Mumbai.	41	Executive Director, WRTS-I, PGCIL, Nagpur.
15	Chief Electrical Engineer, Electricity Dept., Goa	42	Executive Director, WRTS-II, PGCIL, Vadodara.
16	Secretary(P), UT of Daman & Diu, Moti Daman.	43	Vice President, Tata Power Company, Mumbai
17	Director (Comml.), NTPC Ltd., New Delhi.	44	General Manager (Power), RGPPL, Ratnagiri
18	Director (Operation), NPCIL, Mumbai.	45	Executive Director (O&M), Torrent Power, Surat
19	Director (Operation), PGCIL, Gurgaon.	46	Vice President, Torrent Power Ltd., Sola Rd., Ahmedabad
20	Chief Executive Officer, NLDC, New Delhi.	47	AVP, GMR Energy Trading Ltd., Bangluru
21	General Manager, POSOCO, WRLDC, Mumbai	48	Director(Technical&Projects),JSW Energy Ltd.,Delhi
22	Executive Director (O), Tata Power Company, Mumbai.	49	Managing Director, GUVNL, Vadodara
23	Managing Director, RGPPL, Noida	50	Member (Power), NCA, Indore
24	Chief Executive Director, NHDC Ltd, Bhopal.		
25	Executive Director, Torrent Power Generation, Surat		
26	Vice President(BD), APL, Ahmedabad		
27	Executive Director (Gen.),Jindal Power Ltd,Raigarh		



पश्चिम क्षेत्रीय विद्युत समिति
Western Regional Power Committee



REPORT OF THE COMMITTEE TO REVIEW

- ⇒ **Defence mechanisms of AULFS**
- ⇒ **Generation control through RGMO**
- ⇒ **Black start/Restoration Facilities**
- ⇒ **Communication Facilities**

in Western Region

मुंबई

SEPTEMBER-2012

LIST OF PARTICIPANTS

(1)115th Protection Committee Meeting held on 6th & 7th September 2012 at Pune(Mah.).

(2) Group Meeting held on 7th September 2012 at Pune(Mah.).

GETCO (Gujarat Energy Transmission Corporation Limited)

- | | | |
|---|----------------|------------------------|
| 1 | Shri S.A.Patel | Ex. Engineer (Testing) |
|---|----------------|------------------------|

MAHAGENCO (Maharashtra State Power Generation Company Limited)

- | | | |
|---|----------------------|---------------------------------|
| 2 | Shri. P. S. Kulkarni | Superintending Engineer, Nagpur |
| 3 | Shri. Ajit Pachori | Executive Engineer, Mumbai |

MSETCL (Maharashtra State Electricity Transmission Company Limited)

- | | | |
|----|-------------------------|--|
| 4 | Shri Arvind Singh | CMD |
| 5 | Shri S. G. Kelkar | ED (O) |
| 6 | Shri Zalte U.G. | Dir (O) |
| 7 | Shri Shinde | Chief Engineer , SLDC, Kalwa |
| 8 | Shri Shashank Jewalikar | Superintending Engineer (T &C), Auragabad. |
| 9 | Shri A M Kondawar | Superintending Engineer (TCC), Nagpur |
| 10 | Shri Vasant Pandey | EE, SLDC, Kalwa |
| 11 | Shri B L Pasarate | SE(TCC), Vashi |
| 12 | Shri P M Deshpande | EE(Testing), Yavatmal |
| 13 | Shri P S sale | SE(TCC), Karad |
| 14 | Shri P R Deore | CE(Trans.), Pune |
| 15 | Shri R S Parulkar | EE(T&T), Chandrapur |

MPPTCL (Madhya Pradesh Power Transmission Corporation Limited)

- | | | |
|----|----------------------|--|
| 16 | Shri Bende P R | Chief Engineer, SLDC, Jabalpur |
| 17 | Shri R S Shrivastava | Superintending Engineer, 400kV S/S, Bhopal |
| 18 | Shri Sunil Yadav | Superintending Engineer(T&C) , Indore. |

MPPGCL (Madhya Pradesh State Power Generation Co. Ltd.)

- | | | |
|----|----------------------|--|
| 19 | Shri Prakash C. Soni | Superintending Engineer (Engg.), MPPGCL,Jabalpur |
|----|----------------------|--|

CSPTCL (Chattisgarh State Power Transmission Co. Ltd.)

- | | | |
|----|-----------------|---------------------------------------|
| 20 | Shri M Z Rehman | Superintending Engineer (T&C), Bhilai |
|----|-----------------|---------------------------------------|

CSPGCL (Chattisgarh State Power Generation Co. Ltd.)

- | | | |
|----|----------------|---|
| 21 | Shri S K Mehta | Superintending Engineer(O&M), Raipur |
| 22 | Shri P Kolay | Superintending Engineer(Opn.), Korba west |

NPCIL (Nuclear Power Corporation of India Limited)

- | | | |
|----|--------------------|----------------------------|
| 23 | Shri Ruchir Oza | SO/E , TAPS-3&4, Tarapur |
| 24 | Shri Ashwin Yadav | SO/E , TAPS-3&4, Tarapur |
| 25 | Shri V M Daptardar | SME(E), TAPS 1&2 , Tarapur |

NTPC Ltd.

26	Shri Jitendra Tewari	AGM (EMD-I/c) Vindhyachal STPS
27	Shri R K Aash	AGM(Elect.), NTPC, Kawas.
28	Shri Prasun Chakraborty	AGM(EMD-I), NTPC, Sipat.
29	Shri D Roychowdhary	AGM WR-II, Raipur
30	Shri Oswald Menezes	DGM(OS), NTPC, WR-I, Mumbai

RGPPL, Ratnagiri

31	Shri Kundan Rathod	Sr. Manager(E M), RGPPL.
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NARMADA CONTROL AUTHORITY

32	Shri M A K P Singh	Member (Power), NCA
33	Shri Rajesh Sharma	Assist. Director, NCA

PGCIL (Power Grid Corporation of India Limited)

34	Shri Ravi A. Wadyalkar	Manager , WRTS-I, Nagpur
35	Shri Brahananda Doppani	Manager (O&M), WRTS-II, Vadodara.

TPC (Tata Power Company)

36	Shri Murlikrishnan	Asst. Gen. Manager
37	Shri A Uppal	Chief Manager
38	Shri Girish Jawale	Manager, Mumbai

Coastal Gujrat Power Ltd., Mundra

39	Shri K N Athavale	GM(Electrical)
----	-------------------	----------------

Adani Power Ltd, Ahmedabad

40	Shri Uday Trivedi	Manager, Ahmedabad.
----	-------------------	---------------------

Torrent Power Ahmedabad

41	Shri Pravin Chitral	Assistant Gen. Manager (O&M), Ahmedabad.
42	Shri Milind Modi	Manager (Trans.), Ahmedabad.

REL (Reliance Infra Ltd.)

43	Shri M. R. Waigankar	Sr. Manager (T&P), R-Infra, Mumbai
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POSOCO WRLDC (Western Regional Load Dispatch Centre)

44	Shri P Pentayya	GM, POSOCO, Mumbai
45	Shri V A Murty	DGM, POSOCO, Mumbai
46	Smt. Pushpa Seshadri	Chief Manager (OS), POSOCO, Mumbai

WRPC (Western Regional Power Committee)

47	Shri S D Taksande	Member Secretary I/C
48	Shri Satyanarayan S.	Superintending Engineer (O&S)
49	Shri M M Dhakate	Superintending Engineer (P)
50	Shri P D Lone	Executive Engineer (Comm)

ACKNOWLEDGEMENT

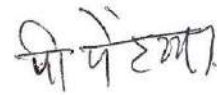
The task entrusted by Shri Ajoy Mehta, Chairman WRPC and Chairman, MSETCL to review the defense mechanism, generation control through governor, black start & recovery facilities and communication facilities in Western Region was highly demanding one. This job would not have been accomplished without the up-front views and data furnished by experts from generation, distribution and transmission utilities. Committee also places on record the analysis and technical inputs provided by Shri V. A. Murty, D.G.M. (OS), WRLDC and Shri S. Satyanarayan, Superintending Engineer (O & S), WRPC. Committee also, acknowledges the pains-taking efforts of Shri M. M. Dhakate, Superintending Engineer (Prot.) and Shri P. D. Lone, Executive Engineer (Comml.) in giving proper shape to this report.



(U.G. ZALTE)
Dir. (Opn.), MSETCL
& TCC Chairperson, WRPC



(S.D. TAKSANDE)
M.S., WRPC



(P. PENTAYYA)
G.M., WRLDC

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Introduction

1. On 30th and 31st July 2012 there were grid disturbances in NR. During the first incident on 30th July 2012, NR system separated from the WR-ER-NER Grid and NR grid collapsed. WR-ER-NER combined grid survived. On 31st July 2012, the WR system separated from NR-ER-NER combined grid. NR-ER-NER systems collapsed, however WR System survived. MOP constituted a three member Committee headed by Chairperson, CEA to inquire into these incidents. The Committee submitted its report alongwith recommendations and is available in public domain.
2. On 7th August 2012 a special meeting was held under the chairmanship of Shri Ajoy Mehta, Chairman, WRPC. He pointed out that on both the days Western Region survived but not due to any designed defense mechanism action but by chance. Therefore Chairman stated that it is very pertinent to discuss issues such as what saved WR, what went wrong in NR and what if it happens in WR. The meeting deliberated various issues in detail. Chairman, WRPC concluded the following :
 - (a) Though this occurrence reflects national problems, we should not assume our house is healthy and we must endeavor to keep our system ready for eventualities.
 - (b) He formulated a group comprising of Shri U. G. Zalte, Director(Operation), MSETCL and Chairman, TCC, Shri S. D. Taksande, Member Secretary (I/c), WRPC and Shri P. Pentayya, GM, WRLDC, POSOCO to look into the following aspects :
 - (i) Review of AUFLS and its performance
 - (ii) Review of Generation control though governor mode of operation
 - (iii) Review of Black start facilities preparedness of stations
 - (iv) Review of communication facilities
3. Accordingly, the group discussed the above issues in a special session of the PCM forum of WRPC which was Chaired by Shri Arvind Singh, CMD, MSETCL at Pune on 7th Sep. 2012.
4. Based on the above discussions the report of the Group along with its recommendations is discussed in the ensuing chapters of the report.

Chapter-1

Review of Automatic Under Frequency Load Shedding scheme (AUFLS) and rate of change of frequency (df/dt) scheme

The report examines the defense mechanisms of AUFLS and df/dt relays against under-frequency situations experienced in WR. It reviews the existing scheme, under normal and grid disturbance conditions, and suggests suitable modifications.

The report is structured as follows :

- i) Existing Plan of AUFLS and df/dt
- ii) Performance of the above under Normal Load-Generation mismatch and Grid disturbance circumstances
- iii) Review of AUFLS and df/dt plans and suggest a new quantum
- iv) Recommendations to make the above scheme more effective.

(i) Existing Plan : The existing plan of AUFLS and df/dt for WR is as given in Table 1.1 and Table 1.2

Freq Setting	Time Delay	Recommended Load Relief WR	Recommended Load relief / (Implemented Load relief) in MW			
Hz	Seconds	MW	GETCO	MPPTCL	MSETCL	CSEB
48.8	NIL	960	220 (506)	152 (247)	550 (567)	38 (38)
48.6	NIL	960	220 (564)	152 (167)	550 (617)	38 (38)
48.2	NIL	1280	295 (525)	205 (187)	730 (936)	50 (51)
	Total	3200	735 (1595)	509 (601)	1830 (2118)	126 (127)

Table 1.1 AUFLS Plan and Implemented quantum

Settings	Recommended Load relief MW	Implemented Load Relief MW				
Hz and rate in Hz / sec	WR	GETCO	MPPTCL	MSETCL	CSPTCL	TPC
49.9 Hz/ 0.1(Stg I)	2000	1006	361	546	27	60
49.9 Hz/ 0.1(Stg I)	2000	905	355	621	37	82
49.9 Hz/ 0.1(Stg I)	2472	1001	392	686	120	273
TOTAL	6472	2912	1108	1853	184	415

Table 1.2 df/dt Plan and Implemented quantum

(ii) Performance of the above schemes:

A. Under Normal Integrated Operation of NEW Grid:

1. The details of month-wise day-wise operations of AUFLS is enclosed at Annexure-1. However the summary of their operation for three years of normal integrated operation (April 2010-July 2012) is as follows: (Refer Tables 1.3-1.5)

Constituent	Total Days	Days when AUFLS Called to operate*	Days when it did not operate	Load Relief MW (Range)	Planned MW Relief
Gujarat	365	65	5	3-346	220
Maharashtra	365	65	5	1-280	550
MP	365	65	14	1-268	152
Chhatisgarh	365	65	29	2-78	38

Table 1.3 Period April 2010-March 2011

Constituent	Total Days	Days when AUFLS Called to operate*	Days when it did not operate	Load Relief MW (Range)	Planned MW Relief
Gujarat	366	32	5	2-84	220
Maharashtra	366	32	9	13-149	550
MP	366	32	23	58-186	152
Chhatisgarh	366	32	26	1-37	38

* In Sept 11 and Oct 11 had 30 days out of 32 calls for AUFLS operation

** In Oct 11 also touched second stage of 48.6 Hz discussed later

Table 1.4 Period April 2011-March 2012

Constituent	Total Days	Days when AUFLS Called to operate	Days when it did not operate	Load Relief MW (Range)	Planned MW Relief
Gujarat	122	19	2	6-243	220
Maharashtra	122	19	7	29-354	550
MP	122	19	8	21-118	152
Chhatisgarh	122	19	8	8-65	38

Table 1.5 Period April 2012-July 2012

2. The number of days the frequency touching AUFLS touching first stage at 48.8 Hz is around 13% days in the period. On some days frequency touched 48.8 Hz more than once.
3. The frequency could touch 48.8 Hz in either a 'Touch and Go up' manner or 'Stay there and go below'. Most of the times this is 'touch and go up' in nature. Unless the frequency dips below 48.8 Hz, complete relief from that stage cannot be fully anticipated.
4. In 'Touch and Go up' case, full load relief may or may not be obtained. This is because of following possibilities.

- (a) There are a large number of relays. So statistically there would be a little error in exact pick up. Relays have a pick up sensitivity of the order (+/-) 0.05 Hz. In a 'Touch and Go up' case some load relief may lift the frequency and so other relays may not take pick up as the conditions have changed.
 - (b) In addition Load Dispatcher may after sensing the conditions ensure generation to pick up or trip load manually.
 - (c) The load relief in such cases would be partial. As long as the frequency rises upward, it is presumed that in such 'Touch and Go up' cases some of the AUFLS have operated and given load relief.
- 5. Out of a total number of days of 116 in the above period, Gujarat operated for 104 occasions, Maharashtra operated for 95 occasions, MP operated for 71 occasions and Chhattisgarh operated for 51 occasions. The load relief varies due to the probable above mentioned reasons. These belong to the 'Touch and Go up' type.
- 6. When the frequency reaches 48.8 Hz and stays there or goes down, full relief from that stage is expected. During this period the full relief from WR stage-I of 960 MW and 800 MW of NR, totaling 1760 MW is anticipated. In ER the Stage-1 is set to operate at 48.5 Hz. So contribution from ER is not anticipated. The frequency relief stages in ER should be in line with NEW grid.
- 7. On 12th Oct 2011, second stage 48.6 Hz also touched. Hence full relief of 1760 MW from Stage I at 48.8 Hz should have been obtained. Considering the fact that the power number is of the order of 2000 MW for the NEW grid, the frequency should have risen by 0.88 Hz (1760/2000) and touch 49.68 Hz. This however did not happen and frequency went down and touched 48.6 Hz and was lifted up by manual distress load shedding. The reasons for not obtaining required load relief could be as under:
 - (a) Due to multiple times frequency touching 48.8 Hz (hovering about 48.8 Hz), relays that operated and tripped feeders, when frequency touched 48.8 Hz for the first time, remained out and so were not available when the frequency touched 48.8 Hz on subsequent occasions.
 - (b) Another factor is that some feeders could have been already on Distress Load shedding.
 - (c) During WRPC inspections carried out at some of substations in the past for AUFLS performance, it was observed that some of the feeders identified for load relief were already under distress load shedding. In such a case, equivalent load from an 'In service' feeder is to be connected, so that the grid can get relief when situation demands so.
 - (d) Another factor is the load relief plan of 1760 MW corresponds to peak conditions and loads fed were much less at that time due to seasonal variations/ average load being less. As detailed in the next section, if the proposed correction factor of 1.73 is applied, this would mean that on 12.10.2012 the effective load was 1073 MW instead of 1760 MW (1760/1.73). Accounting for the effects of (a) and (b), given above, the load MW would be still smaller. Even with all these calculations, it is

clear that frequency should have lifted if there was a net load shedding through AUFLS. Since frequency has gone down, it can be concluded that on this continued low frequency day, the new loads that were added exceeded the tripped loads, causing the frequency to go down.

8. On 12.10.2012 the frequency touched 48.8 Hz multiple times. But only once it went below 48.8 Hz to 48.6 Hz. The relief obtained from Gujarat was 188 MW at 48.8 Hz and nil at 48.6 Hz, MP 176MW and 26 MW, Chhattisgarh 8 and Nil, and Maharashtra 155 MW and Nil respectively. So about 545 MW was obtained from Stage 1 in WR. The WR data is for the whole day which includes many times frequency touching 48.8 Hz. How much relief was obtained from NR and WR for this occurrence at that time needs to be studied as the WR data is for the whole day and NR data is not available. Relief was not adequate from other regions.
9. It may be mentioned that on these days frequency was low and relief from WR was 56-278 MW for second stage 48.6 Hz. Frequency was lifted up by manual distress load shedding. Relief from other regions was also inadequate.
10. The 429th OCC that discussed the above incident, required data of AUFLS relief from other regions to analyse the incident. However it is clear that the AUFLS response in this month was not in line with the plan.
11. During the grid disturbance of 30th and 31st July 2012, frequency did not touch 48.8 Hz in WR and so no relief is expected from WR.
12. Summarizing the above, there is a need to have a good plan, that works considering many of the above aspects, and feeders connected to AUFLS remain in service if one expects results from the AUFLS plans.
13. Further the AUFLS and df/dt being 'protective' in nature should be followed religiously and not used as a load management tool or restricted depending on steady state load management like over drawl / under drawl, since no one knows when a disturbance can strike. As such it should be religiously adopted by the constituents of NEW grid.

B. Operation of AUFLS and df/dt under Grid Disturbances (abnormal conditions)

1. For the period from year 2003- 2012 six major grid disturbances (excluding 30/31st July 2012) were observed. In some cases the WR system further split into multiple parts. The summary of load relief under AUFLS and df/dt for these disturbances is given in the table below.

Grid Disturbance Date	Observations of performance of defense mechanism
25/02/07	Gujarat and Western Maharashtra separated from WR/NEW grid. Gujarat survived and Western Maharashtra collapsed and rest of WR grid survived . In Gujarat 2450MW loads was shed by defense mechanism (AUFLS and df/dt) and in Western Maharashtra 769 MW loads was shed by defense mechanism.
28/02/07	Gujarat and Western Maharashtra separated from WR/NEW grid. Both, Gujarat and Western Maharashtra survived . In Gujarat and Maharashtra 2450 MW and 1160 MW loads were shed under defense mechanism. Rest of WR grid survived.
27/02/2005	Gujarat and Maharashtra along with some parts of MP separated and survived as one system and rest of WR grid with ER survived. In Gujarat (2026 MW), Maharashtra (996 MW) and MP (557 MW) loads were shed under defense mechanism.*
5/11/2003 and 7/11/2003	Gujarat and Western Maharashtra separated from WR/NEW grid. Gujarat survived and Western Maharashtra collapsed and rest of WR grid survived . In Gujarat loads shed by defense mechanism was adequate and in Western Maharashtra loads shed by defense mechanism was inadequate.
6/12/2003	Gujarat and Western Maharashtra separated from WR/NEW grid. Gujarat survived and Western Maharashtra collapsed and rest of WR grid survived . In Gujarat 2300 MW loads shed by defense mechanism was adequate and in Western Maharashtra 524 MW loads shed by defense mechanism was inadequate.

Table 1.6 Performance during Disturbances

*Generally MP/Chhattisgarh and east Maharashtra become part of an island or system with over-generation (high frequency) and hence the situation for AUFLS and df/dt to operate did not arise.

2. It may be seen that for the east-west split of WR West Maharashtra should shed more loads on df/dt to survive.

iii) Review of the AUFLS plan and calculation of expected load relief:

1. This section calculates quantum of AUFLS relief based on a methodology that takes into aspect above shortcomings.
2. In the past the AUFLS schemes of WR were devised region wise based on the typical power number (MW/Hz) observed and co-related to the percentage of demand and was of the order of 3-3.5% of the demand catered. While this rule still gives similar results, a systematic way to anticipate the load relief is presented.
3. The power number of NEW grid is around 1800-2000 MW as observed by WRLDC. A higher power number points to a requirement of larger load shedding for improvement in frequency and being 'worst case' it is selected.

4. Since the stages of AUFLS operates at 48.8 Hz, 48.6 Hz and 48.2 Hz, the plan is to ensure that with each full stage operation of AUFLS, the loads should be disconnected such that the frequency goes up by one Hz.
5. Correction factor for Frequency Dependence of Loads: It is well known that loads are frequency dependent. The damping is assumed to be of the order of 1.5% (as experienced in past). That is a 1% change in frequency gives 1.5% reduction in Load MW (FD 1.5%) . So by the time the first stage operates, the frequency would be 48.8 Hz and loads would be lesser than their nominal value and so requires appropriate correction as explained below.

(FD = 1.5%)

Frequency (A)	Deviation from 50 Hz (B)	% Change in freq (C) = (B/50)*100	% Change in MW (D) = FD*C	Freq Factor correction E =100/(100- D)
48.8	1.2	2.4	3.6	1.037
48.6	1.4	2.8	4.2	1.044
48.2	1.8	3.6	5.4	1.057

Table 1.7 Frequency corrections

6. It is intended to give a load relief of 2000 MW for NEW Grid, but by the time the frequency touches 48.8 Hz, loads have reduced and by giving 2000*1.037 MW (corresponding to old frequency) we get the effect of 2000 MW.
7. Correction for Voltage Dependence of loads: It is also known that loads are voltage dependent. In normal situation this may not be dominant but for larger disturbances this could also play a role in not giving enough load relief. While exact voltage dependencies are generally unknown, it is assumed that 50% loads are sensitive to voltage and 50% sensitive to (voltage)² as a reasonably worst load. That is $P_{L\text{ new}} = P_{L\text{ old}} (0.5*V + 0.5*V^2)$

$$\equiv P_{L\text{ old}} * 0.85$$
assuming voltage falls to say 0.9 pu with system assumed to be integrated
8. Thus the above loads are further corrected by a voltage factor of 1/0.85. For system splits, the voltages fall further, but in such case the more effective protection is df/dt.
9. Seasonal /Daily Load variation factor: Further the ‘load’ on feeder of 100 MW may give ‘average load relief’ of the order of 60-70MW due to daily and seasonal variations, to correct for the combined effects a correction of (100/70) is added.
10. Combining all the above factors, the net AUFLS plan for NEW Grid to raise the frequency by 1 Hz for each AUFLS stage operation is as given in table below :

Assumed power number (P) MW/Hz	Frequency (A)	Freq Factor correction E = 100/(100 - D) (ref prev table)	Voltage Factor Correction F = (1/0.855)	Daily Load Fluctuation Factor G = (1/0.7)	Overall Correction factor H = E*F*G	NEW Required Load relief I = P*H (MW)
2000	48.8	1.037	1.17	1.43	1.73	3460
2000	48.6	1.044	1.17	1.43	1.75	3500
2000	48.2	1.057	1.17	1.43	1.77	3540

Table 1.8 Combined Corrections

11. The NEW Grid comprises of NR, ER, NER and WR regions. The above responsibility is to be shared by all in the ratio of their demands. As per recent data for a NEW Grid demand of 75,000 MW, the ratio of demands of WR is 38%, NR is 44%, ER is 16% and NER is 1% approximately. So pro-rata distribution gives a revised AUFLS scheme as below:

Assumed power number (P) MW/Hz	Frequency (A)	WR (MW)	NR (MW)	ER (MW)	NER (MW)	NEW Required Load relief I = P*H (MW)
2000	48.8	1315	1522	554	35	3460
2000	48.6	1330	1540	560	35	3500
2000	48.2	1345	1558	567	36	3540

Table 1.9 Load relief from AUFLS

12. The distribution of above responsibility of WR between WR constituents is worked out as follows. For July 2012 the WR demands were met by Gujarat (28.8%), MP (17%), Chhattisgarh(7.3%), Maharashtra (43.5%), DD(0.67%), Goa(1.1%) and DNH (1.5%). Accordingly the scheme as per revised AUFLS becomes as shown in table below,(after rounding off decimals)

Constituent	At 48.8 Hz (MW)	At 48.6 Hz (MW)	At 48.2 Hz (MW)	Total (MW)
Gujarat	380	384	389	1153
MP	224	226	229	679
Chhattisgarh	96	97	98	292
Maharashtra	572	579	585	1737
Goa	14	15	15	44
DD	9	9	9	27
DNH	20	20	20	60
WR	1315	1330	1345	3990

Table 1.10 WR Portion of Load relief from AUFLS-Proposed

13. Analysis of df/dt relays and quantum

- a) Earlier a study was done by a sub-group of OCC of NRPC to arrive at df/dt settings for NEW Grid. The group had suggested that df/dt be raised to 49.9 Hz and proposed three rates of 0.1 Hz/s, 0.2 Hz/s and 0.4 Hz/s and the same was adopted.
 - b) As seen from other studies done in WR, past disturbances analysis, it is clear that even for contingencies like loss of largest generating station of NEW grid, df/dt rates will be much smaller than the above and will not pick up, provided system remains in integrated operation. Hence for all such cases AUFLS is the real defense available.
 - c) When system splits like on 30th and 31st July 2012, the regions become isolated (like “old WR”) and the df/dt rates would be higher and relays would pick up.
 - d) As such the df/dt is expected to occur only in such rare cases and the existing scheme had proven in the past for WR and can be kept same.
14. During the discussions in the PCM, Shri U.G. Zalte, Director(Opn), MSETCL suggested that seasonal variations should be accounted for in more rigorous manner. Shri P. Pentayya, GM, WRLDC suggested that df/dt rates may be kept longer to even 200 ms measurement time as per PMU data. Representative from APL stated that newer relays with Discrete FFT principle may be used for df/dt to minimize the errors.
15. These points were discussed and it was agreed that the AUFLS scheme may be implemented as suggested in this chapter. Further review may be done after getting more information about practices being followed in other regions and also any national level policy decisions emerged in the wake of disturbance in NR.

iv) Recommendations to make the above scheme more effective

- AULFS relay setting should be similar across all Regions and shall be periodically checked
- Feeders identified for planned/distress load shedding should be different than those identified for AULFS. Also, feeders identified for different stages of AULFS should be different.
- Feeder for emergency services viz. Railways, Hospitals, Important Buildings, Mines etc. should be separate from rural, agricultural, urban feeders so as to ensure availability of emergency services even under disturbance conditions.
- Quantum of load shedding planned should be around 1.5 times that of load relief required to take care of loading factor across all seasonal variations.
- Load shedding actual relief obtained from other regions should also be discussed in the Monthly OCC meetings.
- Existing df/dt scheme has proven to be working satisfactorily in past and hence no changes is required to be made in the scheme.

Chapter-2

Generation control through Governor mode

2.1 The Committee has reviewed the RGMO performance in WR as presented by WRLDC. WRLDC in their presentation has given the following details:

- a) It was informed that as per eligibility of hydro & thermal units, prescribed in IEGC about 191 No. of units are eligible for participation in RGMO. Out of which 73 No. of units have confirmed their participation. 13 No. of units have been taken up for exemption with CERC by various utilities. About 109 No. of units in various utilities are yet to be made to participate in the RGMO. The details are enclosed at Annexure-2.1(a).
- b) Performance of these units which confirmed their participation has also been presented by WRLDC. On 30-07-12 frequency shot up to 50.96 Hz (frequency trend enclosed at Annexure-2.1(b) when the occurrence took place at 0232 hrs, units in WR have responded in the order of about 1200 MW including manual response (trend enclosed at Annexure-2.1(c). Details of individual units responded is also enclosed at Annexure-2.1(d).
- c) On 30-07-12 at 0339 hrs when start up power was extended to NR from Vindhyachal bypass link, due to fault in the line, 6 no. of units at Vindhyachal tripped (about 2000 MW). Units in WR have only responded with a pick up of generation of 550 MW including manual response. (trend enclosed at Annexure-2.1(e).
- d) On 31-07-12 at 1258 hrs when the system collapse took place in NR, ER & NER, system frequency in WR shot up to 51.46 Hz (trend enclosed at Annexure-2.1(f).
- e) The units in WR responded by lowering their generation to the tune of about 1500 MW (trend enclosed at Annexure-2.1(g).
- f) Response of individual units in RGMO on 31-7-12 is enclosed at Annexure-2.1(h).

2.2 The Committee while noting the above has observed that although the units have responded in the RGMO mode as well as manual response on all the three occasions, it would be essential to bring in complete eligible capacity under RGMO for effectively acting as the safety net in the event of system disturbances.

Accordingly the Committee recommends full Implementation of RGMO in WR expeditiously.

2.3 Committee also reviewed the tripping settings of the generating units under high frequency in view of acute high frequency experienced by WR grid on 31/07/12. It was noted that some of the units did not have high frequency tripping. Few units have alarm at 51.5 Hz and certain units have alarm and tripping at 51.5 Hz. Looking into the disturbances on 30th & 31st July 2012 and on review of RGM performance, the Committee felt that in the event of WR grid getting separated from neighboring regions, WR grid is likely to experience very high frequency along with a high rate of rise in frequency. After deliberations in the Committee, Members suggested that automatic tripping of few Units would help in arresting the rate of rise of frequency and save the system from total collapse. Accordingly, the Committee recommends few units for tripping at 51.5 Hz and directed the same may be identified by WRLDC for approval in OCC forum. Accordingly WRLDC identified the following units for tripping at 51.5 Hz:

1. KSTPS-7 (500 MW)
2. VSTPS-7 (500 MW)
3. CGPL-10 (830 MW) in the OCC forum.

It was decided that NTPC & CGPL will study the various technical aspect of implementing the High frequency trip settings on their Units and would revert to WRPC for taking final decision.

Chapter-3

Review of Black Start/restoration facilities

- 3.1** The Committee reviewed the black start facilities available in WR as presented by WRLDC. The Committee noted that about 30 No. of generating stations in WR are having black start facilities. Further 8 nos. of units have successfully black started during disturbances in the last 10 years. 4 Nos. of stations have undergone black start mock exercise in the last two years.

The Committee also noted that in the recent disturbances of 30 & 31-07-2012, number of units in ER & NR even though tested for mock drill, failed to black start. The list of generating units having black start facilities in WR is enclosed at Annexure-3.1.

- 3.2** The Committee recommends that mock drill exercise of all Units is essential from the point of view of preparedness for black start and to improve the confidence of system operators. Accordingly schedules have been drawn up by the Committee which is enclosed as per Annexure-3.1 and recommends carrying out the black start exercise in all units as per schedules indicated.

- 3.3** The Committee also reviewed the status of present islanding schemes in the constituent States. The Committee felt that the islanding schemes which were earlier functional are presently non functional could be restored back. Islanding schemes for State capitals viz. Bhopal & Raipur need to be developed expeditiously. WRLDC made a basic scheme and in the process of finalisation by interacting with SLDCs and RPC. The constituents can seek the support of RLDC/RPC for any other scheme envisaged by them.

- 3.4** Committee also recommends identification of certain thermal units for extension of start up power for restoration. Schemes for power station islanding have also been prepared by WRLDC and are being circulated to SLDCs/concerned utilities. These would be finalised by SLDC/RLDC/RPC. While focusing on the islanding schemes for captive power plants, the Committee recommends that all the constituents need to identify the captive power plants (more than 100 MW capacity) which can extend start up supply in the respective States. These CPP islanding scheme shall be collected by SLDCs and furnished to WRLDC/RPC.

- 3.5** Issue of identification of synchronizing locations and provision of numerical relays along black start path was also discussed by the Committee. The Committee recommends that it is essential to have synchronizing facilities at some identified stations in each State at 220 kV/132 kV black start paths where part systems can be integrated, speeding up the restoration process. The issue of provision of numerical relays along black start path would enable measurement of voltage magnitudes and angular separation at multiple locations needs to be further deliberated with the constituents and would be taken in PCM.

Chapter-4

Review of Communication facilities

- 4.1** Committee reviewed various communication issues in the light of the two major disturbances. It was noted that WRLDC brought out a telephone directory containing contacts of all executives in WR and at National level. Committee while appreciating the efforts of WRLDC has recommended giving wide publicity of the directory and periodical updation of the same.
- 4.2** WRLDC suggested issuance of messages under two additional categories from their control room to communicate about the ALERT and SOS under emergency conditions of the grid. Appreciating the need for such a communication, the Committee recommends introduction of the above messages.
- 4.3** Committee also reviewed the efforts for enhancement of speech and data communication in WR in the recent past. The Committee noted the following enhancements:
- a) Changing of overhead fibre from underground fibre at Jambuva-Asoj link in Gujarat.
 - b) Extension of fibre at Bhilai-Raipur city for SLDC operation shifting from Bhilai to Raipur.
 - c) Terminal equipment capacity enhancement at Jabalpur & Itarsi for more channels.
 - d) Leased circuit for
 - (i) Jabalpur SLDC-WRLDC
 - (ii) Gotri SLDC-WRLDC
 - (iii) Raipur SLDC-WRLDC (under commissioning)
 - e) Leased circuit from Kalwa SLDC-WRLDC (under process)
 - f) Protection path from Asoj to WRLDC through other circuit. (under process)
- 4.4** The Committee also noted that Video Conferencing equipment was envisaged in the Regional SCADA/EMS upgradation. Committee recommends expeditious placement of award and supply of Video Conferencing equipment at all Load Despatch Centres in the region.
- 4.5** Committee noted that letters of award have been issued for the master communication plan in WR with implementation plan of 24 months. Committee felt that master communication plan finalized in the 14th WRPC meeting was catering to the needs of Western Region. However, Committee recommends that any further suggestions from the constituents could also be intimated for inclusion in the plan.
- 4.6** Committee also recommended to use the internet based audio/video facilities viz. Skype, facebook etc. which are free of cost and readily available to everybody for communicating during normal course and during disturbance.

Chapter-5

Conclusion and recommendations

Review and implementations aspects Automatic Under Frequency Load Shedding (AUFLS) scheme and (df/dt) scheme

5.1 Following revised AULFS scheme for load shedding has been recommended by the Committee which takes care of seasonal location variations on feeders, frequency/voltage dependence of load and non-availability of certain feeders due to outages/planning/distress load shedding:

Constituent	At 48.8 Hz (MW)	At 48.6 Hz (MW)	At 48.2 Hz (MW)	Total (MW)
Gujarat	380	384	389	1153
MP	224	226	229	679
Chhattisgarh	96	97	98	292
Maharashtra	572	579	585	1737
Goa	14	15	15	44
DD	9	9	9	27
DNH	20	20	20	60
WR	1315	1330	1345	3990

5.2 Following df/dt scheme for load shedding has been recommended by the Committee. The scheme/settings are considered to be appropriate eve after NEW grid formation and no revision was envisaged:

Settings	Recommended Load relief MW	Implemented Load Relief MW				
Hz and rate in Hz / sec	WR	GETCO	MPPTCL	MSETCL	CSPTCL	TPC
49.9 Hz/ 0.1(Stg I)	2000	1006	361	546	27	60
49.9 Hz/ 0.1(Stg I)	2000	905	355	621	37	82
49.9 Hz/ 0.1(Stg I)	2472	1001	392	686	120	273
TOTAL	6472	2912	1108	1853	184	415

5.3 Following additional recommendations have been made to make above schemes more effective :

- AULFS relay setting should be similar across all Regions and shall be periodically checked
- Feeders identified for planned/distress load shedding should be different than those identified for AULFS. Also, feeders identified for different stages of AULFS should be different.
- Feeder for emergency services viz. Airports, Railways, Hospitals, Important Buildings, Mines etc. should be separate from rural, agricultural, urban feeders

so as to ensure availability of emergency services even under disturbance conditions.

- Load shedding actual relief obtained from other regions should also be discussed in the Monthly OCC meetings after sharing of load shedding data inter-RPCs.
- Existing df/dt scheme has proven to be working satisfactorily in past and hence no changes is required to be made in the scheme.

Generation control through Governor mode

5.4 Committee recommended to bring in complete eligible capacity under RGMO for effectively acting as the safety net in the event of system disturbances.

Review of Black Start/restoration facilities

5.5 Committee recommended that as per the clause no 5.2(f) of the IEGC all thermal generating units of 200 MW and above and all hydro units of 10 MW and above, which are synchronized with the grid, irrespective of their ownership, shall have their governors in operation at all times. Committee recommended carrying out the black start exercise in all units as per schedules finalised.

5.6 Committee felt that the islanding schemes which were earlier functional are presently non functional could be restored back. Islanding schemes for State capitals viz. Bhopal & Raipur need to be developed expeditiously.

5.7 Committee recommended for identification of certain thermal units and captive power plant (more than 100 MW) for extension of start up power for restoration. Committee recommended for expeditious completion of schemes for power station including CPP islanding to be finalised by SLDC/RLDC/RPC.

5.8 The Committee recommended to provide synchronizing facilities at some identified stations in each State at 220 kV/132 kV black start paths where part systems can be integrated, speeding up the restoration process. Also, provision of numerical relays along black start path for enabling measurement of voltage magnitudes and angular separation at multiple locations needs need to be ascertained.

Review of Communication facilities

5.9 Committee appreciated the suggestion of WRLDC for issuance of messages under two additional categories namely ALERT and SOS from their control room under emergency conditions of the grid.

5.10 The Committee noted the following enhancements of speech and data communication:

- a) Changing of overhead fibre from underground fibre at Jambuva-Asoj link in Gujarat.
- b) Extension of optic fibre at Bhilai-Raipur city for SLDC operation shifting from Bhilai to Raipur.
- c) Terminal equipment capacity enhancement at Jabalpur & Itarsi for more channels.
- d) Leased circuit for
 - (i) Jabalpur SLDC-WRLDC
 - (ii) Gotri SLDC-WRLDC
 - (iii) Raipur SLDC-WRLDC (under commissioning)
- e) Leased circuit from Kalwa SLDC-WRLDC (under process)
- f) Protection path from Asoj to WRLDC through other circuit (under process)

- 5.11** Committee recommended expeditious placement of award and supply of Video Conferencing equipment at all Load Despatch Centres in the region.
- 5.12** Committee recommended that any further suggestions from the constituents could also be intimated for inclusion in the master communication plan.
- 5.13** Committee also recommended to use the internet based audio/video facilities viz. Skype, facebook etc. which are free of cost and readily available to everybody for communicating during normal course and during disturbance.
- 5.14** Committee also recommended the operator conversation has be to clear and mutually understandable termininology.
- 5.15** The system visualisation should be able to detect the system splitting/islanding etc.

5.16 Other Recommendations

A. Defense Mechanism for high frequency

Following units were identified for automatic tripping at high frequency (51.5 Hz) to help arresting the rise of frequency :

1. KSTPS-7 (500 MW)
2. VSTPS-7 (500 MW)
3. CGPL-10 (830 MW)

B. SPS for Agra -Gwalior

Committee recommended following Units in WR were to be considered for backing down to the tune of 500 MW in the event of tripping of Agra-Gwalior lines and Bina-Gwalior lines :

- i) Korba, Sipat, Vindhyachal STPS to control power flow towards ER
- ii) CGPL & SSP* to control power flow in Zerda-Bhinmal-Kankroli lines
- iii) JP Bina to control power flow in Bina-Mehgaon-Gwalior lines &
- iv) ISP* to control power flow in Badod-Kota-modak lines

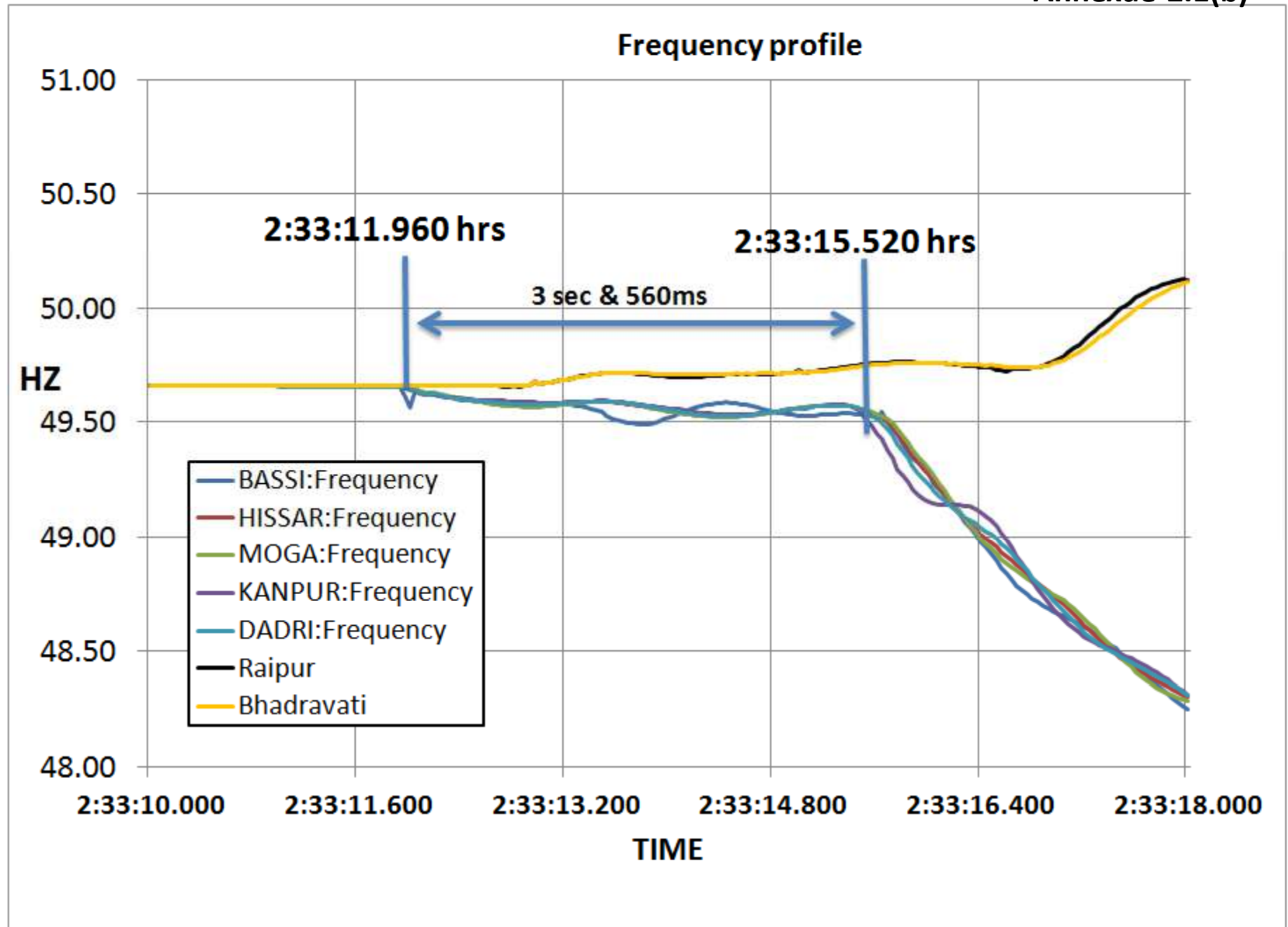
**Since SSP and ISP are hydro units and may not be always available, Committee recommended backing down at Korba, Sipat, Vindhyachal, CGPL and JP Bina.*

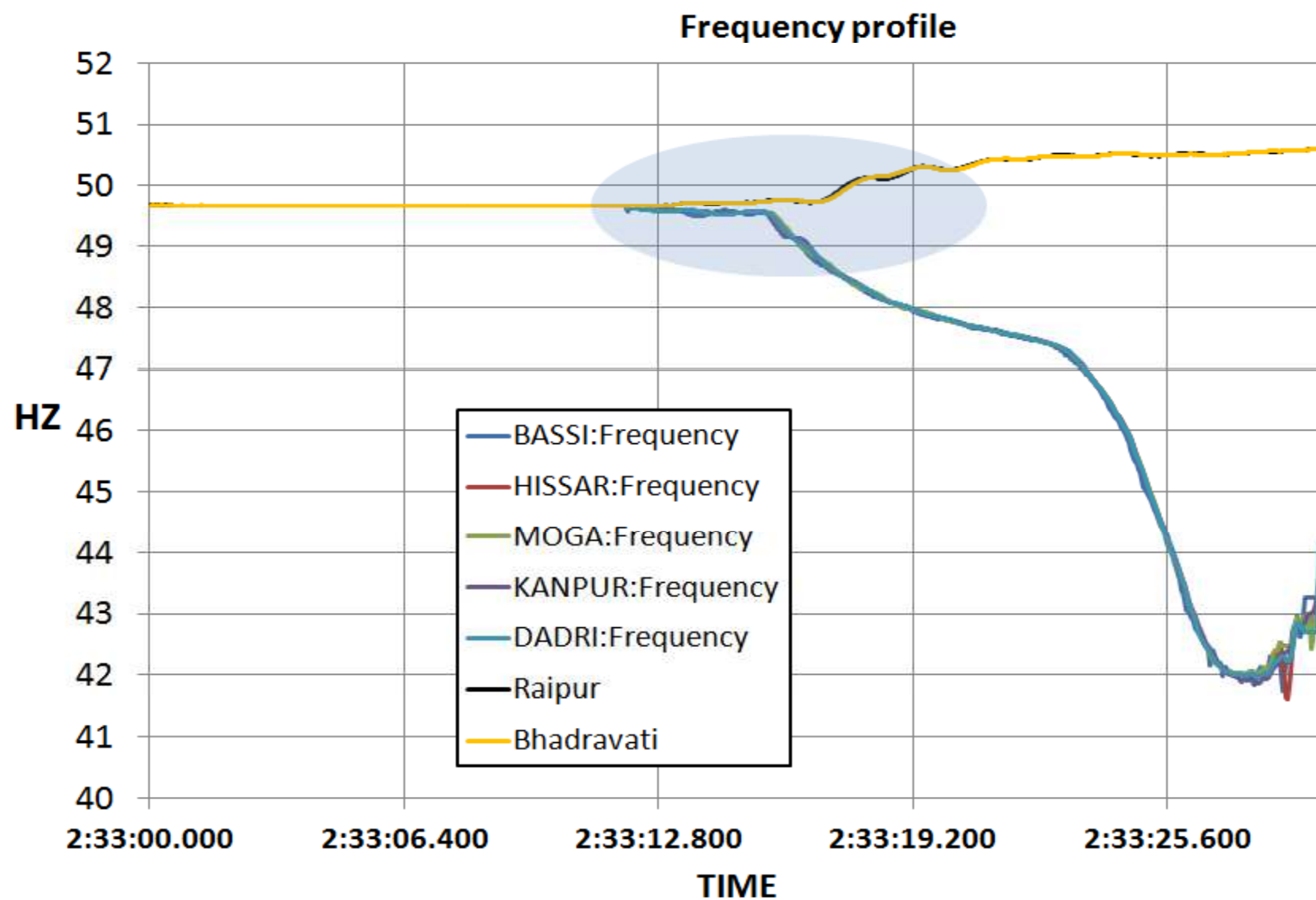
Eligible Units under RGMO

Sr No	Utility/Generator	Power Station	Hydro(H)/Thermal(T)	Unit No	Unit Capacity in MW	GOVERNOR TYPE MHG/EHG	Status of the unit as informed by Gen.	Telemetry status.
1	NTPC	CS_KSTPS	THERMAL	1	200	EHG	IN	YES
2	NTPC	CS_KSTPS	THERMAL	2	200	EHG	IN	YES
3	NTPC	CS_KSTPS	THERMAL	3	200	EHG	IN	YES
4	NTPC	CS_KSTPS	THERMAL	4	500	EHG	IN	YES
5	NTPC	CS_KSTPS	THERMAL	5	500	EHG	IN	YES
6	NTPC	CS_KSTPS	THERMAL	6	500	EHG	IN	YES
7	NTPC	CS_KSTPS	THERMAL	7	500	EHG	OUT	YES
8	NTPC	CS_VSTPS	THERMAL	7	500	EHG	IN	YES
9	NTPC	CS_VSTPS	THERMAL	8	500	EHG	IN	YES
10	NTPC	CS_VSTPS	THERMAL	9	500	EHG	IN	YES
11	NTPC	CS_VSTPS	THERMAL	10	500	EHG	IN	YES
12	NTPC	CS_SIPAT-I	THERMAL	4	500	EHG	OUT	YES
13	NTPC	CS_SIPAT-I	THERMAL	5	500	EHG	IN	YES
14	NTPC	CS_SIPAT-II	THERMAL	1	660	MHG/EHG	OUT	YES
15	NCA	CS_RBPH	HYDRO	1	200	EHG	IN	YES
16	NCA	CS_RBPH	HYDRO	2	200	EHG	IN	YES
17	NCA	CS_RBPH	HYDRO	3	200	EHG	IN	YES
18	NCA	CS_RBPH	HYDRO	4	200	EHG	IN	YES
19	NCA	CS_RBPH	HYDRO	5	200	EHG	IN	YES
20	NCA	CS_RBPH	HYDRO	6	200	EHG	IN	YES
21	GUJRAT	GJ_UKAIHYD	HYDRO	1	75	EHG	EX APPLIED	YES
22	GUJRAT	GJ_UKAIHYD	HYDRO	2	75	EHG	EX APPLIED	YES
23	GUJRAT	GJ_UKAIHYD	HYDRO	3	75	EHG	EX APPLIED	YES
24	GUJRAT	GJ_UKAIHYD	HYDRO	4	75	EHG	EX APPLIED	YES
25	GUJRAT	GJ_KADANAHD	HYDRO	1	60	EHG	EX APPLIED	YES
26	GUJRAT	GJ_KADANAHD	HYDRO	2	60	EHG	EX APPLIED	YES
27	GUJRAT	GJ_KADANAHD	HYDRO	3	60	EHG	EX APPLIED	YES
28	GUJRAT	GJ_KADANAHD	HYDRO	4	60	EHG	EX APPLIED	YES
29	GUJRAT	GJ_GANDHINGR	THERMAL	3	210	EHG	IN	YES
30	GUJRAT	GJ_GANDHINGR	THERMAL	4	210	EHG	IN	YES
31	GUJRAT	GJ_GANDHINGR	THERMAL	5	210	EHG	IN	YES
32	GUJRAT	GJ_WANAKBORI	THERMAL	4	210	EHG	IN	YES
33	GUJRAT	GJ_WANAKBORI	THERMAL	5	210	EHG	IN	YES
34	GUJRAT	GJ_WANAKBORI	THERMAL	6	210	EHG	IN	YES
35	GUJRAT	GJ_WANAKBORI	THERMAL	7	210	EHG	IN	YES
36	M.P.	MP_PENCH	HYDRO	1	80	EHG	OUT	YES
37	M.P.	MP_PENCH	HYDRO	2	80	EHG	OUT	YES
38	M.P.	MP_BARGI	HYDRO	1	45	EHG	OUT	YES
39	M.P.	MP_BARGI	HYDRO	2	45	EHG	OUT	YES
40	M.P.	MP_BIRSINGPUR	HYDRO	1	20	EHG	OUT	YES
41	M.P.	MP_INDIRASGR	HYDRO	1	125	EHG	IN	YES
42	M.P.	MP_INDIRASGR	HYDRO	2	125	EHG	IN	YES
43	M.P.	MP_INDIRASGR	HYDRO	3	125	EHG	IN	YES
44	M.P.	MP_INDIRASGR	HYDRO	4	125	EHG	IN	YES
45	M.P.	MP_INDIRASGR	HYDRO	5	125	EHG	IN	YES
46	M.P.	MP_INDIRASGR	HYDRO	6	125	EHG	IN	YES
47	M.P.	MP_INDIRASGR	HYDRO	7	125	EHG	IN	YES
48	M.P.	MP_INDIRASGR	HYDRO	8	125	EHG	IN	YES
49	M.P.	MP_BANSAGAR-III	HYDRO	1	15	EHG	IN	YES
50	M.P.	MP_BANSAGAR-III	HYDRO	2	15	EHG	IN	YES
51	M.P.	MP_BANSAGAR-III	HYDRO	3	15	EHG	IN	YES
52	M.P.	MP_MADHIKHEDA	HYDRO	1	20	EHG	OUT	YES
53	M.P.	MP_MADHIKHEDA	HYDRO	2	20	EHG	OUT	YES
54	M.P.	MP_MADHIKHEDA	HYDRO	3	20	EHG	OUT	YES
55	M.P.	MP_GANDHISAGAR	HYDRO	1	23	MHG	OUT	YES
56	M.P.	MP_GANDHISAGAR	HYDRO	2	23	MHG	OUT	YES
57	M.P.	MP_GANDHISAGAR	HYDRO	3	23	MHG	OUT	YES
58	M.P.	MP_GANDHISAGAR	HYDRO	4	23	MHG	OUT	YES
59	M.P.	MP_GANDHISAGAR	HYDRO	5	23	MHG	OUT	YES
60	M.P.	MP_OMKSHWR	HYDRO	1	65		OUT	YES
61	M.P.	MP_OMKSHWR	HYDRO	2	65		OUT	YES
62	M.P.	MP_OMKSHWR	HYDRO	3	65		OUT	YES
63	M.P.	MP_OMKSHWR	HYDRO	4	65		OUT	YES

Sr No	Utility/Generator	Power Station	Hydro(H)/Thermal(T)	Unit No	Unit Capacity in MW	GOVERNOR TYPE MHG/EHG	Status of the unit as informed by Gen.	Telemetry status.
64	M.P.	MP_OMKSHWR	HYDRO	5	65		OUT	YES
65	M.P.	MP_OMKSHWR	HYDRO	6	65		OUT	YES
66	M.P.	MP_OMKSHWR	HYDRO	7	65		OUT	YES
67	M.P.	MP_OMKSHWR	HYDRO	8	65		OUT	YES
68	M.P.	MP_AMARKANTAK	THERMAL	5	210	EHG	OUT	YES
69	M.P.	MP_SGTPS	THERMAL	1	210	EHG	OUT	YES
70	M.P.	MP_SGTPS	THERMAL	2	210	EHG	OUT	YES
71	M.P.	MP_SGTPS	THERMAL	3	210	EHG	OUT	YES
72	M.P.	MP_SGTPS	THERMAL	4	210	EHG	OUT	YES
73	M.P.	MP_SGTPS	THERMAL	5	500	EHG	IN	YES
74	Chhattisgarh	CH_HAS_BANGO	HYDRO	1	40	EHG	EX Applied	YES
75	Chhattisgarh	CH_HAS_BANGO	HYDRO	2	40	EHG	EX Applied	YES
76	Chhattisgarh	CH_HAS_BANGO	HYDRO	3	40	EHG	EX Applied	YES
77	Chhattisgarh	CH_KORBAWEST	THERMAL	1	210	EHG	EX Applied	YES
78	Chhattisgarh	CH_KORBAWEST	THERMAL	2	210	EHG	EX Applied	YES
79	Chhattisgarh	CH_KORBAWEST	THERMAL	3	210	EHG	EX Applied	YES
80	Chhattisgarh	CH_KORBAWEST	THERMAL	4	210	EHG	EX Applied	YES
81	Chhattisgarh	CH_KORBAEASTEXT	THERMAL	1	250	EHG	IN	YES
82	Chhattisgarh	CH_KORBAEASTEXT	THERMAL	2	250	EHG	IN	YES
83	Maharashtra	MS_KOYNA1_2	HYDRO	1	70		IN	YES
84	Maharashtra	MS_KOYNA1_2	HYDRO	2	70		IN	YES
85	Maharashtra	MS_KOYNA1_2	HYDRO	3	70		IN	YES
86	Maharashtra	MS_KOYNA1_2	HYDRO	4	70		IN	YES
87	Maharashtra	MS_KOYNA1_2	HYDRO	5	80		IN	YES
88	Maharashtra	MS_KOYNA1_2	HYDRO	6	80		IN	YES
89	Maharashtra	MS_KOYNA1_2	HYDRO	7	80		IN	YES
90	Maharashtra	MS_KOYNA1_2	HYDRO	8	80		IN	YES
91	Maharashtra	MS_KOYNA3-9	HYDRO	9	80		OUT	YES
92	Maharashtra	MS_KOYNA3-10	HYDRO	10	80		OUT	YES
93	Maharashtra	MS_KOYNA3-11	HYDRO	11	80		OUT	YES
94	Maharashtra	MS_KOYNA3-12	HYDRO	12	80		OUT	YES
95	Maharashtra	MS_KOYNA4-1	HYDRO	1	250		OUT	YES
96	Maharashtra	MS_KOYNA4-2	HYDRO	2	250		OUT	YES
97	Maharashtra	MS_KOYNA4-3	HYDRO	3	250		OUT	YES
98	Maharashtra	MS_KOYNA4-4	HYDRO	4	250		OUT	YES
99	Maharashtra	MS_KOYNA DPH-1	HYDRO	1	20		OUT	YES
100	Maharashtra	MS_KOYNA DPH-2	HYDRO	2	20		OUT	YES
101	Maharashtra	MS_BHIRA TR	HYDRO	1	40		OUT	YES
102	Maharashtra	MS_BHIRA TR	HYDRO	2	40		OUT	YES
103	Maharashtra	MS_VAITERNA	HYDRO	1	60	EHG	OUT	YES
104	Maharashtra	MS_TILLARY	HYDRO	1	60	EHG	OUT	YES
105	Maharashtra	MS_CHANDRAPUR	THERMAL	5	500	EHG	OUT	YES
106	Maharashtra	MS_CHANDRAPUR	THERMAL	6	500	EHG	OUT	YES
107	Maharashtra	MS_CHANDRAPUR	THERMAL	7	500	EHG	IN	YES
108	Maharashtra	MS_KORADI	THERMAL	5	200		IN	YES
109	Maharashtra	MS_KORADI	THERMAL	6	210		OUT	YES
110	Maharashtra	MS_KORADI	THERMAL	7	210		OUT	YES
111	Maharashtra	MS_NASIK	THERMAL	3	210		OUT	YES
112	Maharashtra	MS_NASIK	THERMAL	4	210		IN	YES
113	Maharashtra	MS_NASIK	THERMAL	5	210		OUT	YES
114	Maharashtra	MS_KAPERKHEDA	THERMAL	1	210	EHG	OUT	YES
115	Maharashtra	MS_KAPERKHEDA	THERMAL	2	210	EHG	OUT	YES
116	Maharashtra	MS_KAPERKHEDA	THERMAL	3	210	EHG	OUT	YES
117	Maharashtra	MS_KAPERKHEDA	THERMAL	4	210	EHG	OUT	YES
118	Maharashtra	MS_PARLI	THERMAL	3	210		OUT	YES
119	Maharashtra	MS_PARLI	THERMAL	4	210		OUT	YES
120	Maharashtra	MS_PARLI	THERMAL	5	210		OUT	YES
121	Maharashtra	MS_PARLI-EX	THERMAL	1	250		OUT	YES
122	Maharashtra	MS_PARLI-EX	THERMAL	2	250		OUT	YES
123	Maharashtra	MS_BHUSAWAL	THERMAL	2	210		OUT	YES
124	Maharashtra	MS_BHUSAWAL	THERMAL	3	210		OUT	YES
125	Maharashtra	MS_PARAS-EX	THERMAL	1	250	EHG	OUT	YES
126	Maharashtra	MS_PARAS-EX	THERMAL	2	250	EHG	OUT	YES
127	Mah_Tata	MS_TATA_BHIRA PSS	HYDRO	1	150	EHG	OUT	YES
128	Mah_Tata	MS_TROMBAY	THERMAL	5	500	EHG	IN	YES
129	Mah_Tata	MS_TROMBAY	THERMAL	6	500	EHG	IN	YES
130	Mah_Tata	MS_TROMBAY	THERMAL	8	250	EHG	OUT	YES

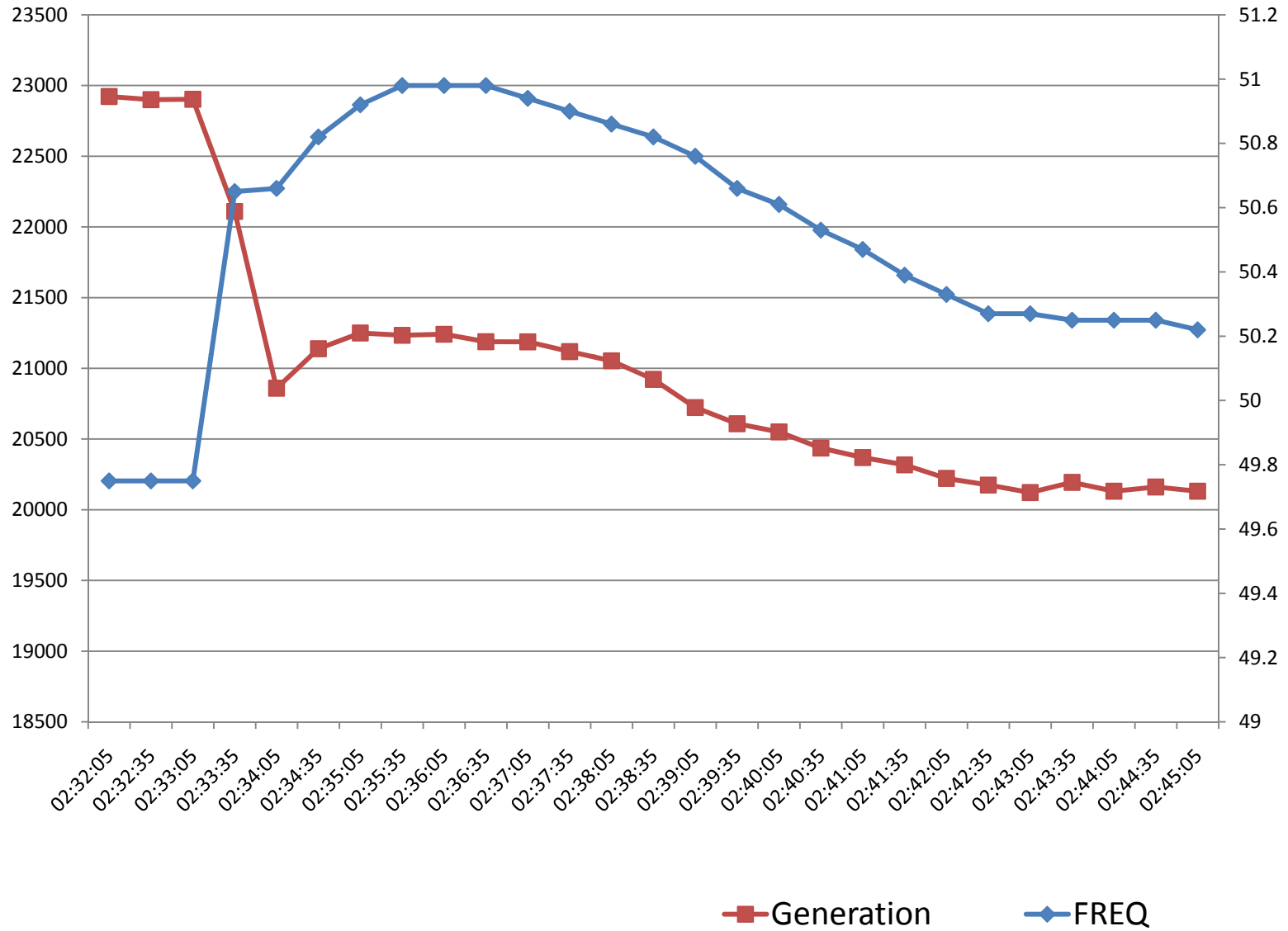
Sr No	Utility/Generator	Power Station	Hydro(H)/Thermal(T)	Unit No	Unit Capacity in MW	GOVERNOR TYPE MHG/EHG	Status of the unit as informed by Gen.	Telemetry status.
133	Mah_JSW	MS_JAIGAD	THERMAL	1	300	EHG	IN	YES
134	Mah_JSW	MS_JAIGAD	THERMAL	2	300	EHG	IN	YES
135	Mah_JSW	MS_JAIGAD	THERMAL	3	300	EHG	IN	YES
136	Mah_JSW	MS_JAIGAD	THERMAL	4	300	EHG	IN	YES
137	IPP	IP_JINDAL	THERMAL	1	250	EHG	IN	YES
138	IPP	IP_JINDAL	THERMAL	2	250	EHG	IN	YES
139	IPP	IP_JINDAL	THERMAL	3	250	EHG	IN	YES
140	IPP	IP_JINDAL	THERMAL	4	250	EHG	IN	YES
141	IPP	IP_NSPCL	THERMAL	1	250	EHG	IN	YES
142	IPP	IP_NSPCL	THERMAL	2	250	EHG	IN	YES
143	IPP	IP_LANCO	THERMAL	1	300	EHG	IN	YES
144	IPP	IP_LANCO	THERMAL	2	300	EHG	IN	YES
145	IPP	IP_APL	THERMAL	1	330	EHG	IN	YES
146	IPP	IP_APL	THERMAL	2	330	EHG	IN	YES
147	IPP	IP_APL	THERMAL	3	330	EHG	IN	YES
148	IPP	IP_APL	THERMAL	4	330	EHG	IN	YES
149	IPP	IP_APL	THERMAL	5	660	EHG	IN	YES
150	IPP	IP_APL	THERMAL	6	660	EHG	IN	YES
151	IPP	IP_APL	THERMAL	7	660	EHG	IN	YES
152	IPP	IP_APL	THERMAL	8	660	EHG	IN	YES
153	IPP	IP_APL	THERMAL	9	660	EHG	IN	YES
154	UMPP	TATA-Mundra	THERMAL	1	830	EHG	OUT	YES
155	NCA	CHPH	HYDRO	1	50	EHG	EX Applied	NO
156	NCA	CHPH	HYDRO	2	50	EHG	EX Applied	NO
157	NCA	CHPH	HYDRO	3	50	EHG	EX Applied	NO
158	NCA	CHPH	HYDRO	4	50	EHG	EX Applied	NO
159	NCA	CHPH	HYDRO	5	50	EHG	EX Applied	NO
160	M.P.	Birsingpur-IV	HYDRO	1	10		OUT	NO
161	M.P.	Rajghat	HYDRO	1	15		OUT	NO
162	M.P.	Rajghat	HYDRO	2	15		OUT	NO
163	M.P.	Rajghat	HYDRO	3	15		OUT	NO
164	Maharashtra	Ghatghar	HYDRO	1	125		No info	NO
165	Maharashtra	Ghatghar	HYDRO	2	125		No info	NO
166	Maharashtra	Bhatghar	HYDRO	1	16		OUT	NO
167	Maharashtra	Paithan	HYDRO	1	12		OUT	NO
168	Maharashtra	BHANDARDARA	HYDRO	1	12	EHG	OUT	NO
169	Maharashtra	BHANDARDARA	HYDRO	2	34	EHG	OUT	NO
170	Maharashtra	DUDHGANGA	HYDRO	1	12		OUT	NO
171	Maharashtra	DUDHGANGA	HYDRO	2	12		OUT	NO
172	Maharashtra	PAWANA	HYDRO	1	10		OUT	NO
173	Maharashtra	BHATSA	HYDRO	1	15		OUT	NO
174	Maharashtra	UJJANI	HYDRO	1	12		OUT	NO
175	Mah_Tata	Bhivpuri	HYDRO	1	24		IN	NO
176	Mah_Tata	Bhivpuri	HYDRO	2	24		IN	NO
177	Mah_Tata	Bhivpuri	HYDRO	3	24		IN	NO
178	Mah_Tata	Bhivpuri	HYDRO	4	12		IN	NO
179	Mah_Tata	Bhivpuri	HYDRO	5	12		IN	NO
180	Mah_Tata	Bhira	HYDRO	1	25		IN	NO
181	Mah_Tata	Bhira	HYDRO	2	25		IN	NO
182	Mah_Tata	Bhira	HYDRO	3	25		IN	NO
183	Mah_Tata	Bhira	HYDRO	4	25		IN	NO
184	Mah_Tata	Bhira	HYDRO	5	25		IN	NO
185	Mah_Tata	Bhira	HYDRO	6	25		IN	NO
186	Guj-IPP	ESAAR Vadinar	THERMAL	1	600		No info	Yes
187	Guj-IPP	ESAAR Vadinar	THERMAL	2	600		No info	Yes
188	M.P.-JBTPP	JB TPP	THERMAL	1	250		No info	Yes
189	NTPC	CS_SIPAT-II	THERMAL	2	660		No info	Yes
190	NTPC	CS_SIPAT-II	THERMAL	3	660		No info	Yes
191	UMPP	TATA-Mundra	THERMAL	2	830		No info	Yes



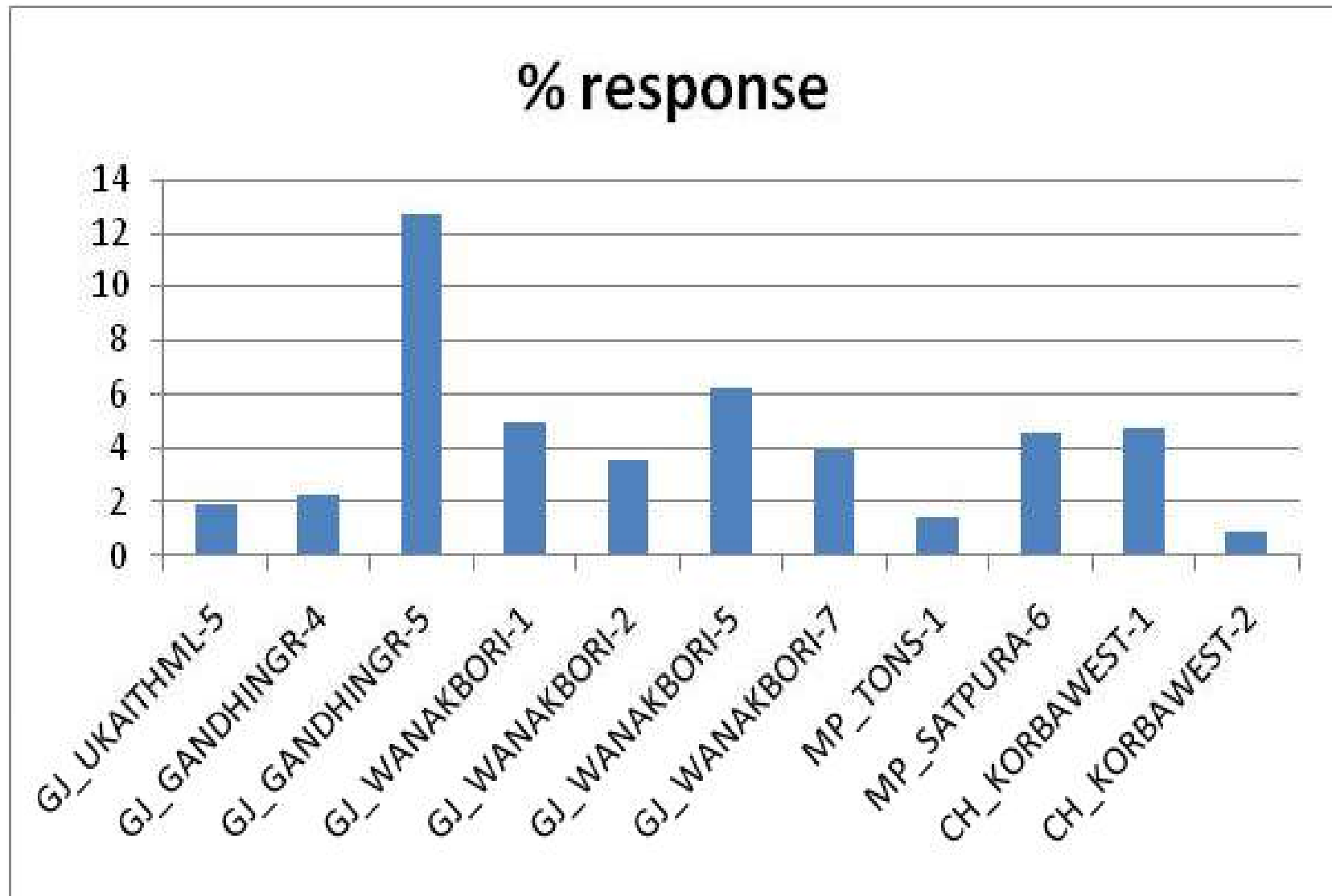


30.07.2012

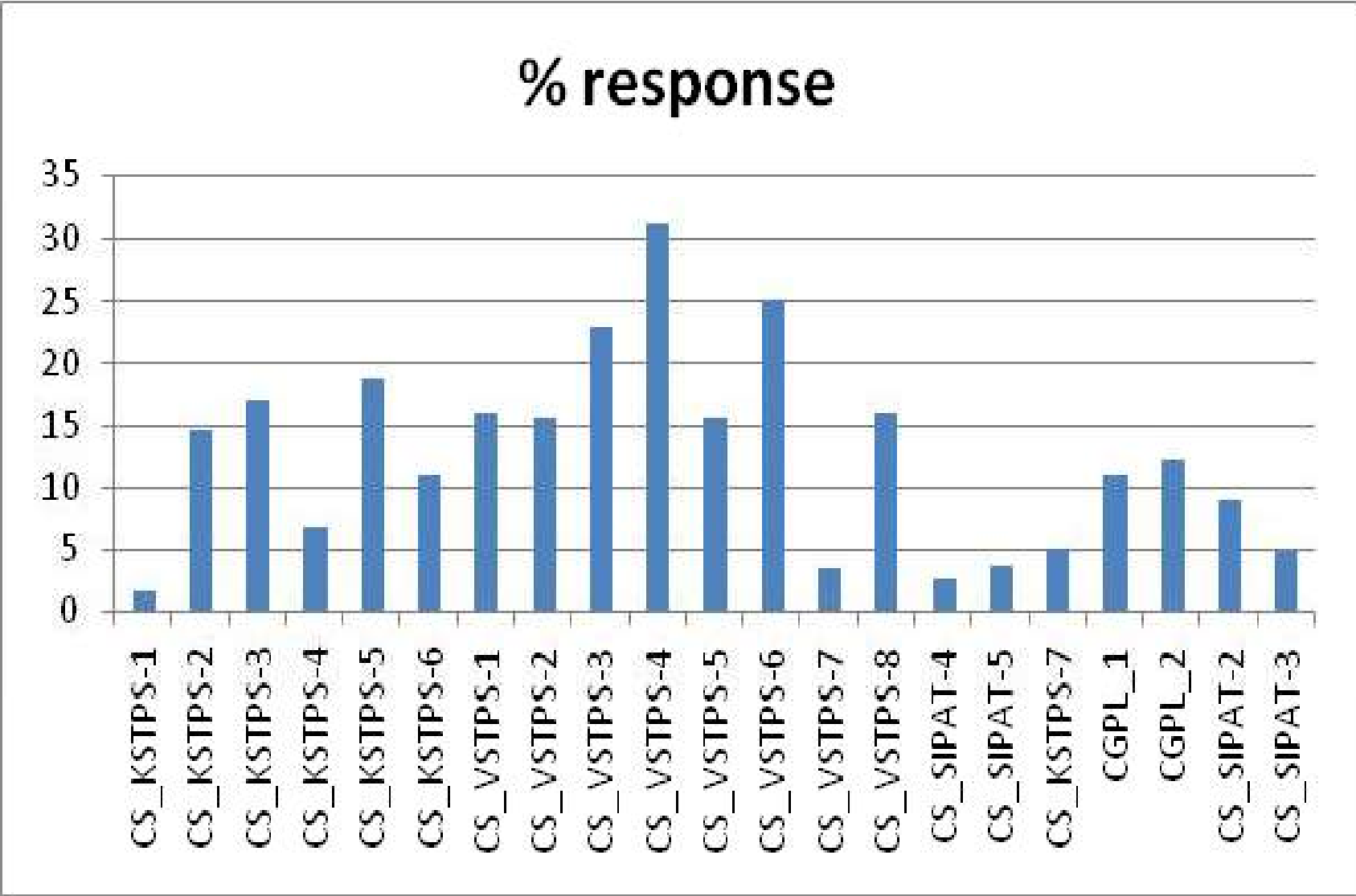
Annexure-2.1(c)



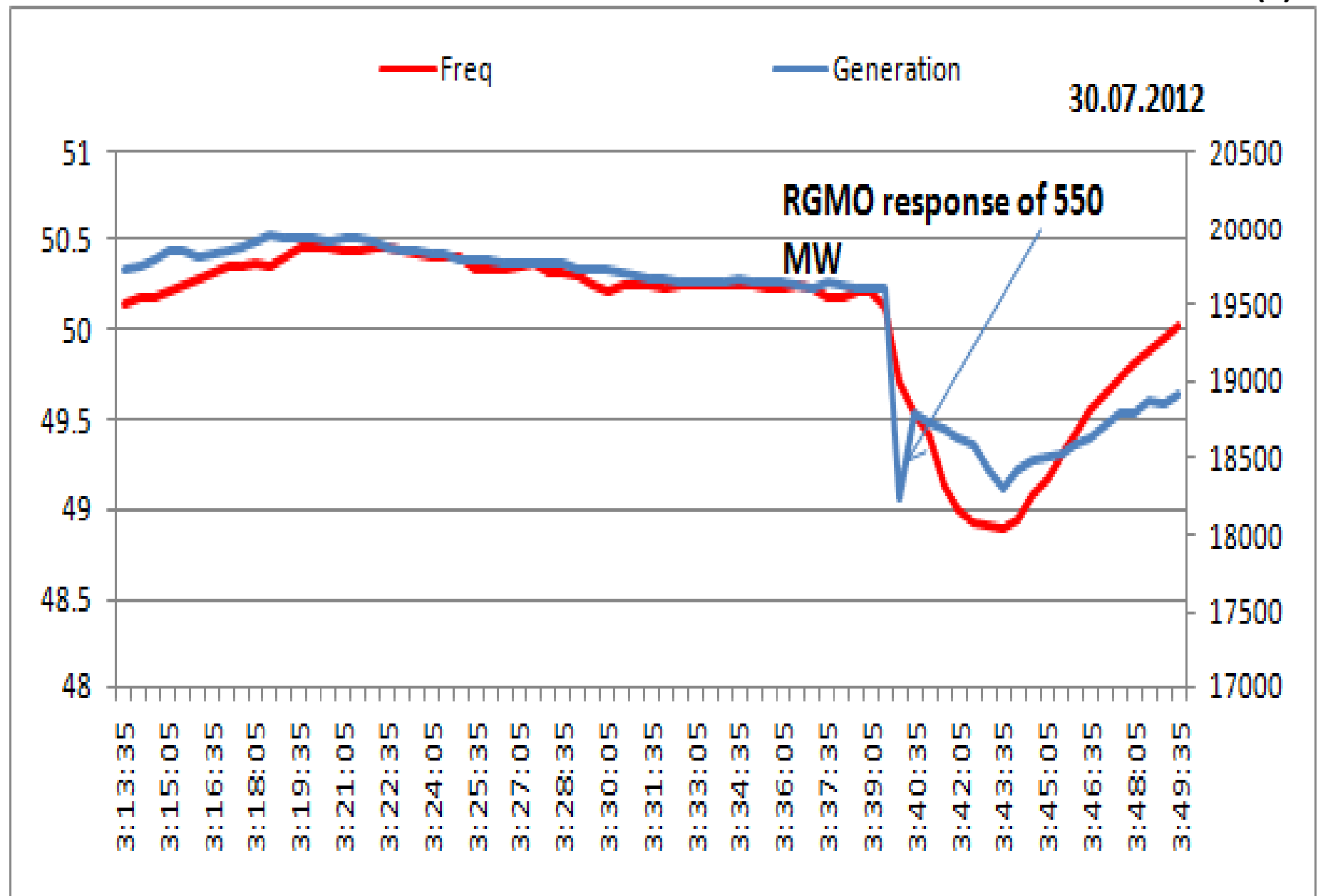
Annexure-2.1(d)



Annexure-2.1(d)

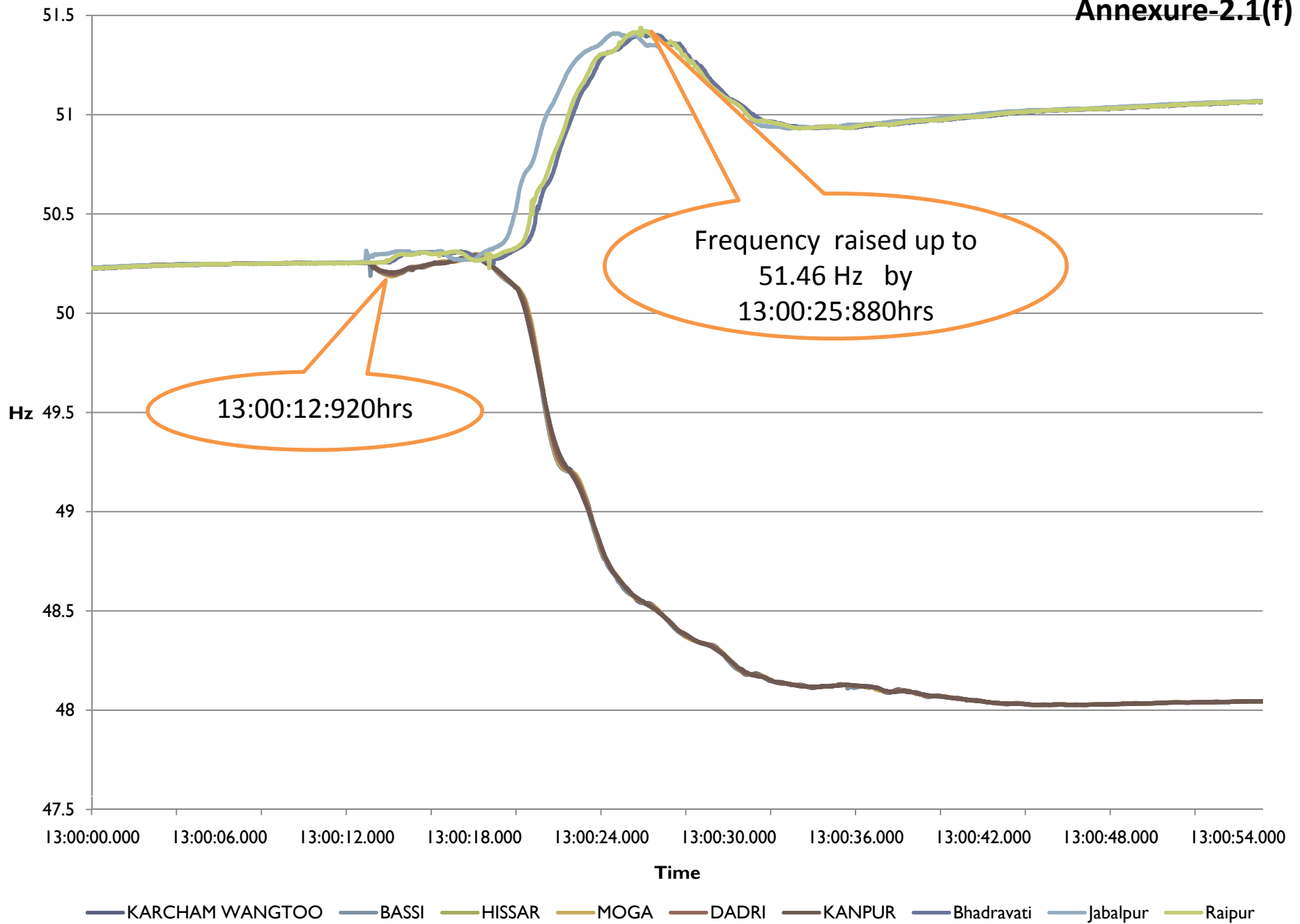


Annexure-2.1(e)



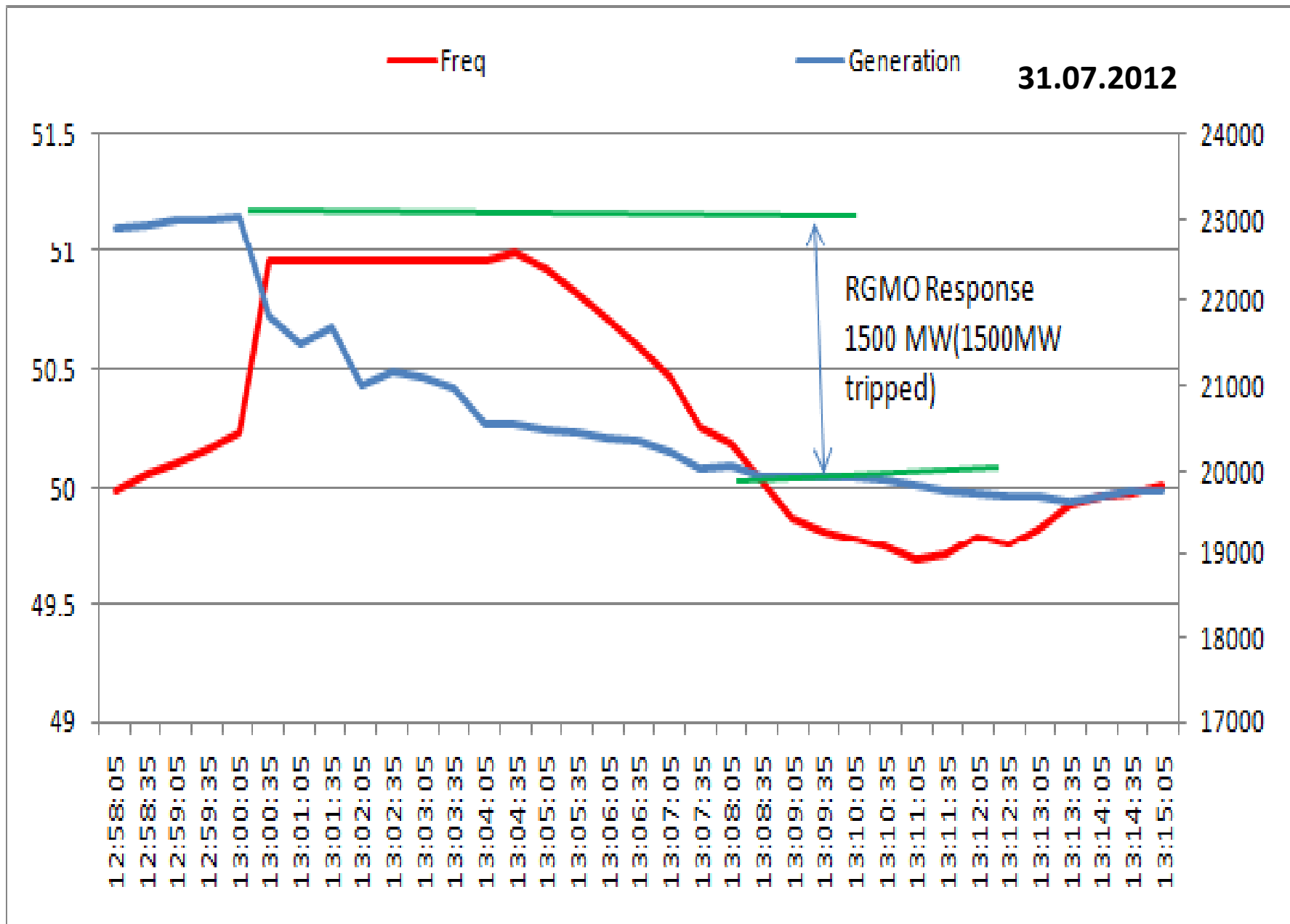
Frequency Plots for 31.07.12

Annexure-2.1(f)

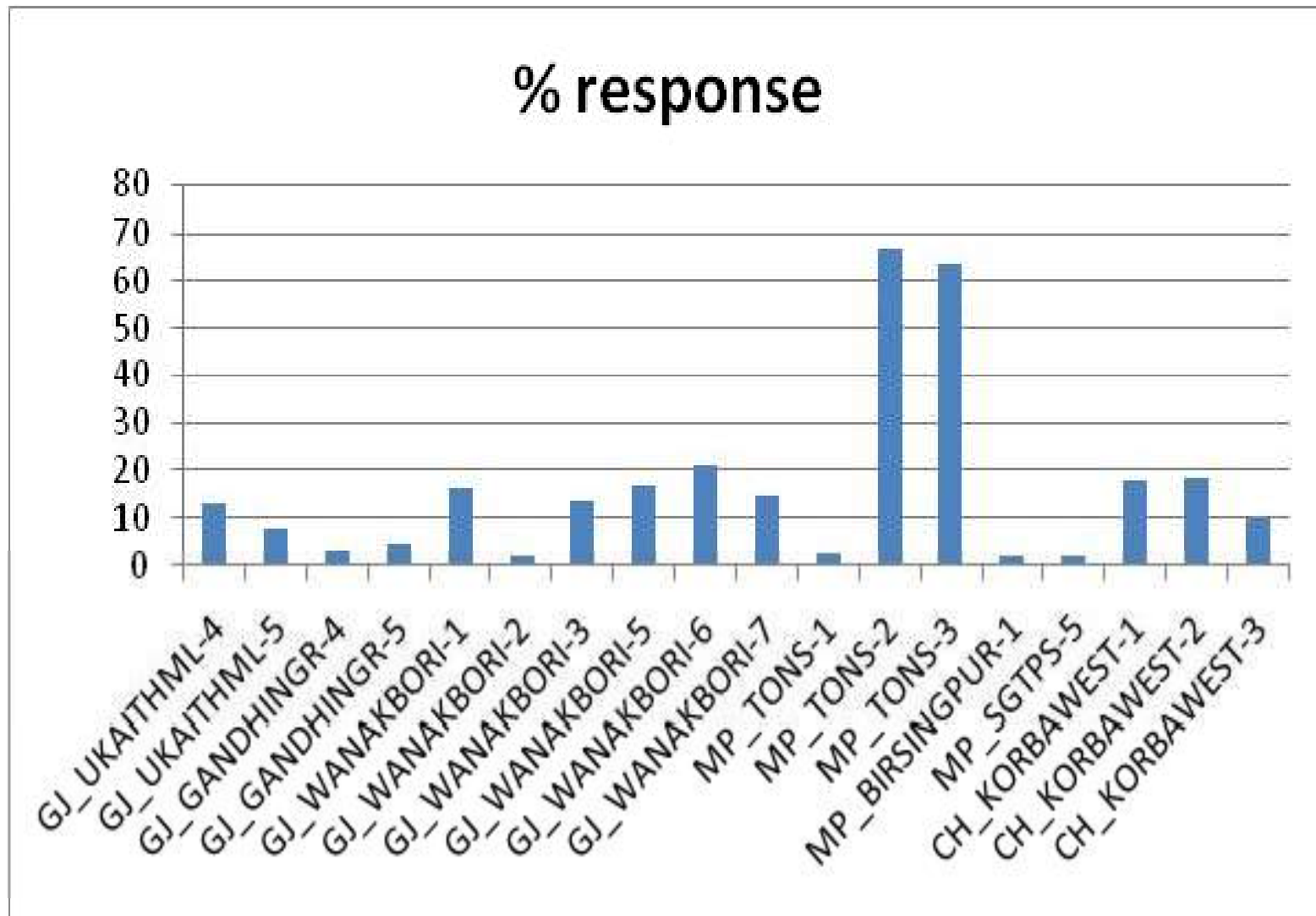


Annexure-2.1(g)

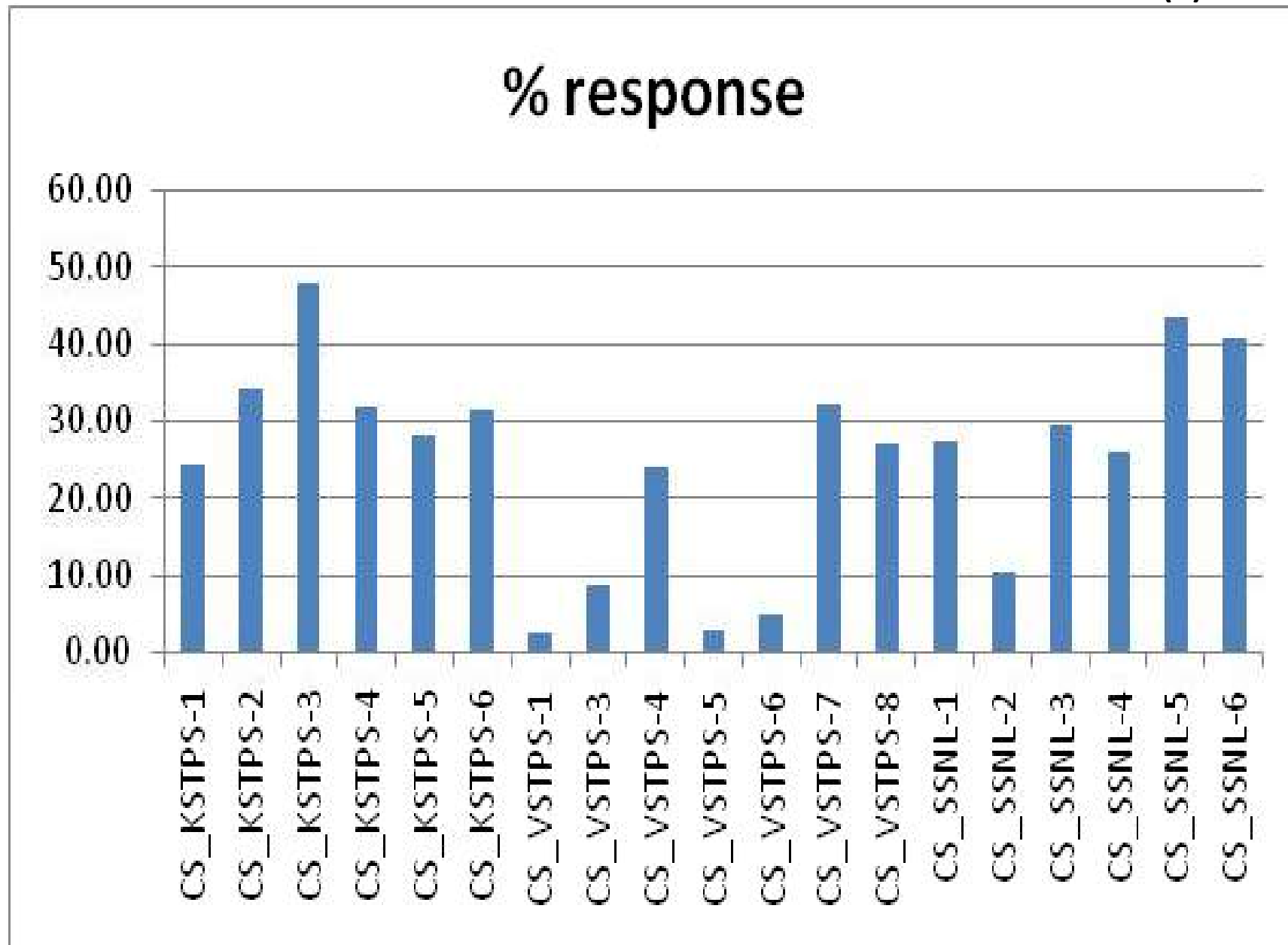
31.07.2012



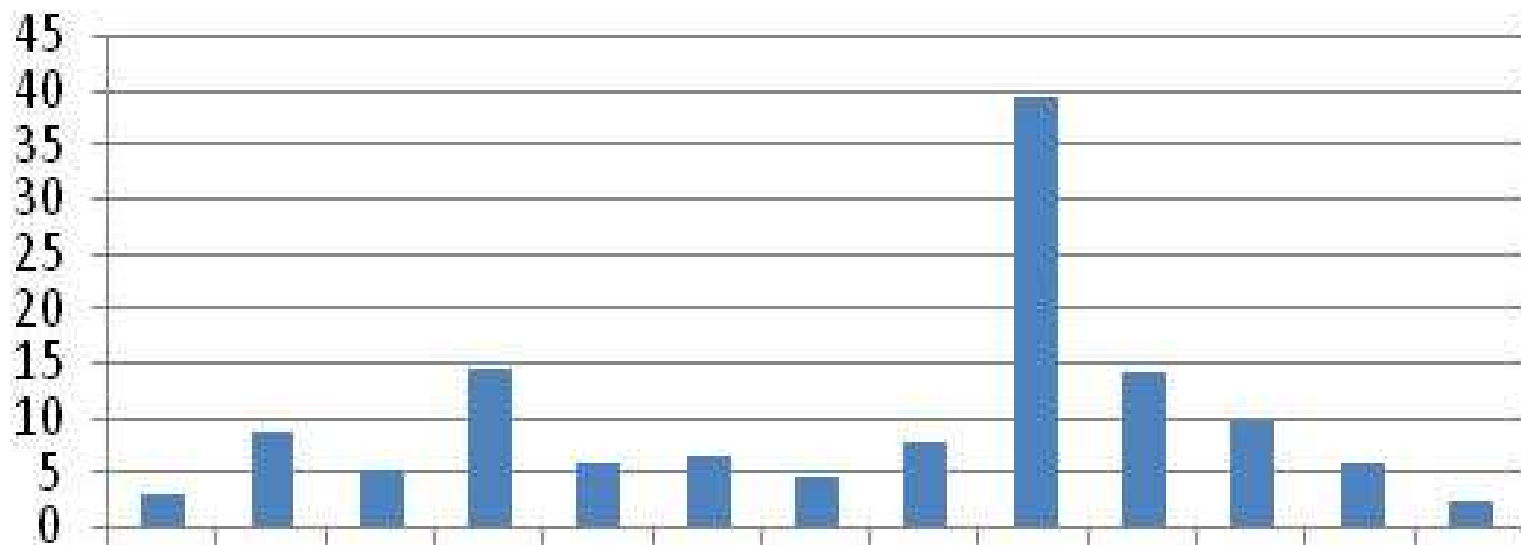
Annexure-2.1(h)



Annexure-2.1(h)



% response



MS_CHANDRAPUR-D
MS_CHANDRAPUR-E
MS_BHUSAWAL-3
IP_JINDAL-1
IP_JINDAL-2
IP_JINDAL-3
IP_NSPCL-1
IP_NSPCL-2
IP_ADANI-1
IP_ADANI-2
CS_KSTPS-7
IP_ADANI-5
MS_JAIGAD-1

Annexure-3.1
1. Tentative Schedule for Mock- Drill of Units with Black Start Facility in Western Region

Sl.No.	Power Station	Installed Cap. (MW)	Unit Type	Black Start Source	Capacity	Date
GUJARAT						
1	Ukai (H)	4 x 75	Hydro	Diesel	500 kVA	2nd week, Nov'12
2	Mini Hydro	2 x 2.5	Hydro	Diesel	50 KW	2nd week, Nov'12
3	Kadana	4 x 60	Hydro	Diesel	500 KVA	3rd week ,Oct'12
4	Dhuvaran	1 x 107 (68+39) + 1 x 112 (72+40)	Gas	Details to be furnished by Gujarat	Details to be furnished by Gujarat.	3rd Week , Oct'12
5	GIPCL-I	3 x 32 + 1 x49	Gas / Steam	Diesel	141 KW	4th week, Oct'12
6	GIPCL-II	1x104+1x56	Gas / Steam	Diesel	500 kVA	4th week, Oct'12
7	A.E.Co. Stn. C Stn.-D,E,F,CCPP	StnC:2x30 StnD:120 Stn.E,F(110MW each)CCPP:100MW	Thermal (Units-C,D,E,F)/ Gas(CCPP)	Stn-C islands Diesel	Stn.C:15kVA; Stn.D,E ,F and CCPP(500 kVA each)	1st Week, Nov'12
8	GPEC	3x138+1x241	Thermal	Natural Gas	3000 kVA	2nd Week , Nov'12
9	Sugen	3x382.5 MW	Gas	Diesel	2x6MVA	1st week, Nov'12
	Madhya Pradesh					
10	Gandhisagar	5 x 23	Hydro	DG set	100 kVA	4th Week, Sept'12
11	Birsinghpur	1 x 20	Hydro	Battery	220 Volt Battery	4th Week, Sept'12
12	Pench	2 x 80	Hydro	DG set	250 kVA	3rd Week, Sept'12
13	Bargi	2 x 45	Hydro	DG set	250 kVA	Completed
14	Bansagar Stage-I	3 x 105	Hydro	DG set	250 kVA	3rd Week, Sept'12
15	Indira Sagar	8x125	Hydro	DG set	2x1000 KVA	Completed
	Chhatisgarh					
16	Hasdeo Bango	3 x 40	Hydro	DG Set	250 kVA	Completed
17	Korba(E)-phse-I	Power plant retired but Black start DG set available and on- load trial is reported to be carried out regularly		DG Set	1500 kW(3.3kV)	4th Week, Dec'12
	Maharashtra					
18	Koyna I & II	4 x 65 4 x 75	Hydro	House generator	2 MVA	3rd Week, Nov'12
19	KDPH	2 x20	Hydro	DG set	310 KW	3rd Week , Dec'12
20	Eldari	3 x 7.5	Hydro	DG set	6 KW	3rd week, Dec'12

Sl. No.	Power Station	Installed Cap. (MW)	Unit Type	Black Start Source	Capacity	Date
21	Uran (Gas)	4 x 60 (GT) + 4x108 (GT)+ 2x120 WHR	Gas	DG set	4 MW PH1:412kVA PH2:450kVA WH:520kVA	3rd Week Nov'12
22	RGPL	Block 1: 640MW+Block 2: 663.54MW+Block 3: 663.54MW	Gas	Gas Turbine (Frame-6)	35 MW (Under testing): Details to be provided by RGPL.	1st Week, Oct'12
23	Ghatghar	2x125	Hydro	DG set	1x1250 kVA	1st Week, Oct'12
24	Khopoli	3x24+2x12	Hydro	DC Governor & bearing oil pumps	DC power (self start)	1st week , Dec'12
25	Bhivpuri	3 x 24 + 2 x 1.5 +2x12	Hydro	DC Governor & bearing	-do-	4th Week, Nov'12
26	Bhira	6 x 25	Hydro	1 No.of 500 KVA house generator with water turbine	500 kVA	1st Week, Dec'12
27	Bhira PSS	1 x 150	Hydro	DG set	500 kVA	2nd Week, Dec'12
28	Trombay	1 x 120 1 x 60	Gas Turbine Steam Turbine	DG Set	2.5 MW	4th Week, Nov'12
	NTPC					
29	Kawas	4 x 106 2 x 116	Gas	Diesel	2850 KW	2nd Week, Oct'12
30	Gandhar	3 x 144 + 1x225	Gas	Diesel	2975 KW	2nd week, Oct'12
	NCA					
31	SSP(RBPH & CHPH)	6x200+5*50	Hydro	Diesel	2x1000kVA	Completed

Report of the Committee on Automatic Under frequency Load shedding

Background

- Zalte committee was formed to review the defense mechanism for WR after the July 2012 blackout. Zalte Committee while formulating the AUFLS plan considered the factors such as frequency dependence of loads, voltage dependence of load relief and seasonal variations of the loads.

- In the 2nd NPC meeting held on 16-July-2013, AUFLS scheme was adopted at a national level and comprised four stages of UFLS at 49.2 Hz, 49.0 Hz, 48.8 Hz and 48.6 Hz. Prior to that, each region adopted a three-stage plan for flat UFLS, with similar settings. The above calculation of load relief was based on the methodology adopted by Zalte Committee recommendations, formed in WR, after the July 2012 blackout. The implemented settings at that time was as follows;

AUFLS	Frequency (Hz)	Load relief in MW					
		NR	WR	SR *	ER	NER	Total
Stage-I	49.2	2160	2060	2350	820	100	7490
Stage-II	49.0	2170	2070	2360	830	100	7530
Stage-III	48.8	2190	2080	2390	830	100	7590
Stage-IV	48.6	2200	2100	2400	840	100	7640
Total (MW)		8720	8310	9500	3320	400	30250

**SR grid not integrated with NEW grid at that point of time.*

In the 10th NPC meeting it was decided to raise the frequency settings of the four stages to 49.4,49.2,49.0 & 48.8Hz. with the same quantum

AUFLS sub-Committee formation

- NPC constituted a sub-Committee in Jan 2020 with following TOR;
 - To examine the AUFLS scheme for all Indian Grid currently deployed and suggest any revision for the same.
 - To examine the df/dt settings in different regions for all India grid and suggest a suitable approach for effective working of the same.
- The Committee met on 7th Apr 2021, 7th Dec 2021, 06th Sept 2022 and 12th Oct 2022 through online meetings.
- Factors affecting fall of frequency when there is generation/demand loss/rise:
 - “D” Frequency dependence of Loads.
 - Governor action of generation through RGMO/FGMO.
 - Power Number
 - Voltage dependence of Load,
 - Role of seasonal factor

International Practices

There is a gap of 1Hz from 50 Hz for initiation of UFLS at 49 Hz, more or less similar is the case for 60Hz system in US.

Stringent regulations to control the frequency and all constituents adhere to maintain interchange for controlling frequency.

The final stage of demand disconnection is 48/57.5 Hz (Europe/US) mostly.

Almost 50% of the load is to be shed in European system, up to 25% in American system & 32% in New Zealand.

recommendations of consultant Powertech labs. Section 3.2 of Task-III report of POWERTECH Labs Inc indicates that UFLS relays are generally designed for load-generation mismatch of up to 25%.

Approach of sub-Committee

- DSM mechanism is in place for frequency control, many States have Automatic Demand Management System (ADMS) in place. RGMO/FGMO is also widely implemented. This ensures frequency regulation in operating range.
- The sub-committee focused on following factors.
 - “D” Frequency dependence of Loads.
 - Governor action of generation through RGMO/FGMO.
- The other three factors
 - Power Number- It is variable for different loading scenarios of system
 - Voltage dependence of Load-this factor has less relevance now a days and can be taken care in the safety margins
 - Role of seasonal factor-It is assumed that when the system load varies, the load shedding quantum wired up also varies linearly in most cases. This factor is taken care with safety margins.

Theoretical aspects

- When the load/generation is suddenly increased / decreased
 - Initially, frequency changes (reduces) As the time “t” increases governor regulation “R” comes into play and the
 - frequency reduction causes the steam valve to open and result in increased turbine power.
 - Further, the “old” load decreases at the rate of D MW / Hz.
 - This results in (a). Rate of decrease of kinetic energy from the rotating system, (b). Increased turbine power and (c) “Released” old customer load.
 - Initially the components (b) and (c) are zero. After that, component (a) keeps decreasing and components (b) and (c) keeps on increasing. Finally, the frequency and hence the KE settle at a lower value and the component (a) becomes zero.
- At $t=0+$, : the rate of fall of freq. is highest and the rate of fall reduces. The df/dt relay therefore will come into play during the initial period.
- At $t=30+\text{secs}$:the rate of fall of freq. becomes approx. zero and the freq. settles at new operating point. The AUFLS will come into play during this period.

Selection criterion for trigger frequency for lower end and upper end Stage:

- With D assumed 1.5% and a meager frequency response of governor system $R=50\text{Hz/pu MW}$ (40% generation provides only a 5% governor response), for a credible contingency of 5000MW generation loss for a system of 210GW;
 - it is observed that the frequency settles at 49.52Hz and the nadir frequency would touch 49.4Hz.
 - With a lightly loaded system of size of " 150GW, these figures would be far more on the lower side.
 - There can be a momentary drop of frequency (nadir freq) to 49.4 Hz and the AUFLS 1st stage would trigger if the 1st stage is set at 49.4Hz and trigger the AUFLS. However, the settling frequency would be more than 49.5Hz.
 - The load connection to system is not automatic and is manual, though the load shedding is automatic.

Therefore, the 1st stage (Stage-IA) is recommended at 49.2Hz.

- Thermal/Hydro generators low frequency trip setting generally in the range 47.5 Hz.
- For RE generators especially Wind:
 - RE generators, CEA standard operating range is 49.5 to 50.2 Hz .
 - The generators shall not trip, if the frequency falls below the operating frequency range.
 - it is recommended that the governors on the wind generators be enabled and accordingly this enabling provision be included in the CEA regulations.
- The Island separation frequency for Islanding schemes is 48.0/47.9Hz with pre islanding load shedding frequency ranging from 48.2 to 48.5Hz.
- Therefore, the trigger frequency for Stage-I AUFLS is Stage-IA=49.2Hz, Stage-IB=49.0Hz, Stage-IC=48.8Hz, Stage-ID=48.7Hz and Stage-IE=48.6Hz.
- Desperate measures if frequency falls below 48.6Hz Stage-II has been recommended. The trigger frequencies for Stage-II would be Stage-IIF=48.4Hz with 6% of Load shed; Stage-IIG=48.2Hz with 6% of Load shed & Stage-IIH=48.0Hz with 6% of Load shed in each stage.

Approach formulation

- For a given generation loss where would the frequency settle is estimated. For a given frequency setting point (49.2Hz, 49.0, 48.8, 48.7 & 48.6Hz) how much generation loss has to be there is estimated.
- $D=1.5\%$ assumed and R as 50 the estimates were made for different scenarios of system loading and following steps are followed;
 - Generation and loads assumed to be 210000MW.
 - Frequency drops to 49.2Hz from 50Hz.
 - Calculate D in p.u. MW/Hz.
 - Calculate R in Hz/p.u. MW.
 - Calculate change(drop) in load due to fall of freq from 50Hz to 49.2Hz (0.8Hz)
 - Calculate β ($FRC=D+1/R$)
 - Find $f_0 = (\text{loss of gen})/\beta$.
 - Find the settling freq. by adjusting the generation loss till freq become 49.2Hz.

- The new load and generation due to freq drop is calculated as follows.
 - New Load ($NL1$) = Initial Load ($NL0$) - Load Drop ($LD0$) due to freq. fall.- (1)
 - New Generation ($NG1$) = Initial Gen. ($NG0$) - Gen Loss + $RGMO/FGMO$. (2)
 - load shedding quantum to raise the frequency above 49.2 Hz.
- $(LS11) = (NL1) - (NG1)$ -----(3)
 - If this quantum is shed, the frequency will start rising however will not reach 50Hz, since the loads would also rise due to frequency dependence and frequency will settle below 50Hz.
 - To avoid this the additional load is included in the load shedding quantum $LS11$ above so that a corresponding load rise ($LS12$) due to frequency dependence is estimated for shedding so that frequency settles at 50Hz, if the new load shedding quantum is shed.
 - Load Shedding quantum in Stage-IA ($LS1$) = $LS11 + LS12$. -----(4)
- The above steps are repeated for settling frequencies of 49.0, 48.8, 48.7 & 48.6hz for generation loss.
- In each stage the load shedding quantum estimated is such that the frequency settles to 50Hz if the load shedding quantum is shed.

Recommended trigger frequency load shedding quantum

S. No.	Stage	Frequency	Demand disconnection	
1	I-A	49.2 Hz	3.5%	
2	I-B	49.0 Hz	3.5%	
3	I-C	48.8 Hz	4%	
4	I-D	48.7 Hz	4.5%	
5	IE	48.6 Hz	4.5%	20%
Desperate measures- Load Shedding				
6	II-F	48.4 Hz	6%	
7	II-G	48.2 Hz	6%	
8	II-H	48.0 Hz	6%	18%
	Total			36%

- For a 210 GW system the above % demand disconnection translates;
- Stage-IA=7350MW; Stage-IB=7350MW; Stage-IC=8400MW; Stage-ID=9450MW & Stage-IE=9450MW;
- Stage-II-F=12600MW; Stage-II-G=12600MW & Stage-II-H=12600MW;

Approach-B of AUFLS



Load shedding quantum's estimation same as described above, with Load shedding approach based on import/export of regions.



In the real time, the interregional power flow is not unidirectional, but changes season to season & period during the day.



The settings implemented would have to be dynamic during the day/season.



This approach was discussed and it was felt that this is a futuristic approach which can be implemented when the automation and communication becomes mature at transmission/distribution level.

df/dt based Load shedding

- Enabling frequency at 49.9Hz.
- Following terminology is used while deriving the quantum of load shedding.
- RE rich: RE installed capacity $>1/4$ of Total installed capacity
- RE low: RE installed capacity

Sr. No	Stage	'X' in MW = Largest generating station or peak import in the region whichever is higher			
		Enabling Frequency 'Hz'	df/dt setting 'Hz/sec'		Quantum of Load Shedding 'MW'
			RE rich	RE low	
1	Stage 1	49.9	0.1	0.05	30% of 'X'
2	Stage 2	49.9	0.15	0.1	40% of 'X'
3	Stage 3	49.9	0.2	0.25	50% of 'X'

- The validation shall be 6 cycles for 0.05 Hz/sec setting and 5-7 cycles for setting of 0.1Hz/sec and above on a sliding window basis.
- The quantum is for a region as whole, and the RPCs shall decide how to further distribute the quantum amongst the States.

Recommendations :

- The quantum of load shedding required in above AUFLS Stages (Stage I & II) shall be decided on the basis of Regional Peak Loading conditions during the last year. The quantum shall be reviewed/revised by NPC accordingly and informed to RPCs by 1st of November. If the peak demand is lower than the last year peak demand, the quantum shall be revised accordingly.
- AUFLS should be distributed within the region by the RPCs by 1st December, in consultation with the stakeholders after receipt of the allocated load shedding quantum from NPC. mand, the settings will remain unchanged.
- AUFLS relays under Stage-I should be implemented preferably on downstream network at 11/22/33 kV level.
- AUFLS relays under Stage-II should be implemented on upstream network at EHV (66/110/132 kV) level so that load relief obtained is fast and reliable as it is a desperate measure for areas that have disintegrated.

- As far as possible, the df/dt relays shall be installed on feeders electrically in proximity to Largest Generating Station in the States or State Loads being fed through Import of power from ISTS network.
- Feeders to be wired under AUFLS Stage-I, Stage-II and df/dt shall be connected to serving loads and shall not be under Planned/distress load shedding, SPS, ADMS, feeders etc. The AUFLS shall not include the
- The feeders selected for AUFLS and df/dt shall not have RE generation or any other distributed generator connected to these feeders. In such cases instead of tripping the feeder, the relays can be installed to shed loads on the feeders. However, if this is not possible the low RE generation or distributed generation feeders shall be selected by proper ranking, preparatory LS for Islanding Schemes if any.
- The df/dt load shedding is specific to regions and therefore, the quantum of load shedding required to be wired up under the df/dt scheme be discussed at regional levels in the RPCs. The RPCs in consultation with the stakeholders can decide on the quantum of Load shedding required to be wired up in Stage-1, 2 & 3 of the df/dt schemes. The trigger criteria can also be reviewed by the RPCs, based on the a) The validation shall be 6 cycles for 0.05 Hz/sec setting and 5-7 cycles for setting of 0.1Hz/sec and above on a sliding window basis. b) The quantum is for a region as whole, and the RPCs shall decide how to further distribute the quantum amongst the States. Page 53 of 53 observed df/dt rates in the regions, if it feels so. The quantum indicated in above df/dt Table 10.2 is for reference only.

Testing of AUFLS and df/dt relays:

- Wherever relays are installed at 110 / 132 kV level and above S/s: The periodicity of testing shall be Twice in a year.
- Wherever relays are installed at 66 kV level and below S/s: The periodicity of testing shall be Once in a year.
- SLDCs shall in consultation with the Utilities responsible for testing should chalk out a plan of relays testing schedule before 1st of December and submit the same to RPC/RLDC.
- Test shall be carried out by the State testing teams and report of the test carried out should be submitted to SLDC. SLDC shall submit a compiled progressive report of the same to RPC/RLDC every month. The format for testing of AUFLS is enclosed at Annexure-IV.
- SLDC should monitor the periodicity of test and ensure that the relays are tested as per the schedule. Deviation if any shall be intimated to RPC/RLDC with proper justification.
- If possible, relays through test up to breakers may be carried out. If this is not possible the continuity of trip circuit of UFR up to the trip coil of breaker should be checked during the testing.
- SLDC's shall ensure that at least 10% of the total relay testing be witnessed/carried out by other Circle Testing Engineer/RLDC/RPC.



भारत सरकार केंद्रीय विद्युत प्राधिकरण दक्षिण क्षेत्रीय विद्युत समिति 29, रेसकोर्स क्रॉस रोड बेंगलूर 009 560 -	 सत्यमेव जयते	Government of India Central Electricity Authority Southern Regional Power Committee 29, Race Course Cross Road Bengaluru-560 009
Email:mssrpc-ka@nic.in		Phone: 080-22287205
सं/No. SRPC/42(SRPC)/2022/		दिनांक /Date 05 th July 2022

सेवा में / To

मुख्य अभियंता /The Chief Engineer

राष्ट्रीय विद्युत समिति प्रभाग /NPC Division

केंद्रीय विद्युत प्राधिकरण /Central Electricity Authority

सेवा भवन, आरपुरम.के./ Sewa Bhavan, R.K.Puram

नई दिल्ली / New Delhi-110 066

Subject: Membership for RE Generators in RPC forum- reg.

Ref: Minutes of 11th meeting of NPC Item No.18

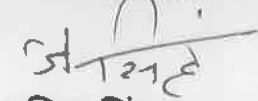
मोहदया /Madam,

As you are kindly aware, in the 11th meeting of NPC (28.02.2022), it was observed that the issue of membership of RE generators in RPC forum needs deliberation at the RPC level first and afterward may be discussed at NPC level.

Accordingly, this issue was discussed in the 42nd meeting of SRPC (04.06.2022), wherein, after detailed deliberation, SRPC recommended the following:

“Membership of two (02) RE generators with a threshold of 1000 MW (and above) installed capacity in the region on rotational basis. The participation of such generators would be limited to technical and operational issues”.

भवदीय/Yours faithfully,



(असित सिंह/ Asit Singh)

सदस्य सचिव/Member Secretary

Copy for kind information to:

Member (GO&D), CEA, New Delhi