सत्यमेव जयते

भारत सरकार/Government of India
विद्युत मंत्रालय/Ministry of Power
केन्द्रीय विद्युत प्राधिकरण/Central Electricity Authority
एन.पी.सी. प्रभाग/National Power Committee Division
6th Floor (North), Sewa Bhawan, R.K. Puram, New Delhi-66

No. CEA-GO-15-14/1/2021-NPC Division/108 Date: 13.10.2026

To
(As per distribution list)

विषय: 18.09.2026 को राजगीर, बिहार में आयोजित एनपीसी की 18वीं बैठक का कार्यवृत्त के संबंध में।
Subject: Minutes of the 18th Meeting of NPC held on 18.09.2026 at Rajgir, Bihar -reg.

18.09.2026 को राजगीर, बिहार में आयोजित एनपीसी की 18वीं बैठक का कार्यवृत्त आपकी जानकारी और आवश्यक कार्रवाई के लिए संलग्न है।

The Minutes of the 18th meeting of NPC held on 18.09.2026 at Rajgir, Bihar is enclosed herewith for your kind information and necessary action, please.

भवदीय/Yours faithfully

Encl: As above

13/10/2026

(ऋषिका शरण/Rishika Sharan)
मुख्य अभियन्ता एवं सदस्य सचिव,रा.वि.स /
Chief Engineer & Member Secretary, NPC

Distribution List (Members of NPC):

1. Shri. Metbah Lyngdoh, Hon'ble Minister of Power, Govt. of Meghalaya & Chairperson, NERPC, MG Road, Secretariat Hills, Meghalaya, Shillong – 793 001 [Email:metbah@gmail.com]
2. Shri. Hemant Jain, Member(Go&D), CEA, Room No. 601 (North), 6th Floor, Sewa Bhawan, Sector-1, R.K. Puram, New Delhi-110066 [Email: member.god@cea.nic.in/ hemjain.cea@nic.in]
3. Chairperson TCC (NERPC) & Director(Transmission), MePTCL, Meghalaya– 793001 [Email: directormeptcl@gmail.com/dt.meptcl@meghalaya.gov.in]
4. Shri. Ajay Yadav, IAS, Chairperson, ERPC & Chairman & Managing Director, BSPHCL, Vidyut Bhawan, Jawahar Lal Nehru Marg, Patna, Bihar - 800021 [Email: cmdbsphcl@bihar.gov.in]
5. Shri. Abdesh Kumar Singh, Chairperson, TCC (ERPC) & Director (Operation), BSPTCL, Vidyut Bhawan, Bailey Road, Patna, Bihar - 800021 [Email-operation.dir@bsptcl.bihar.gov.in]
6. Dr. J. Radhakrishnan, IAS, Chairperson, SRPC & CMD, TNPDCL, TNEB Ltd., Chairman, TANTRANSCO, TNPGCL & TNGECL, 10th Floor,144, NPKRR Maligai, TNEB HQs Office, Anna Salai, Chennai-600 002 [Email: chairman@tnebnet.org]
7. Ms. I. S. Mercy Ramya, IAS, Chairperson TCC(SRPC) & Managing Director, TANTRANSCO, Chennai-600 002 [Email: mdtantransco@tnebnet.org]
8. Shri. Gurkirat Kirpal Singh, IAS, Chairperson NRPC & Chairman-Cum-Managing Director, PSTCL, PSEB Head Office, The Mall, Patiala, Punjab-147001 [Email: cmd@pstcl.org]
9. Shri. Sanjeev Kumar Sood, Chairperson, TCC(NRPC) & Director/ Technical, PSTCL, Patiala, Punjab-147001 [Email: dir-tech@pstcl.org]
10. Shri. Stephen Fernandes, Chairman, WRPC & Chairperson TCC (WRPC), Chief Electrical Engineer & Ex-Officio Additional Secretary to Government of Goa, Office of the CEE, 3rd Floor, Vidyut Bhavan, Electricity Department, Government of Goa, Panaji, Goa: 403 001. [Email: cee-elec.goa@nic.in] and [Email: stephenrfernandes@gmail.com]
11. Shri. K.B. Jagtap, Member Secretary, ERPC,14,Golf Club Road, ERPC Building, Tollygunje,Kolkata-700033. [Email: mserpc-power@nic.in]
12. Smt. Rishika Sharan, Member Secretary, NRPC, 18-A, Shaheed Jeet Singh Marg, Katwaria Sarai, New Delhi-110016.[Email: ms-nrpc@nic.in]
13. Shri. Asit Singh, Member Secretary, SRPC, No.29, Race Course Cross Road, Bengaluru-560009. [Email: mssrpc-ka@nic.in]
14. Shri. Deepak Kumar, Member Secretary, WRPC, Plot No- F-3, MIDC Area, Marol, Opp. SEEPZ, Central Road, Andheri (East), Mumbai-400093.[email: ms-wrpc@nic.in]
15. Shri. B. Lyngkhoi, Member Secretary, NERPC, NERPC Complex, Dong Parmaw, Lapalang, Shillong-793006. [Email: ms-nerpc@gov.in]

16. Shri. S. C. Saxena, CMD, GRID-INDIA, B-9, Qutab Institutional Area, Katwaria Sarai, New Delhi -110016 [Email: cmd@grid-india.in]
17. Shri. Kailash Kumar Gupta, COO, CTU, Saudamini, Plot No.2, Sector-29, Gurugram-122001. [Email: coo-ctu@ctuil.in]

Special Invitee:-

1. CMD, POWERGRID, Saudamini, Plot No.2, Sector-29, Gurugram- 122001
2. Shri. V.K. Singh, Member (Power System), CEA, Sewa Bhawan, Sector-1, R.K. Puram, New Delhi-110066

Copy for kind information to:-

1. SA to Chairperson, CEA, New Delhi
2. SA to Member (Go&D),CEA, New Delhi

******

Minutes of 18th Meeting of National Power Committee (NPC) held on 18.09.2026 at Rajgir, Bihar.

The 18th meeting of National Power Committee (NPC) was held on 18.09.2026 at Rajgir, Bihar. The meeting was hosted by ERPC. The list of participants is enclosed at **Annexure-A**.

1.1 **Member Secretary, ERPC,** extended a warm welcome to Shri Ghanshyam Prasad, Chairperson, CEA/NPC; Shri Hemant Jain, Member (GO&D), CEA, Shri V.K. Singh, Member (PS), CEA, Shri Ajay Yadav, Chairperson, ERPC, Shri S.C. Saxena, CMD, Grid-India, Shri Nawal Kishor Choudhary, MD, BSPTCL and all NPC members and delegates participating in the 18th NPC Meeting. He highlighted the role of NPC as a national platform for coordinated deliberations and harmonization of operational, protection, commercial, and communication practices among the regions in line with policy/guidelines/regulations of MoP, CERC, and CEA. He emphasized the growing need for coordinated solutions under "One Nation, One Grid and One Frequency," particularly in view of increasing renewable energy penetration, system oscillations, low SCR, system-strength concerns, and restoration challenges. The importance of flexible operation of thermal generation, BESS, pumped-storage projects, and dynamic islanding schemes was also highlighted. Further, he stressed the need of holistic resource adequacy planning for generation, transmission, and storage to ensure reliable 24×7 power supply and grid stability during non-solar peak periods, specifically considering the anticipated increase in electricity demand during the forthcoming festive season, particularly Durga Puja, Diwali and Chhath Puja.

1.2 The importance of maintaining adequate coal availability and stock at thermal power stations was also emphasized, considering the prevailing constraints at certain generating stations. The expected synchronization of Teesta-V HEP (510 MW) hydroelectric project of NHPC and Teesta-III hydroelectric project of approximately 600 MW was noted as a positive development towards meeting the anticipated demand of Eastern Region. The need for deliberation on an effective SOP for diversion of transformers and reactors in pool of regional spares, was highlighted. States were advised to maintain sufficient spare-transformer capacity at their own level, while also utilizing ISTS support, to facilitate timely restoration. MS, ERPC, emphasized coordinated deliberations through the NPC platform to evolve practical and implementable solutions for a secure, reliable, resilient, and efficient power system.

1.3 **Chairperson, ERPC**, observed that the Indian power sector has undergone significant transformation, with universal electricity access and the achievement of **"One Nation, One Grid."** He acknowledged the sustained efforts towards developing an integrated national grid and strengthening transmission infrastructure. He stated that the present focus is on developing a credible and resilient power system, supported by digital technologies and large volumes of data from smart meters, grid systems, and consumers. He emphasized effective utilization of granular and network-level data for improved system planning, optimized electricity consumption, and customized consumer services. He further highlighted the operational challenges arising from increasing renewable

energy penetration due to its intermittent nature and emphasized the growing importance of BESS and other storage technologies. The need for accurate forecasting of electricity demand, renewable generation, weather conditions, and other relevant parameters was also emphasized.

1.4 He, further observed that changes in agricultural demand, rainfall patterns, and policy measures such as free or subsidized electricity are influencing consumption patterns and should be duly considered in power system planning. He highlighted the critical role of the distribution sector and emphasized the need for DISCOMs to improve operational efficiency, reduce losses, and strengthen overall performance. He stressed the importance of effective coordination among regional, State, and national control centres and emphasized integrated strengthening of electricity infrastructure. The need for a coordinated national vision, supported by appropriate policy direction from MoP, CEA, and other concerned organizations, along with effective implementation at State and regional levels, was highlighted. He also emphasized for an effective feedback mechanism between State/regional and central levels for communicating operational issues and implementing policy directions. He expressed hope that the deliberations would contribute to further strengthening the Indian power system and advancing its overall vision.

1.5 Addressing the gathering, **Chairperson, CEA/NPC** extended a warm welcome to Chairpersons of RPCs/TCC, Member Secretaries of all RPCs, distinguished delegates and officials from the member Central and State sector utilities. He noted that several important issues concerning the power sector and regional systems had already been brought out. In this context, the need to identify optimal solutions, particularly for the Eastern Region, was stressed. He observed that despite the availability of substantial coal resources and generating stations, the Eastern Region continues to have relatively low per-capita electricity consumption. The need to promote industrial and economic development across the States of the region was accordingly brought out. In this context, the significant growth in electricity demand in Bihar was cited, which has increased from about 2,500 MW in 2014 to around 9,500–10,000 MW at present and is projected to increase further to approximately 20,000 MW by 2035–36. He stated that growth in industrial activity would require an enabling business environment, supported by 24×7 reliable and uninterrupted power supply at competitive tariffs. The need for coordinated efforts to facilitate economic development across the region was accordingly emphasized.

1.6 He, further brought out the importance of resource adequacy and informed that CEA has undertaken the requisite resource adequacy assessment. The need to ensure adequate backup resources within the country, considering the evolving geopolitical situation, was noted. It was stated that the Eastern and Southern Regions would also need to ensure adequate resource availability, while inter-regional transfer could be utilized wherever required. The importance of timely commissioning of planned resources was also stressed in view of emerging shortages in certain States during periods of high demand. He further underlined the need for advance and coordinated transmission planning by integrating ISTS planning with State-level transmission networks. The ongoing exercise by CEA, in coordination with CTUIL and STUs, was noted, with the need to complete the

same for all States at the earliest. Transmission planning was stated to require periodic revision in line with changes in generation, load and emerging low-carbon resources, including solar, wind and Battery Energy Storage Systems. The importance of considering future generation projects, load centers and emerging pumped-storage potential while undertaking transmission planning was also brought out. The significant increase in identified pumped-storage potential, both in Bihar and at the national level, was noted as an important development requiring due consideration in future planning. He concluded and expressed the hope that the deliberations would lead to meaningful and implementable outcomes. He then requested MS, NPC, to proceed with the agenda of the meeting.

2.0 MS, NPC extended a warm welcome to Chairperson, CEA/NPC, Member (GO&D), CEA, Member (PS), CEA, CMD, Grid-India, Chairpersons of RPCs/TCC, Member Secretaries of all RPCs, and the distinguished delegates and officials from the member Central and State sector utilities. She highlighted that discussions at the NPC provide an opportunity to understand the practical difficulties faced by stakeholders and, wherever appropriate, evolve uniform, transparent and consistent approaches across regions. She emphasized that one of the important strengths of NPC forum is that a regional experience becomes a national learning, and a regional challenge can lead to a nationally applicable solution.

She, thereafter proceeded with the deliberations on the agenda items of the 18th NPC Meeting in a sequential manner.

2.1 Confirmation of Minutes of 17th Meeting of NPC:

2.1.1 The Minutes of 17th Meeting of NPC held on 27.02.2026 at Vizag, A.P. were circulated vide letter No. CEA-GO-15-14/1/2021-NPC division/47 dated 15.04.2026. No comments had been received from the members.

The Committee confirmed the minutes of 17th NPC meeting.

2.2 Final SOP/ Guidelines for diversion of RPC approved Spare Transformers and Reactors to the constituents / State Transmission Utilities (Agenda from SRPC and NRPC):

2.2.1 Briefing the agenda item, **MS, NPC** informed that the matter had earlier been discussed in the 17th NPC Meeting, wherein the periodic rotation/use of spare transformers and reactors and inclusion of Private Transmission Service Providers (TSPs) in the SOP were proposed for examination. Accordingly, the Operation Sub-Group of NPC finalized the SOP, which was subsequently deliberated in the pre-meeting of NPC, where all RPCs agreed to the proposed SOP. She further briefed the members on the key features and general provisions of the SOP.

2.2.2 **After detailed deliberations,** it was proposed that the SOP (attached at **Annexure-I**) may be adopted at the national level. The members were invited to offer their comments. It was observed that since all RPCs had considered the matter and the diversion would be undertaken with the approval of the concerned RPC, there was no objection to its adoption.

2.2.3 Member (GO&D), CEA suggested that the SOP, presently covering diversion of regional spare transformers and reactors maintained by Power Grid, may also be adopted for sharing of spare assets available with State Transmission Utilities (STUs) of the state.

2.2.4 Chairperson, CEA/NPC agreed with the suggestion and stated that state-level spare transformers and reactors may also be made available to other utilities, wherever required. He further suggested that the SOP may be adopted as a standard procedure by the concerned utilities/Boards and placed before their respective Boards for approval, wherever necessary. The SOP may thus provide a common mechanism for utilizing spare assets belonging to another utility, transmission entity or State, wherever required. All members agreed with the proposal.

2.2.5 Decisions of the NPC:

i. **The Standard Operating Procedure (SOP) for diversion of regional spare transformers and reactors was approved for adoption at the national level.**

(Action: All RPCs)

ii. **The provisions of the SOP may also be suitably adopted/ or developed by STUs/SLDCs for diversion/sharing of state-level spare transformers and reactors, wherever required, subject to the necessary approval of the concerned authorities/Boards.**

(Action: Concerned STU/SLDC)

2.3 Examination of implementation challenges in the existing DSM computation methodology for RE aggregation and deliberation on Contract Rate for QCA (Agenda from SRPC):

2.3.1 Briefing the agenda, **MS, NRPC** informed that RPCs are facing implementation difficulties in DSM computation for RE aggregation, particularly in block-wise computation and in cases involving different tariff structures under Sections 62, 63 and 86(1)(b) of the Electricity Act, 2003. The matter was deliberated in the Commercial Sub-Group Meeting of NPC, wherein the RPCs agreed that the existing provisions are operationally difficult to implement and supported a simplified methodology. It was agreed that the Contract Rate for QCA shall be determined as the weighted average of the applicable rates for capacity transactions governed by Sections 62, 63 and 86(1)(b). For the remaining capacity for which no specific Contract Rate is available, the Weighted Average Area Clearing Price (ACP) of the Day Ahead Market (DAM) across all Power Exchanges for the relevant 15-minute time block shall be considered. It was further agreed that the Contract Rate shall be calculated based on the available capacity for the concerned time block.

2.3.2 Director (Market Operation), Grid-India highlighted the need for clarity regarding the basis on which weightage is to be assigned to different contract rates. She referred to Para 2.16 of the Statement of Objects and Reasons (SOR) to the CERC

DSM Regulations 2024, wherein it has been clarified that, where an entity sells power through multiple contracts or transactions, including PPAs and Power Exchange transactions, the Contract Rate for deviation in a given time block is to be determined as the weighted average of the applicable contract rates, considering the schedule under each contract or transaction. Thus, the schedule, rather than merely the contracted capacity, provides the appropriate basis for assigning weightage for the concerned time block.

Quote

"As per Central Electricity Regulatory Commission (Deviation Settlement and Related Matters) Regulations, 2024 – Statement of Objects & Reasons (SOR):

"As regards the suggestion to provide clarity on the methodology for the calculation of contract rate under multiple contracts or transactions in a time block by an entity, the Commission would like to clarify that in case an entity is selling power through multiple modes, e.g., under PPA or through Power Exchanges (PXs), the contract rate for the purpose of deviation for such entity, for a given time block, would be the weighted average of contract rates considering schedules under each contract or transaction (including power exchange transactions)."

Unquote

2.3.3 **Chairperson, CEA/NPC** agreed that the weightage of the respective Contract Rates should be assigned on the basis of the schedule applicable to each contract or transaction, since the actual dispatch in a time block is based on the corresponding schedule. It was observed that adopting the scheduled quantity as the basis would provide a consistent methodology for determining the Contract Rate where an entity has multiple contracts, transactions or tariff arrangements. This would also ensure that the Contract Rate used for DSM computation appropriately represents the transactions actually scheduled during the concerned time block.

2.3.4 During the deliberations, **MS, WRPC** informed that WRPC was already calculating the Contract Rate on the basis of schedule, whereas such methodology was not being followed uniformly across all RPCs. **MS, SRPC** stated that the RPCs require validated rate of the contracts or transactions along with schedule data from Grid-India for undertaking the calculation on a schedule basis. It was clarified that, if validated and authenticated rate of contracts or transactions are made available to the RPCs, there would be no difficulty in calculating the Contract Rate based on the scheduled quantity for each relevant time block.

2.3.5 NPC forum also discussed the requirement for systematic collection and validation of the relevant contract-rate and schedule data. It was noted that the concerned data is being collected from the regional entities and that the use of a common and validated data source would help ensure consistency in DSM computation across the RPCs. The possibility of using the information available in the NOAR portal of Grid-India, where the relevant contract-rate information is provided by regional entities, was also discussed as a means of streamlining the data flow and reducing discrepancies arising from multiple sources.

2.3.6 **Chairperson, CEA/NPC** suggested that Grid-India shall prepare a procedure for validation of the rate of the contracts or transactions before the same is shared with the RPCs. It was further suggested that the regional entities may provide the relevant Contract Rate information through the NOAR portal of Grid-India, and that, after validation, Grid-India shall provide the requisite scheduled data along with rate of the contract or Transactions to the respective RPCs. This arrangement was considered necessary to establish a uniform and reliable data-validation mechanism for Contract Rate/Reference Rate calculation under DSM Regulation.

2.3.7 **After detailed deliberations**, the members agreed that the Contract Rate for QCA shall be calculated based on the scheduled data for the concerned time block, in accordance with provisions of CERC (DSM &Related matters) Regulation 2024. NLDC/RLDCs shall forward the Schedule data along with rate of all the contracts/transactions submitted by QCA/Generators through NOAR portal to the respective RPCs for calculation of contract rate/Reference Rate of QCA/Generators. Further, it was agreed that Grid India shall prepare a procedure for validation of the rates of all contracts/transactions submitted by QCA/Generators for the purpose of calculating Contract Rate/Reference Rate.

2.3.8 **Decisions of the NPC:**

i. **QCA/Generators shall submit the rate of all contracts/transactions in the NOAR/WBES portal of Grid India.**

(Action: All Regional entities)

ii. **Grid India shall prepare a procedure for validation of the rates of all contracts/transactions submitted by QCA/Generators for the purpose of Contract Rate/Reference Rate calculation.**

(Action: Grid India)

iii. **NLDC/RLDCs shall provide the schedule data, along with rate of all contracts/transactions to respective RPCs, for calculation of contract rate/Reference Rate of QCA/Generators.**

(Action: Grid India)

iv. **RPCs shall calculate the Contract rate/Reference Rate in accordance with the provisions of CERC (DSM & Related matters) Regulations, 2024 and subsequent amendments from time to time. The Contract rate of QCA shall be calculated based on the applicable scheduled data for concerned time block.**

(Action: All RPCs)

2.4 Uniform accounting methodology for Transmission Deviation Charges (RTDA) across RPCs (Agenda from NRPC):

2.4.1 Briefing the agenda, **MS, NPC/NRPC** informed the members that different RPCs are presently following different methodologies for computation of Transmission Deviation Charges (RTDA). It was stated that WRPC is presently computing RTDA at the QCA level, whereas other RPCs are generally undertaking the accounting

at the level of individual entities. The matter had been deliberated in the Commercial Subgroup Meeting of NPC, wherein it was proposed that RTDA may be computed at the QCA level to bring uniformity in accounting across RPCs. She further informed that during the pre-meeting, all RPCs had agreed in principle to undertake RTDA accounting at the QCA level.

2.4.2 She further informed that as per Clause 4(viii) of the detailed procedure for Metering, Accounting and scheduling of the Entities under Regulation 5.6, 17.3 & 39.2 of the CERC GNA Regulation:

Quote

"The accounts for deviation charges, congestion charges, transmission deviation charges and reactive energy charges shall be calculated for the entities by the concerned RPC at the ISTS interconnection point. Provided that if scheduling is done through Principal entity or QCA then the de-pooling of the charges among the entities shall be done by the concerned Principal entity or QCA, as applicable. The de-pooling of charges amongst the individual entity may be carried out using above methodology or any other suitable methodology."

Unquote

2.4.3 **Director (Market Operation), Grid-India** pointed out that, under the existing regulatory framework, Transmission Deviation Charges are required to be calculated at the entity level. She further informed that QCA is not specifically recognized as an entity for this purpose under the role assigned to QCA in IEGC, 2023, and a QCA is also not a GNA grantee. Accordingly, treating the QCA as the entity for computation of RTDA may result in issues relating to cross-utilization of GNA among the constituent entities. The regulatory implications of aggregating the transmission deviation of multiple entities under a QCA were therefore discussed.

2.4.4 NPC forum discussed the role of QCA in scheduling, dispatch and commercial settlement of RE generating entities connected at a common pooling station. It was observed that considering the QCA as a common entity may help in consolidated scheduling and settlement of the connected generators. However, **Director (Market Operation), Grid-India** pointed out that the existing regulatory framework does not specifically provide for QCA as an entity for calculation of RTDA. **Chairperson, CEA/NPC** was of the view that QCA may be considered as a common entity on behalf of the connected RE generators for accounting and settlement all the Regional Energy accounts. In view of this regulatory gap, it was suggested that the matter may be referred to CERC for suitable clarification/amendment in the extant Regulations.

2.4.5 **After detailed deliberations,** the members agreed that in order to maintain uniformity in the accounting methodology across all RPCs, the RPCs may proceed with the computation of Transmission Deviation Charges at the QCA level, as discussed and agreed upon during the meeting. It will be implemented for prospective accounts. CTU may take necessary action for RTDA billing to QCA. At the same time, the regulatory issue concerning recognition of the QCA as an entity for accounting and settlement of all applicable Energy Accounts, such as deviation charges, congestion charges, transmission deviation charges, reactive energy charges, etc., on behalf of all RE generators aggregated at a Pooling

Station, may be referred to CERC for consideration and necessary amendments to the extant Regulations.

2.4.6 <u>Decisions of the NPC</u>:

i. **RPCs may proceed with the implementation of Regional Transmission Deviation Charges (RTDA) Computation at the QCA level to maintain a uniformity in accounting methodology across RPCs. It will be implemented for prospective accounts.**

(<u>Action</u>: All RPCs)

ii. **CTU may take necessary action for RTDA billing to QCA.**

(<u>Action</u>: CTUIL)

iii. **The matter is to be referred to CERC for consideration of necessary amendments in the extant Regulations to recognize QCA as an Entity responsible for accounting and settlement of all applicable Energy Accounts, such as deviation charges, congestion charges, transmission deviation charges, reactive energy charges, etc., on behalf of all RE generators aggregated at a Pooling Station.**

(<u>Action</u>: CERC/NPC Secretariat)

2.5 <u>Uniform methodology for verification of partial outage data and clarification on treatment of fuel quality variation as partial outage (Agenda from SRPC):</u>

2.5.1 Briefing the agenda, **MS, NPC** referred to **CERC Order No. 14/SM/2023 dated 30.09.2023**, wherein it was directed that, to avoid misdeclaration of Declared Capacity (DC) by generating stations, the generating station should maintain a digital record of the reasons for revision of DC, which may be independently verified by the concerned RLDC or RPC. It was further noted that the reasons for revision of DC are required to be examined at the RPC level with a view to minimizing such revisions. The Committee accordingly discussed the need for a uniform and effective mechanism for verification of partial outage data submitted by generating stations.

2.5.2 She also informed that the RLDCs are presently forwarding partial outage data to the concerned RPCs based primarily on the information received from generating stations, without detailed independent verification in all cases. In this regard, ERPC has developed a verification procedure under which the reasons furnished by generating stations are examined with the help of SCADA data, time-stamped screenshots and other supporting information. It was informed that implementation of this verification mechanism in ERPC has resulted in a significant reduction in the number of partial outage cases being accepted for accounting purposes.

2.5.3 Chairperson, CEA/NPC opined that the verification procedure developed by ERPC may be adopted by all other RPCs to establish a uniform methodology for verification of partial outage data. It was emphasized that the reported partial outage should be supported by appropriate operational evidence and that the

reasons furnished by the generating station should be capable of independent verification. **MS, NPC** further suggested that, the partial outage data may initially be vetted/verified at the RLDC level before being forwarded to the concerned RPC for consideration in DSM settlement.

2.5.4 **Director (Market Operation), Grid-India** was of the view that detailed verification of every partial outage event may not be practically feasible. CMD, Grid-India suggested adopting a sample-based physical audit mechanism, under which selected cases may be examined in detail using operational records and supporting evidence at plant site. **MS, NPC** stated that, where detailed verification by RLDCs is not feasible, RLDCs should at least vet the partial outage data before forwarding it to the concerned RPC. She also emphasized that SCADA data should be used as an important source for verifying the actual operating condition of the generating station during the reported event.

2.5.5 **Director (Operation), BSPTCL** supported the use of SCADA data for verification and suggested that the reasons reported by generating stations should be cross-checked with available operational data. **Chairperson, CEA/NPC** suggested that a team/group at RPC level may be formed to conduct sample/random audits on a monthly/Quarterly basis to verify selected partial outage cases and compliance with the prescribed procedure. He also suggested that other supporting evidence, such as photographs, videos and time-stamped records, and physical verification at the generating station, wherever necessary, may be used for verification.

2.5.6 NPC forum also discussed the consequences of furnishing incorrect or unsupported information for claiming partial outage. It was agreed that where verification or audit establishes that the information submitted by a generating station is incorrect or is not supported by adequate evidence, the corresponding partial outage claim should not be permitted for accounting/settlement purposes. It was further suggested that repeated or deliberate instances of incorrect reporting may be identified through analysis of the audit findings and that appropriate penal action may be considered against entities violating the prescribed requirements.

2.5.7 Further, NPC forum deliberated on the treatment of fuel quality variation as a partial outage. **MS, NPC** stated that variation in fuel quality should not be considered as a partial outage for DSM settlement. **Chairperson, CEA/NPC** agreed with the view and observed that arranging adequate fuel of the required quality is the responsibility of the generating station. Accordingly, reduction in generation due to fuel quality variation shall not be considered as a qualifying partial outage for DSM accounting.

2.5.8 **After detailed deliberations**, the members agreed that variation in fuel quality shall not be considered as Partial Outage for DSM settlement. It was also decided that the procedure developed by ERPC for verification of partial outage data for DSM settlement may be adopted by all RPCs. Further, a team comprising representatives of RPCs, RLDCs and the beneficiary States may conduct sample-based/random physical audits on a Quarterly/yearly basis for verification of partial outage data furnished by the generating station. In cases where incorrect

information is found to have been submitted by a generating station, the corresponding partial outage claim shall not be considered for settlement. Suitable penal action may also be taken in cases of repeated or deliberate incorrect reporting.

2.5.9 <u>Decisions of the NPC</u>:

i. The procedure developed by ERPC for verification of partial outage data for DSM Settlement to be adopted by all RPCs to ensure a uniform methodology in DSM Settlement.

(<u>Action</u>: All RPCs)

ii. Fuel quality variation shall not be considered as a Partial Outage for the DSM settlement.

(<u>Action</u>: All RPCs)

iii. Sample-based/random physical audits for verification of partial outage data shall be conducted on a Quarterly/yearly basis, as considered appropriate, by a team comprising representatives of RPC Secretariat, RLDCs and 1-2 beneficiary States. Where physical verification establishes that a generating station has furnished incorrect or unsupported information for claiming partial outage, the corresponding partial outage claim shall not be allowed. Repeated or deliberate violations may be considered for appropriate penal action.

(<u>Action</u>: All RPCs)

iv. RPCs shall examine and explore suitable penal provisions for repeated or deliberate incorrect reporting of partial outage data by generating stations and submit their recommendations to CERC for consideration of appropriate penal action.

(<u>Action</u>: All RPCs)

2.6 <u>Compensation Calculation for Secondary Fuel Oil Consumption (Agenda from SRPC)</u>:

2.6.1 Briefing the agenda, **MS, NPC** informed the members that the CERC Order dated 14.07.2025 provides for compensation towards Secondary Fuel Oil (SFO) Consumption associated with eligible start-ups of generating units. She highlighted a difference between the draft and final procedures submitted by NLDC regarding the permissible number of start-ups. While the draft procedure had considered seven start-ups per generating unit, the final procedure referred to seven start-ups for the generating station as a whole**.**

2.6.2 She informed that, during the meetings of the Commercial Sub-Group of NPC and the pre-meeting, all RPCs agreed that compensation may be considered for eligible start-ups exceeding 7 × the number of generating units, subject to the applicable regulations/procedure. It was further suggested that where the eligible Reserve Shutdown (RSD) events exceed the permissible limit and include different categories, i.e. Cold, Warm and Hot RSD, a weighted-average methodology may be adopted to proportionately allocate the permissible number of events among

the different categories. However, where all eligible RSD events belong to a single category, the permissible number of events exceeding the threshold may be considered for compensation without applying a weighted average.

2.6.3 **Chairperson, CEA/NPC** observed that, logically, the station as a whole is not the appropriate basis for determining the number of start-ups for SFO compensation, as start-up and shutdown operations are carried out at the individual generating-unit level. Accordingly, the permissible limit should be considered as 7 start-ups per generating unit. He further suggested that the matter may be referred to CERC for necessary amendment/clarification in its Order dated 14.07.2025.

2.6.4 **After detailed deliberations,** the members agreed that the compensation for Secondary Fuel Oil Consumption shall be calculated by considering seven start-ups per generating unit**,** rather than Seven start-ups for the generating station as a whole. Further, it was agreed that where eligible Reserve Shutdown (RSD) events exceed the permissible limit and include different categories, i.e. Cold, Warm and Hot RSD, a weighted-average methodology may be adopted to proportionately allocate the permissible number of events among the different categories for Secondary Fuel Oil Consumption compensation. All members also agreed that Grid-India may prepare the draft Procedure after incorporating the decision of the NPC meetings and after the stake holder consultation the same may be submitted to CERC for necessary amendments.

2.6.5 **<u>Decisions of the NPC</u>:**

i. **Compensation towards Secondary Fuel Oil Consumption shall be calculated by considering Seven start-ups per generating unit, instead of seven start-ups for the generating station as a whole.**

ii. **Where eligible Reserve Shutdown (RSD) events exceed the permissible limit and include different categories, i.e. Cold, Warm and Hot RSD, a weighted-average methodology may be adopted to proportionately allocate the permissible number of events among the different categories.**

iii. **Grid-India shall prepare the draft Procedure for mechanism of compensation for degradation of Station Heat Rate, Auxiliary Energy Consumption and Secondary fuel oil consumption due to part-load operation and multiple start/stop of the units after incorporating the above decisions of the NPC meetings and after the stake holder consultation submit the same to CERC for necessary amendments.**

(<u>Action</u>: Grid-India)

2.7 **<u>Accounting Arrangement for RE Entities (Agenda from SRPC)</u>:**

2.7.1 **MS, NPC** informed about the challenges in DSM and Reactive Energy accounting arising due to multiple SPVs/projects, common PSS and bay-sharing arrangements. She informed that separate accounting becomes difficult in cases where connectivity is held by a parent entity and generation from multiple SPVs/projects is intermixed downstream.

2.7.2 She further informed that during the commercial subgroup meeting of NPC, it was decided that for entities having multiple SPVs/projects or renewable energy (RE) entities sharing a common bay, a single DSM and Reactive Energy accounting and settlement mechanism shall be implemented through the Lead Generator, QCA or connectivity holder, as applicable.

2.7.3 NPC forum discussed the applicability of QCA-based accounting for entities having capacity of more than 50 MW. **Director (Market Operation), Grid-India** informed that an eligible entity may opt for independent scheduling without being part of a QCA. Therefore, an entity eligible for independent scheduling should not be denied this option merely because other entities at the same location are operating through a QCA.

2.7.4 **MS, SRPC** stated that an entity having capacity above 50 MW, when directly connected to the ISTS, may have separate DSM accounting based on its independent connectivity and scheduling arrangement. However, where such an entity is connected downstream through the PSS of another entity, separate accounting may not be practically feasible, as the generation and transmission flows are mixed below the common connectivity point. Therefore, the Committee discussed the need to clearly define the accounting boundary based on the Point of Interconnection (PoI).

2.7.5 **Chairperson, CEA/NPC** suggested that accounting should not be carried out below the Point of Interconnection (PoI). He observed that the PoI should be treated as the appropriate boundary for accounting and settlement, avoiding unnecessary segregation of flows at downstream locations where multiple entities share common infrastructure. He further stated that generators may be accounted for at the QCA level where they mutually agree to be part of a QCA, while entities not opting for a QCA may be considered for separate accounting, subject to the applicable connectivity and scheduling arrangements.

2.7.6 NPC forum also discussed the treatment of RE projects connected through intermediate pooling stations. It was observed that such projects may follow the QCA route for coordination, scheduling and settlement wherever the common pooling arrangement requires aggregation. The PoI-based approach was considered useful for maintaining a uniform framework for RE connectivity and commercial settlement and for avoiding separate accounting arrangements at multiple downstream points.

2.7.7 NPC forum further discussed the metering arrangement required for accounting and settlement. **MS, NPC** informed that, during the pre-meeting, all RPCs agreed that the metering scheme should be examined and approved by Commercial Sub-Committee of the respective RPC**. Chairperson, CEA/NPC** agreed with the proposal and observed that such approval would ensure proper oversight while allowing the metering arrangement to be considered based on the specific configuration of each project or group of projects.

2.7.8 **After detailed deliberations,** it was agreed by all the members that the accounting may not be undertaken below the Point of Interconnection (PoI).

DSM/Reactive accounting SPV wise, projects getting connected to bus of other entities, mixing of sources/ESS below PoI voltage level will not be undertaken separately. Where RE generators agree to be part of a QCA/Lead Generator, accounting may be carried out at the QCA/Lead generator level.

2.7.9 Decisions of the NPC:

i. **DSM, Reactive Energy, Congestion account & Transmission Deviation charges accounting shall not be undertaken below the Point of Interconnection (PoI). DSM/Reactive accounting SPV wise, projects getting connected to bus of other entities, mixing of sources/ESS below PoI voltage level will not be undertaken separately. Where RE generators agree to be part of a QCA/Lead Generators, accounting may be carried out at the QCA/Lead Generator level.**

(Action: All RPCs)

ii. **The above decision may be intimated to CERC.**

(Action: NPC Secretariat)

iii. **The metering scheme for accounting and settlement shall be examined and approved by the Commercial Sub-Committee of the respective RPCs.**

(Action: All RPCs/RLDCs)

2.8 Assignment of responsibility for meter installation for Commercial Accounting Purpose (Agenda from SRPC):

2.8.1 Briefing the agenda, **MS, NPC** informed the members about the requirement of accounting meters at locations other than ISTS interface points for commercial accounting and settlement purposes. She explained that CTU presently provides interface meters/SEMs at ISTS interface points, whereas additional accounting meters may be required at other locations for determining the actual injection/drawl of individual generating stations and ESS. It was further noted that, as per the CERC DSM Regulations, 2024, appropriate metering arrangements are required for determination of individual actual injection and drawl.

2.8.2 She further informed that, in the commercial sub-group meeting of NPC, it was decided that CTU may be assigned the responsibility for accounting meters in addition to interface meters, with the cost of such meters being borne by the respective entity.

2.8.3 NPC forum discussed the distinction between the responsibility for meters at ISTS interface points and that for accounting meters at other locations. **CGM, CTUIL** informed that under the applicable CEA Metering Regulations, CTUIL is responsible for installation of meters at ISTS interface points, whereas for locations other than the designated interface points, the responsibility for installation rests with the respective entity. She suggested that the concerned entities may arrange installation of such accounting meters in accordance with the Technical Specifications finalized/prepared by CEA/NPC, as applicable.

2.8.4 **MS, SRPC** suggested that CTUIL may provide the commercial meters located one level below the interface meters, while the remaining accounting meters may be installed by the respective entities in accordance with the Technical Specifications finalized by CEA/NPC.

2.8.5 **Chairperson, CEA/NPC** suggested that CTU may act as a service provider for supplying/procuring accounting meters on behalf of the concerned entities, with the cost borne by the respective entities. He observed that coordinated procurement through CTUIL would help maintain uniform meter specifications, ensure standardization across installations and simplify the procurement process for individual entities. It was clarified that as the meter is procured using the funds of the concerned entity, the commercial responsibility and ownership of the meter shall remain with that entity.

2.8.6 NPC forum further discussed the practical requirement for maintaining an adequate inventory of different types of accounting meters. **CGM, CTUIL** highlighted that maintaining inventory of different types of meters may be challenging unless the requirements are known sufficiently in advance. **MS, SRPC** therefore suggested that reasonable time may be provided to CTUIL to develop the necessary inventory. It was also noted that the exact number, type and location of interface and accounting meters can be finalized only after the respective metering schemes are finalized.

2.8.7 **CMD, Grid-India** informed that the exact requirement and locations of interface meters and accounting meters would become clear only after finalization of the respective metering schemes. NPC forum accordingly discussed the need for advance collection of requirements from the concerned entities. **Chairperson, CEA/NPC** suggested that RLDCs may consolidate the requirements of accounting meters in consultation with RPCs and communicate the same to CTUIL, in advance to facilitate procurement planning and minimize delays in meter availability.

2.8.8 **After detailed deliberations**, the members agreed that the RLDCs shall consolidate the requirements of accounting meters in consultation with RPCs based on the finalized metering schemes and communicate the same to CTUIL in advance. CTUIL shall arrange/provide the required accounting meters to the concerned entities through a coordinated procurement/supply mechanism, with the cost being borne by the respective entity. The arrangement shall ensure standardization of meter specifications while retaining the applicable responsibility and commercial ownership of the concerned entity.

2.8.9 **<u>Decisions of the NPC</u>:**

i. CTUIL shall arrange/provide the required accounting meters to the concerned entities through a coordinated procurement/supply mechanism, with the cost being borne by the respective entity.

(<u>Action</u>: CTUIL)

ii. **RLDCs shall consolidate the requirement of accounting meters in consultation with RPCs based on the finalized metering schemes and communicate the same to CTUIL in advance.**

(Action: RLDCs/RPCs)

iii. **The meters shall conform to the applicable Technical Specifications finalized by CEA/NPC, as applicable, to ensure uniformity in meter specifications.**

(Action: CTUIL)

2.9 Monitoring of meter calibration/testing and Readings of Main/Check Meter (Agenda from SRPC):

2.9.1 Briefing the agenda, **MS, NPC** informed about the requirements under the applicable CEA Metering Regulations, wherein interface meters are required to undergo on-site routine accuracy testing at least once every five years. She further informed that the associated Instrument Transformers (CTs/PTs) are also required to be tested to ensure the overall accuracy and reliability of the metering system. The responsibility for carrying out the prescribed testing and calibration rests with the concerned entity, and the proposed monitoring mechanism is intended only to facilitate timely compliance.

2.9.2 She further informed that the matter had been deliberated in the Commercial Subgroup Meeting of NPC, wherein the need for systematic monitoring of the testing/calibration status of interface meters was emphasized. It was observed that despite the prescribed five-year periodicity, instances have occurred where testing/calibration was not completed within the stipulated period.

2.9.3 NPC forum discussed the development of a meter-wise inventory and calibration monitoring facility in the existing metering portal. It was suggested that the portal should include details such as meter identification/serial number, location, installation date and the date/status of the last testing or calibration. This centralized database would help monitor the compliance status of interface meters and identify meters approaching the prescribed five-year calibration period.

2.9.4 **Chairperson, CEA/NPC** suggested that CTUIL may incorporate an automatic alert mechanism in the metering portal to generate an alert during the fourth year, if the testing/calibration status of a meter has not been updated. This advance alert would provide sufficient time to the concerned entity to arrange and complete the required testing before expiry of the five-year period. It was emphasized that the alert would only serve as an advance compliance measure and would not transfer the responsibility for testing or calibration from the concerned entity. **COO, CTUIL** agreed with the suggestion.

2.9.5 NPC forum discussed the need for an exception-reporting mechanism for meters whose prescribed testing/calibration has not been completed within the five-year period. **Chairperson, CEA/NPC** suggested that CTUIL may prepare a report identifying such meters/entities and place before the Commercial Sub-Committees

meetings of concerned RPC. The RPCs may review the status as a regular agenda item in the meetings of their respective Commercial Sub-Committees for deliberation and remedial actions for timely compliance.

2.9.6 During the discussion, it was reiterated that the role of CTUIL/RPCs would be limited to monitoring, maintaining the relevant database and facilitating follow-up, while the responsibility for testing and calibration would continue to rest with the concerned entity. NPC forum agreed that the monitoring mechanism should be automated to the extent practicable and should generate timely alerts and exception reports. This would provide a transparent and uniform mechanism for monitoring compliance across RPCs and reduce the need for manual tracking of individual meters.

2.9.7 After detailed deliberation, the members agreed that CTUIL may develop the required monitoring facility in the existing metering portal, including meter-wise calibration status, advance alerts and exception reports. CTUIL shall identify entities that have not completed the prescribed testing/calibration within the five-year period and place before the Commercial Sub-Committee meetings of concerned RPCs for deliberation and remedial actions for timely compliance.

2.9.8 <u>Decisions of the NPC</u>:

i. **CTUIL shall incorporate a provision in the metering portal for meter-wise monitoring of testing/calibration status and generation of an automatic alert during the fourth year where the testing/calibration status has not been updated, providing advance intimation before expiry of the prescribed five-year period.**

(<u>Action</u>: CTUIL)

ii. **CTUIL shall prepare an exception report identifying entities/meters for which the prescribed testing/calibration has not been completed within five years and place before the Commercial Sub-Committee meetings of concerned RPCs for deliberation and remedial actions for timely compliance.**

(<u>Action</u>: CTUIL/Commercial Sub-Committee of RPCs)

2.10 <u>Sealing and Opening of Meters installed at TBCB Licensees and RE developers Nodes (Agenda from SRPC):</u>

2.10.1 Briefing the agenda, **MS, NPC** informed that there is a need to clearly define the responsibility and supervision mechanism for sealing and opening of meters installed at the nodes of TBCB licensees and RE developers, as these meters are used for commercial energy accounting and settlement. She further informed that the Commercial Sub-Group of NPC had decided to assign the supervisory responsibility for sealing and opening of such meters to an independent organization, i.e. CTUIL.

2.10.2 It was proposed that an independent organization, such as CTUIL, may undertake the supervisory responsibility for sealing and opening of such meters. However, **COO, CTUIL** observed that, considering the large number of installations and the operational requirements involved, assigning CTUIL the responsibility for

physically supervising the sealing and opening of all such meters may not be practical. **Member (GO&D), CEA** suggested that, if independent supervision is considered necessary, an external agency may be engaged for carrying out such activities.

2.10.3 **MS, SRPC** emphasized that, with the increasing integration of RE generating stations and TBCB transmission licensees into the grid, there is a need for a clear and standardized methodology for the installation, sealing, opening and verification of SEMs used for commercial energy accounting at the interfaces of TBCB licensees and RE developers.

2.10.4 NPC forum also discussed the practical difficulty of physically supervising the sealing and opening of every meter. **CMD, Grid-India** suggested that, instead of continuous supervision by CTUIL or any other agency, random/sample-based checks may be carried out through a group constituted at the RPC level. This would provide an additional supervisory mechanism while avoiding the need for continuous deployment of an agency for every meter-related activity.

2.10.5 **CGM, CTUIL** informed that, as per the applicable CEA Metering Regulations, the responsibility for sealing and opening of meters rests with the respective supplier and buyer entities, as applicable. She further informed that the meters currently installed are digital meters equipped with the capability to detect and have the capability to record indications of tampering. It was also stated that no complaints regarding tampering or improper sealing/opening of meters have been reported so far. In view of the existing regulatory provisions and available safeguards, NPC forum may discuss whether any additional third-party supervision is required.

2.10.6 NPC forum observed that the primary responsibility for sealing and opening of meters should continue to rest with supplier and buyer. The concerned supplier and buyer shall ensure that the prescribed procedure is followed and the necessary records are maintained. In case of any discrepancy or specific concern regarding meter sealing, opening or installation, the concerned parties may carry out appropriate verification. Sample/random checks may also be undertaken through the RPC mechanism, wherever considered necessary.

2.10.7 **After detailed deliberations**, the members agreed that routine engagement of a separate third-party agency for sealing and opening of meters is not required. In view of the provisions of the CEA Metering Regulations, the digital nature of the meters and the absence of reported complaints regarding tampering or improper sealing/opening, the responsibility shall continue to rest with the respective supplier and buyer entities.

2.10.8 **<u>Decision of the NPC</u>:**

i. The responsibility for sealing and opening of meters shall remain with the respective supplier and buyer entities, as provided under the applicable CEA Metering Regulations.

(<u>Action</u>: Concerned Supplier/Buyer Entities)

2.11 <u>Uniform Anti-islanding Protection Philosophy of the connected RE plants and Inclusion of RE Generation in the Islanding schemes (Agenda from SRPC):</u>

2.11.1 SE, WRPC gave a brief presentation on the recommendations of the report on Uniform Anti-Islanding Protection Philosophy of the connected RE plants and inclusion of RE Generation in the Islanding Scheme.

2.11.2 Chairperson, CEA/NPC suggested that RPT Division, CEA may examine the concerns and challenges identified in the report and explore suitable solutions for each of the issues. It was further suggested that RPT Division, CEA may prepare a comprehensive table clearly indicating (i) the issues identified, (ii) the analysis/observations, and (iii) the proposed solutions or remedial measures for each issue. The consolidated report, along with the proposed solutions, may be presented in the next NPC meeting for consideration and approval.

2.11.3 <u>Decision of the NPC</u>:

i. RPT Division, CEA to examine the concerns and challenges and recommendations identified in the report. It was further decided that RPT Division, CEA may prepare a comprehensive table clearly indicating (i) the issues identified, (ii) the analysis/observations, and (iii) the proposed solutions or remedial measures for each issue. The consolidated report, along with the proposed solutions, may be presented in the next NPC meeting for consideration and approval.

(<u>Action:</u> RPT Division, CEA)

ii. The report may be discussed in RPC Sub Committee. Observations may be shared with RPT Division of CEA, if any.

(<u>Action:</u> All RPCs)

2.12 <u>SOP for Certification of Transmission system availability of deemed ISTS/natural ISTS lines of States (Agenda from NRPC):</u>

2.12.1 Briefing the agenda, **MS, NPC** informed in the 17th NPC Meeting held on 27.02.2026, NRPC was entrusted with preparation of the draft SOP for certification of Transmission System Availability of Deemed ISTS/Natural ISTS lines of States received prior to October 2020. Accordingly, NRPC prepared and submitted the draft SOP to NPC Secretariat which was circulated to all RPCs for comments. The draft was deliberated and revised by the Operation Sub-Group of NPC and recirculated to all RPCs. Comments received from SRPC were examined and incorporated, and the revised SOP is now placed before NPC for consideration and approval. She also briefed the general features of the SOP to the NPC forum.

2.12.2 Director (Market Operation), Grid-India stated that, for ISTS lines, the process for verification of outages may be carried out first by the SLDC, followed by verification by the RLDC, after which the RPC may certify the transmission system

availability in accordance with the provisions of the CERC (Terms and Conditions of Tariff) Regulations. However, in the case of STU lines, outage verification may be carried out by the SLDC, followed by certification by the RPC, as the RLDC has no role in verifying the outage duration of STU transmission lines.

2.12.3 **After detailed deliberations,** it was decided that Intrastate lines which are carrying ISTS power shall be in control of RLDCs, certification of transmission system availability of Intra-State transmission lines carrying interstate power and certified as ISTS, RLDC shall complete vetting of outage verification done by SLDC. However, for old cases of period upto October 2020, the SLDC shall verify the outage duration and the reasons for the outage submitted by the concerned STU/Transmission Licensee and forward the verified details to the concerned RPC for certification of transmission system availability in accordance with the provisions of the CERC (Terms and Conditions of Tariff) Regulations.

2.12.4 Accordingly, based on the above decisions draft SOP for Certification of Transmission system availability of deemed ISTS/natural ISTS lines of States carrying interstate power may be modified and circulated to all concerned stakeholders (SLDC/ RLDC/ RPCs) for implementation. The revised SOP is attached at **Annexure-II.**

2.12.5 **Decision of the NPC:**

i. **The forum approved the draft SOP for Certification of Transmission system availability of deemed ISTS/natural ISTS lines carrying interstate power with modification mentioned below.**

(Action: NPC Secretariat, CEA)

ii. **Intrastate lines which are carrying ISTS power shall be in control of RLDCs, and for certification of transmission system availability of Intra-State transmission lines carrying interstate power and certified as ISTS, RLDC shall complete vetting of outage verification done by SLDC. However, for old cases of period upto October 2020, the SLDC shall verify the outage duration and the reasons for the outage submitted by the concerned STU/Transmission Licensee and forward the verified details to the concerned RPC for certification of transmission system availability in accordance with the provisions of the CERC (Terms and Conditions of Tariff) Regulations.**

(Action: SLDC/RLDCs/RPCs)

2.13 SOP for Submission of Master Data by Entities (Agenda from NRPC):

2.13.1 **MS, NPC** informed that accurate and reliable commercial energy accounting requires, in addition to time-block-wise schedule and metering data, various technical, connectivity, operational and commercial details of generating stations, Energy Storage Systems (ESS), QCAs and other concerned entities. Such master data is required to determine the applicable accounting configuration, capacity and connectivity, beneficiary-wise allocation, applicable tariff/contract or reference

rate, and other parameters necessary for preparation of Renewable Energy Accounts (REA) and Deviation Settlement Mechanism (DSM) accounts.

2.13.2 She further informed that NRPC and NPC have prepared an SOP for Submission of Master Data by Entities for Commercial Energy Accounting to establish a uniform procedure for submission, updating, validation and maintenance of the required technical, commercial and operational master data. The SOP defines the roles and responsibilities of generating stations, ESS, QCAs, RLDCs, CTU/STUs and RPC Secretariats, thereby providing a common framework for maintaining reliable and updated information required for commercial energy accounting.

2.13.3 NPC forum discussed that the master-data system should have exception reporting facilities to identify missing, outdated or non-compliant information. Such reports may be generated based on the data submitted by entities and made available to the concerned RPCs for review and follow-up. The Committee emphasized that master data should not be treated as a one-time submission and shall be updated by the concerned entities whenever there is any change in their technical configuration, connectivity, capacity, commercial or metering arrangement, or any other parameter relevant to accounting.

2.13.4 MS, NPC informed that the finalized SOP has been agreed to by all RPCs and is proposed to be integrated with the Unified Accounting Software. She stated that, until full integration is completed, an interim mechanism may be followed to ensure timely submission, updating and access to the required master data. NPC forum emphasized that the implementation mechanism should ensure that RPCs have access to the latest validated master data required for preparation of REA and DSM accounts.

2.13.5 Chairperson, CEA/NPC observed that several entities already maintain their technical, commercial and operational information through dedicated portals and databases. He suggested that, instead of relying mainly on manual submission and transfer of data, the system should progressively move towards machine-to-machine exchange of master data through Application Programming Interfaces (APIs), wherever technically feasible. Such integration would reduce repetitive data entry, minimize discrepancies and enable timely transfer of updated information between the concerned systems.

2.13.6 NPC forum further emphasized that the proposed digital arrangement should clearly define responsibility for the accuracy and timely updating of master data. The concerned entity shall remain responsible for providing correct and updated information, while RPCs, RLDCs, CTU/STU and other concerned agencies shall use the data for their respective accounting, scheduling, settlement and monitoring functions. The transition towards API-based data exchange should be carried out in a manner that ensures proper data validation, traceability and accountability.

2.13.7 After detailed deliberations, the members approved the finalized SOP (attached at **Annexure-III**) for Submission of Master Data by Entities for Commercial Energy Accounting for uniform implementation across all RPCs. It was also agreed that

the master-data mechanism shall be integrated with the Unified Accounting Software and progressively moved towards machine-to-machine data exchange through APIs, wherever technically feasible.

2.13.8 Decisions of the NPC:

i. **The finalized SOP for Submission of Master Data by Entities for Commercial Energy Accounting is approved for uniform implementation for accurate and reliable Commercial Energy Accounts.**

(Action: All RPCs)

ii. **The stakeholders shall progressively move towards machine-to-machine data transfer through APIs, wherever technically feasible, to improve efficiency, reliability and consistency of data exchange. The master data shall not be treated as a one-time submission and shall be updated by the concerned entities whenever there is any change in their technical configuration, connectivity, capacity, commercial or metering arrangement, or any other parameter relevant to accounting.**

(Action: RPCs/RLDCs/CTU/STU/All Regional Entities)

iii. **The master-data system shall be integrated with the Unified Accounting Software, with an interim mechanism to be followed until full system integration is achieved.**

(Action: All RPCs/ UAS implementation Committee)

2.14 Introduction of MPLS Technology in ISTS Communication system (Agenda from CTU):

2.14.1 Explaining the agenda item, **representative from CTUIL** informed that in the 17th NPC Meeting held on 27.02.2026, the Joint Committee was entrusted with finalizing the Technical Specification (TS) for introduction of MPLS-TP technology in the ISTS communication system. CTUIL incorporated the observations of JC members and circulated the finalized TS on 13.08.2026 for concurrence. As per the approved methodology, MPLS-TP will initially be implemented in NER covering about 60 nodes/stations, with one standby channel migrated first and further channels migrated after stabilization and satisfactory feedback. For NER implementation, 2+2 channel availability and 2-pair spare fiber are to be ensured, and MII relaxation may be updated by CEA (ET&I). Subject to successful NER implementation and necessary approvals, the technology will subsequently be rolled out in other regions, with the scheme and implementing agency to be placed before NERPC forums.

2.14.2 The issue of Make in India (MII) relaxation was specifically deliberated. It was noted that MII relaxation is presently a pending matter and that its requirement needs to be examined before finalizing the procurement/implementation approach. The possibility of proceeding without MII relaxation was also discussed in the context of ensuring technical and commercial compatibility.

2.14.3 It was further discussed that in case implementation is proposed without MII relaxation, the indicative requirements and commercial implications may be clearly established. The prices offered by the concerned vendors would need to be examined and compared with the applicable requirements before taking a final decision on the procurement route.

2.14.4 During the deliberations, **Chairperson, CEA/NPC** emphasized that CTU shall proceed with the MPLS-TP pilot implementation after completion of the requisite concurrence and approval process. The issue of MII relaxation may be examined and finalized during implementation. The pilot shall cover the identified nodes, with the detailed technical configuration, port requirements and procurement approach to be finalized in accordance with the approved specification and suggested CTUIL, may submit the proposal in the next NCT meeting for approval. All members agreed for the same.

2.14.5 **After detailed deliberations,** all members agreed that the MPLS-TP pilot implementation shall be taken forward after finalization of the technical specifications, and completion of the necessary concurrence and approval process. The experience and outcomes of the pilot implementation may subsequently be considered for wider deployment of MPLS technology in the ISTS communication network. The approved Technical Specifications of MPLS-TP for ISTS communication system is attached at **Annexure-IV.**

2.14.6 **Decision of the NPC:**

i. **NPC approved the Technical Specifications of MPLS-TP for ISTS communication system submitted by Joint Committee for Introduction of MPLS Technology in ISTS Communication system.**

ii. **CTUIL shall proceed with the MPLS-TP pilot implementation after completion of the requisite concurrence and approval process.**

(Action: CTUIL)

iii. **The issue of MII relaxation shall be examined and finalized during implementation of the project.**

(Action: CTUIL/CEA(ET&I))

iv. **CTUIL shall submit proposal, incorporating the finalized technical requirements and necessary approvals/concurrences, interoperability issues with Regional/National UNMS for consideration in the next NCT meeting.**

(Action: CTUIL)

2.15 Implementation of Travelling Wave Fault Locator (TWFL) on critical transmission lines in the Northern Region (Agenda from NRPC):

2.15.1 Briefing the agenda, **Member (Power System), CEA** informed that a Committee was constituted under the Chairmanship of Chief Engineer, PSE&TD Division,

CEA, with representatives from NRPC, NERPC, Grid-India, PowerGrid and MSETCL to prepare the Guidelines/Procedure for implementation of Travelling Wave Fault Locators (TWFLs) on critical transmission lines. The Committee held two meetings and finalized its report on 15.09.2026 (attached as **Annexure-V**).

2.15.2 He, further informed the Committee recommended both online and offline monitoring for critical transmission lines. Online monitoring may provide early indication of waveform disturbances and help in timely identification and analysis of transmission-line events. The Committee also noted that suitable analysis of the recorded waveforms would be required to determine the nature and characteristics of such disturbances.

2.15.3 He also informed the NPC forum about the availability of vendors and technological options for both online and offline TWFL systems. He requested all RPCs to discuss the recommendations of the Committee at RPC/sub-forum for implementation of TWFL Technology.

2.15.4 **Chairperson, CEA/NPC** suggested that the technology may initially be implemented on new transmission lines instead of modifying existing lines. This would allow the technology to be incorporated at the design stage and its performance to be evaluated under actual operating conditions. He also observed that providing the facility during the initial design and construction stage may be more economical than retrofitting it on existing lines.

2.15.5 He further suggested that critical existing transmission lines may be identified for priority implementation based on system requirements. Such lines would provide useful operational experience and help assess the effectiveness of the technology.

2.15.6 **After detailed deliberations,** NPC forum agreed to take forward the recommendations of the concerned Committee. It was decided that travelling-wave-based monitoring shall be included in the technical specifications in the RFP of new transmission lines, while selected critical existing lines may also be considered for implementation based on system requirements.

2.15.7 **Decision of the NPC:**

i. **RPCs to discuss the recommendations of the report of the Committee on Guidelines/Procedure for implementation of TWFL Technology at the RPC/sub-forum level.**

(Action: All RPCs)

ii. **Implementation of TWFL shall be included as part of the technical specifications in the RFP of new transmission lines.**

(Action: CTUIL)

iii. **RLDCs/RPCs/TSPs to identify existing critical transmission lines in their respective regions for implementation of TWFL.**

(Action: RLDCs/RPCs/TSPs)

2.16 <u>Requirement of Voice Communication for Operational Co-ordination (Agenda from SRPC):</u>

2.16.1 Briefing the agenda, **MS, NPC** informed that, in the 17th NPC Meeting held on 27.02.2026, it was decided that CERT-Grid Operation (NLDC) would prepare a comprehensive plan for cyber security of voice and data communication systems covering QCAs, large open-access consumers, data centres, green hydrogen facilities and peer-to-peer market participants, considering the evolving power sector. She further informed that Grid-India has submitted comprehensive generic guidelines for implementation of cyber security controls and requested Grid-India to brief the NPC forum on the same.

2.16.2 It was observed that the guidelines circulated by Grid-India were general in nature and did not clearly specify the technical and cybersecurity requirements for QCA connectivity. It was therefore suggested that the guidelines be revised to make them more detailed and implementation-oriented, clearly specifying the requirements to be fulfilled by entities seeking connectivity with the existing voice communication system.

2.16.3 Chairperson, CEA/NPC highlighted the need to include appropriate cybersecurity measures in the proposed communication arrangement. These should include multi-factor authentication, firewall-based network traffic filtering, deep-packet inspection, wherever applicable, and maintenance of audit logs for traceability and cybersecurity monitoring. **CMD, Grid-India** agreed with the views of **Chairperson, CEA/NPC.**

2.16.4 It was informed that a new voice exchange system is under development and incorporates several required cybersecurity features. In view of this, it was suggested that the existing guideline may be reviewed and suitably revised to align with the new system and cybersecurity requirements. The revised guideline should clearly specify the minimum technical and cybersecurity requirements for QCA and open access connectivity.

2.16.5 Chairperson, CEA/NPC highlighted the need to clearly define the responsibilities of the QCA and the concerned system/operator. It was suggested that the connectivity application and approval procedure should clearly state the requirements to be fulfilled by the applicant. The revised guideline should be in proper format for ease of understanding.

2.16.6 After detailed deliberations, it was agreed that the existing guidelines should be suitably revised to include specific technical and cybersecurity requirements for QCA and other entities getting connected to Control Centres, and to clearly define the connectivity procedure and responsibilities of the concerned entities. The revised draft guidelines shall be discussed with the concerned stakeholders and submitted in the next NPC meeting for consideration and approval.

2.16.7 <u>Decision of the NPC</u>:

i. The revised guidelines for voice communication connectivity of QCA and other entities getting connected to Control Centres would be submitted by

Grid-India and shall be discussed with the concerned stakeholders to incorporate specific technical and cybersecurity requirements. The same shall be presented in next NPC meeting for consideration and approval.

(Action: Grid-India)

2.17 PARAM (Protection Activities Reporting, Audit and Monitoring) Portal (Agenda from NRPC):

2.17.1 Briefing the agenda, **MS, NRPC/NPC** informed that NRPC Secretariat has developed the web-based **PARAM Portal** as an in-house platform for reporting and monitoring protection-related data in compliance with the Protection Code of IEGC, 2023. The portal enables utilities to submit monthly protection performance indices, annual/third-party protection audit plans and audit reports digitally, replacing the earlier email and hardcopy-based system. Utilities have been requested to use the portal for reporting from FY 2025-26 onwards. The initiative was presented for information of NPC, and other RPCs may consider adopting similar digital platforms as per their regional requirements.

2.17.2 Representative from NRPC presented the features of the existing PARAM database, which covers a large number of substations and utilities, including renewable energy generators. The system provides information on the number of substations, audit plans received and pending. It also allows users to view detailed lists and download data in Excel format for further analysis and monitoring.

2.17.3 He, further informed that the system provides monthly protection performance indices and enables identification of utilities having performance below the specified level. Such cases can be filtered along with the reasons for the low performance, facilitating timely identification of deficiencies and corrective action by the concerned utilities.

2.17.4 NPC forum was informed that different RPCs are currently using different systems for maintaining and reporting protection-related information. SRPC and ERPC are examining their existing software arrangements, WRPC has a similar system available on its website, while NERPC is exploring the use of its existing PDMLF software for the required reporting.

2.17.5 Chairperson, CEA/NPC enquired whether the systems maintained by different RPCs could be integrated or standardized to develop a common database. **MS, NRPC** informed that although similar information is maintained by the RPCs, the databases are presently not interconnected. Chairperson, CEA/NPC emphasized that a common database would provide a consolidated national-level view of protection audit status, protection performance and compliance across all regions.

2.17.6 After detailed deliberations, it was agreed that the RPCs through Protection Subgroup of NPC may examine the useful functionalities available in each other's systems and identify features that can be incorporated into a common and comprehensive features and database. The system should be capable of capturing relevant protection-related data and accommodating future requirements.

2.17.7 Decision of the NPC:

i. **RPCs through Protection Subgroup of NPC may examine the useful functionalities available in each other's systems and identify features that can be incorporated for a common and comprehensive features and database.**

(Action: Protection Subgroup of NPC/All RPCs)

ii. **The feasibility of integrating the existing systems and providing national-level visibility of protection audit plans, audit reports, and monthly protection performance indices may also be explored.**

(Action: Protection Subgroup of NPC)

2.18 Revised Procedure for Compensation due to Part Load Operation (Agenda from SRPC):

2.18.1 Briefing the agenda, **MS, NPC** informed that, in the 17th NPC Meeting held on 27.02.2026, the Commercial Sub-Group of NPC was tasked with examining the feasibility of provisional compensation statements and related regulatory issues. The matter was deliberated in the Commercial Sub-Group meeting held on 04.05.2026, wherein it was agreed that only final REA/Compensation Accounts would be issued. Accordingly, designated Generating Stations/RLDCs shall submit the required data and compensation calculations to the respective RPC Secretariat by the 8th of every month for the preceding month. Based on the submitted data, the RPCs shall issue the final Compensation Statement by the 20th of the month. Any delay in submission of data beyond the 8th of the month shall be suitably recorded. The proposed timeline was placed before NPC for consideration and approval. She further informed that Grid-India may take up with CERC the proposal to remove the provision permitting designated generating stations to recover the carrying cost from the beneficiaries or the pool, as the case may be.

2.18.2 After detailed deliberations, NPC forum approved the timelines recommended by the Commercial Sub-Group of NPC for submission of required data by designated Generating Stations/RLDCs by the 8th of every month and issuance of the final Compensation Statement by the 20th of every month. Grid India will take up the matter of removal of “Carrying cost” Clause in the approved Procedure with CERC.

2.18.3 Decision of the NPC:

i. **The designated Generating Stations/RLDCs shall submit the required data and compensation calculations to the respective RPC Secretariat by the 8th of every month for the preceding month. Any delay in submission of data beyond the 8th shall be suitably recorded.**

(Action: Generating Stations / RLDCs)

ii. **The respective RPCs shall issue the final Compensation Statement by the 20th of every month, based on the data submitted and compensation calculations furnished by the concerned Generating Stations/RLDCs.**

(Action: All RPCs)

iii. **Grid India will take up the matter of removal of "Carrying cost" Clause in the approved Procedure with CERC.**

(Action: Grid India)

2.19 Regional Cyber Security Coordination Forums (Agenda from SRPC):

2.19.1 Explaining the agenda, **MS, NPC** informed that, in the 17th NPC Meeting held on 27.02.2026, RPCs were advised to sensitize utilities on cyber security coordination, while the NPC Secretariat was tasked with facilitating training programmes and coordination forums. Accordingly, letters were issued to the Cyber Security Division, CEA and MNRE on 24.04.2026 and 27.04.2026, respectively. DP&T Division, CEA informed that CERT-D under CSIRT-Power is already undertaking the prescribed activities for DISCOMs, including capacity-building and monitoring, and suggested establishing Regional Cyber Security Coordination Forums at RPC level under the guidance of CSIRT-Power, with inputs from CERT-D.

2.19.2 NPC forum discussed the need to strengthen the existing regional mechanism for coordination of cyber security matters. It was noted that the increasing integration of renewable energy and other entities into the power system is creating additional cyber security interfaces, requiring wider participation of utilities at the regional level. It was also informed that the Cyber Security Division, CEA is conducting meetings/awareness program and taking steps to extend cyber security activities to the appropriate level.

2.19.3 Chairperson, CEA/NPC observed that participation of central representatives in every regional meeting may not be practical. He, therefore, suggested that each RPC may identify a lead DISCOM in its respective region in consultation with DP&T Division, CEA, which may constitute a Regional Cyber Security Coordination Forum with representation from the DISCOMs, RLDC, CSIRT-Power, DP&T Division and RPC. The Forum may facilitate capacity building, periodic monitoring and review of cyber security issues, and establish an appropriate regional mechanism for their identification, resolution and follow-up. The mechanism shall function in accordance with the applicable regulatory framework, with clearly defined responsibilities and proper recording, follow-up and reporting of issues. He further emphasized that matters requiring specialized technical or policy intervention shall be referred to the Cyber Security Division, CEA, for necessary action. It was agreed by all the members.

2.19.4 Decision of the NPC:

i. **RPCs shall identify a lead DISCOM in its respective region in consultation with DP&T Division, CEA, which shall constitute a Regional Cyber Security Coordination Forum with representation from the DISCOMs, RLDC, CSIRT-Power, DP&T Division and RPC. The Forum shall facilitate capacity building, periodic monitoring and review of cyber security issues, and establish an appropriate regional mechanism for their identification, resolution and follow-up. The mechanism shall function in accordance with the applicable regulatory framework, with clearly defined responsibilities and proper recording, follow-up and reporting of issues.**

(Action: All RPCs)

ii. **Matters requiring specialized technical or policy intervention shall be referred to Cyber Security Division, CEA for necessary action.**

(Action: Cyber Security Division, CEA/ All RPCs)

2.20 DC meter requirement for Solar & BESS/Storage Projects for Energy Accounting & Scheduling (Agenda from SRPC):

2.20.1 MS, NPC briefed the members on the requirement for DC metering in Solar PV projects integrated with BESS/Storage, particularly where the BESS is connected on the DC side before the inverter. She explained that the metering requirement needs to be examined based on the system configuration and the point at which commercial energy accounting is carried out.

2.20.2 Referring to Regulation 8(6) of the CERC DSM Regulations, 2024, **MS, NPC** stated that, where a WS Seller with ESS is connected at the same interconnection point, the applicable deviation charges depend on whether power is being injected by the solar/wind/hybrid generating station, injected by the standalone ESS, or drawn by the ESS from the grid. She further stated that the Regulation requires each generator and ESS to be metered through Special Energy Meters (SEMs) to capture their individual actual injection and drawl. As per Regulation 8(6) of CERC DSM Regulations, 2024, the relevant provision is reproduced below:

Quote

"*Charges for Deviation including the formula for computation of Deviation, in respect of a WS Seller with ESS connected at the same interconnection point shall be the same (i) as applicable to a WS seller of respective category during the period solar or wind or hybrid generating station is injecting power, (ii) as applicable to a standalone ESS as per sub-clause (5) of this Regulation, when only ESS is injecting power, and (iii) as applicable to a standalone ESS for drawl by ESS based on drawl schedule from the grid as per sub-clause (5) of this Regulation.*

Note: Each generator and ESS shall be metered with Special Energy Meter (SEM) so that individual actual injection/drawl can be captured."

Unquote

2.20.3 MS, SRPC stated that, in view of the above provision, separate SEMs may be required for the generating station and ESS for capturing their individual

injection/drawl. It was further explained that in DC-coupled Solar/BESS configurations, where energy exchange takes place on the DC side before the inverter, the requirement of DC metering may arise if the accounting is required at the DC level for compliance of CERC Regulation. In the absence of appropriate metering at the relevant point, the corresponding individual energy flows cannot be captured for accounting purposes.

2.20.4 NPC forum deliberated on the distinction between AC-coupled and DC-coupled BESS configurations. In AC-coupled arrangements, the relevant AC-side metering point may be considered for accounting, whereas in DC-coupled configurations, the appropriate metering point requires examination, particularly where solar generation and storage are integrated before conversion to AC for injection into the grid.

2.20.5 Chairperson, CEA/NPC suggested that, for the purpose of energy accounting and settlement, an integrated Solar PV and BESS/Storage arrangement may be considered as one integrated system/entity at the applicable accounting point, rather than treating the individual internal components separately. All members also emphasized that a uniform principle should be followed for similarly configured systems.

2.20.6 After detailed deliberations, the members agreed that where the integrated Solar PV/Wind and BESS/Storage arrangement is accounted for as one integrated system at the applicable AC-side accounting point, individual internal DC-side energy flows need not be accounted for separately. Accordingly, DC meters would not be required for accounting purposes under such an integrated arrangement. Further, it will be treated as WS seller in case there is no interchange from ISTS by BESS envisaged and would be treated as General Seller if interchange with ISTS by BESS is envisaged.

2.20.7 <u>Decision of the NPC</u>:

i. **For energy accounting and settlement, an integrated Solar PV/Wind and BESS/Storage arrangement may be considered as one integrated system at the applicable accounting point, rather than accounting for individual internal components separately. Accordingly, DC metering shall not be required for accounting purposes by RPCs under such an integrated arrangement. It will be treated as WS seller in case there is no interchange from ISTS by BESS envisaged and would be treated as General Seller if interchange with ISTS by BESS is envisaged.**

(<u>Action</u>: All RPCs/RLDCs)

ii. **The above decisions may be communicated to CERC.**

(Action: NPC Secretariat)

2.21 <u>Conducting the Examination for Protection Auditor Certification (Agenda from NRPC):</u>

2.21.1 Briefing the agenda, **MS, NPC** informed that, in the 17th NPC Meeting held on 27.02.2026, NPTI was entrusted with developing structured training and certification programmes for Protection Auditors in coordination with CEA, RPCs and PowerGrid. Accordingly, nominations of 2–3 protection audit experts from each RPC, PowerGrid and HRD Division, CEA were sought to support development of the course content and technical modules. NPTI was subsequently requested to develop the training modules and certification framework. The inputs from NPTI are awaited.

2.21.2 NPC forum discussed the role of NPTI and other concerned organizations in development of the programme. **Member (GO&D), CEA** suggested that NPTI should be part of the Committee but the curriculum and examination requirements should be developed collectively, based on inputs from RPCs, PowerGrid and other concerned organizations.

2.21.3 **Chairperson, CEA/NPC** suggested constituting a Committee under **Principal Chief Engineer-I, CEA**, with representatives from NPC Division, CEA, HRD Division, CEA, RPCs, PowerGrid and NPTI. The Committee shall identify the required courses, finalize the curriculum and examination methodology, and consider relevant experience from existing protection audit and system operator certification programmes to ensure that the proposed programme meets practical operational requirements.

2.21.4 **After detailed deliberations,** it was agreed that the Committee shall develop the training curriculum and certification framework with participation from all relevant stakeholders. The finalized course structure and examination framework shall thereafter be submitted in the next NPC meeting for consideration and approval.

2.21.5 **Decision of the NPC:**

i. **A Committee shall be constituted under the Principal Chief Engineer-I, CEA, with representatives from NPC Division, CEA, HRD Division, CEA, RPCs, PowerGrid, and NPTI to identify the courses required for the proposed training and certification programme, keeping in view the practical requirements of protection audit and system operation.**

(Action: NPC Secretariat/ Principal Chief Engineer-I, CEA)

ii. **The finalized course structure and examination framework shall thereafter be submitted in the next NPC meeting for consideration and approval.**

(Action: Principal Chief Engineer-I, CEA)

2.22 Training on Emergency Restoration System (ERS) in the Southern Region as per MoP Guidelines (Agenda from SRPC):

2.22.1 Briefing the agenda, **Member (Power System), CEA** informed that a Committee was constituted under the Chairmanship of Chief Engineer, PSE&TD Division,

CEA, with representatives from NPC Secretariat, PGCIL, GETCO, CPRI, CSIR-SERC and NPTI on Emergency Restoration System (ERS) Tower Requirement Standardization and Setting up ERS Training Facility at NPTI. The Committee held two meetings and two site visits (Raipur S/S of PGCIL and HLTC, Bengaluru) and finalized its report on 15.09.2026.

2.22.2 He further informed that significant gaps were observed between the required and available ERS sets, with non-uniform tower configurations across utilities. Accordingly, the Committee finalized the minimum requirement of Suspension and Tension Towers in each ERS set, considering the possible configurations, as follows:

i. 400 kV & below, up to Twin configuration: 10 Suspension + 6 Tension towers.
ii. 400/765 kV with Quad/Hexa/Octa configuration: 15 Suspension + 9 Tension towers.
iii. 765 kV & HVDC: 15 Suspension + 9 Tension towers.
iv. ERS set requirement continues to be linked to transmission line length: 1 set up to 5,000 ckt-km; 2 sets for 5,000–10,000 ckt-km; 3 sets for 10,000–15,000 ckt-km, and so on.

2.22.3 He also informed that rental arrangement may be considered where dedicated ERS procurement is not economically or operationally viable, particularly for smaller networks. He also highlighted the need for establishing ERS training facilities at both the utility and national levels. Accordingly, a dedicated training facility was proposed at NPTI/HLTC, Bengaluru**.** The report envisages two levels of training:

i. Basic Training for technicians/executives involved in ERS deployment and restoration; and
ii. Advanced Training for personnel involved in ERS planning and design.

2.22.4 NPC forum discussed the need for proper nomination of personnel by States/STUs/utilities for ERS training. It was observed that the training programme would be effective only if utilities regularly nominate adequate personnel and participants in the training. Accordingly, training may be organized in regular batches in coordination with the concerned utilities to ensure effective use of the available training facilities and development of sufficient trained manpower.

2.22.5 The members also expressed concern regarding the availability of in-house ERS capability in some utilities. It was observed that excessive dependence on contractors may lead to loss of practical technical expertise within the utilities. The members emphasized that utility personnel should have adequate hands-on experience in ERS deployment and restoration so that the required in-house capability is maintained for effective response during emergencies.

2.22.6 **Chairperson, CEA/NPC** suggested that training facilities at institutes other than NPTI may also be considered so that the training capacity can be increased. He further suggested that 1~2 out of twenty ERS sets procured by PowerGrid may be

utilized for training purposes, thereby providing suitable equipment for practical training.

2.22.7 **Chairperson, CEA/NPC** also suggested that the status of ERS training should be placed periodically before the OCC meetings of the RPCs, including the number of personnel trained. This would provide a regular mechanism for monitoring the progress of training and identifying States/STUs/utilities where additional training is required.

2.22.8 **After detailed deliberations,** NPC forum agreed and approve the Report of the Committee on ERS Set Standardization, ERS rental arrangements and ERS Training Facility (attached as **Annexure-VI**). The forum also agreed that training facilities at institutes other than NPTI may be considered, 1~2 out of twenty ERS sets recently procured by PowerGrid may be utilized by NPTI and other identified Institutes for training purposes, and the status of ERS training, including the number of personnel trained, may be placed before the OCC meetings of the RPCs.

2.22.9 **Decisions of the NPC:**

i. **The Report of the Committee on ERS Set Standardization and ERS Training Facility was approved.**

ii. **Training facilities at institutes other than NPTI may also be considered and 1~2 out of twenty ERS sets recently procured by Powergrid may be utilized by NPTI and other identified Institutes for training purposes.**

(Action: PSE&TD, CEA /NPTI)

iii. **The Report would be sensitized in the RPC Forum /Sub Committees. The status of ERS training, including the number of personnel trained, shall be placed before the OCC meetings of the RPCs for monitoring and follow-up.**

(Action: All RPCs)

2.23 Status of Emergency Restoration System (ERS) (Agenda from NPC):

2.23.1 Briefing the agenda, **MS, NPC** informed that RPCs have confirmed that ERS availability is being regularly reviewed and updated in OCC meetings.

2.23.2 **Members noted the information.**

2.24 Protection philosophy for RE plants (Agenda from NRPC):

2.24.1 **MS, NPC/NRPC** informed that NRPC has prepared a Protection Philosophy for Renewable Energy (RE) Plants, which was approved in the 83rd NRPC Meeting and subsequently adopted in the Northern Region. She further informed that, during the pre-meeting of NPC, all RPCs agreed that the agenda may be taken forward through the NPC Protection Sub-Group for consideration at the national level.

2.24.2 **After detailed deliberation,** it was agreed that Protection Philosophy for RE Plants prepared by NRPC would be discussed in RPC Sub Committee(s). The

comments/ inputs of all RPCs shall be discussed by the Protection Sub-Group of NPC for consideration at the national level. Based on the recommendations of the Protection Sub-Group, the Protection Philosophy shall thereafter be placed before the next NPC meeting for consideration and approval.

2.24.3 Decision of the NPC:

i. **Protection Philosophy for RE Plants prepared by NRPC would be discussed in RPC Sub Committee(s).**

(Action: All RPCs)

ii. **The comments/ inputs of all RPCs shall be discussed by the Protection Sub-Group of NPC for consideration at the national level. Based on the recommendations of the Protection Sub-Group, the Protection Philosophy shall thereafter be placed before the next NPC meeting for consideration and approval.**

(Action: Protection Sub Group of NPC)

2.25 Unified Accounting Software (UAS) for RPCs and NPC (Agenda from NRPC):

2.25.1 NPC forum reviewed the status of implementation of UAS and noted that the progress was considerably delayed. **Chairperson, CEA/NPC** expressed concern over the delay and emphasized that the development and implementation should be completed in a time-bound manner. The status of procurement/award and other pending activities was also reviewed.

2.25.2 Decision of the NPC:

i. **NRPC shall expedite the implementation with regular monitoring of progress against the approved milestones.**

(Action: NRPC)

2.26 Installation of OPGW on the existing lines of ISTS and STU (Agenda from CTUIL):

2.26.1 Representative from CTUIL informed in the 17th NPC Meeting held on 27.02.2026, CTUIL was advised to place the proposal for OPGW installation on existing ISTS lines before the NCT after obtaining approval from the concerned regional forums. Subsequently, the proposal for OPGW installation on existing ISTS lines has received approval from NCT across all regions.

2.26.2 COO, CTUIL informed that approximately 18,000 km of OPGW works under ISTS and intra-State networks have been approved during the last six months and are at various stages of implementation across different regions. Out of this, approximately 17,000 km pertains to the ISTS network and 1,000 km to intra-State networks. He further suggested that the FOTE associated with the intra-State OPGW works should be planned and implemented within a matching timeframe so that the communication system is available along with the OPGW and overall system efficiency can be ensured.

2.26.3 He further informed that, in the ISTS transmission schemes under planning, around 45–50 schemes have corresponding intra-State transmission systems, including systems at and above 220 kV level. In some cases, a mismatch in the implementation timelines of the ISTS and intra-State systems may occur. He suggested that the concerned RPCs and States may monitor the implementation of such systems at their respective levels to ensure that the timelines are aligned.

2.26.4 **Chairperson, CEA/NPC** suggested that CTUIL may identify such transmission lines/schemes on a State-wise or region-wise basis and communicate the details to the CMDs of the concerned STUs, requesting them to align the implementation timelines of the corresponding intra-State systems with the ISTS schemes.

2.26.5 **Decision of the NPC:**

i. **CTUIL shall identify the ISTS transmission lines/schemes having corresponding intra-State transmission systems, including systems at and above 220 kV level, on a State-wise/region-wise basis.**

ii. **CTUIL shall communicate the identified lines/schemes to the CMDs of the concerned STUs, requesting them to align the implementation timelines of the corresponding intra-State systems with the ISTS schemes.**

(Action: CTUIL)

2.27 Uniform criteria on Harmonics measurement in the grid (Agenda from NERPC):

2.27.1 **MS, NPC** informed that, in the 17th NPC Meeting held on 27.02.2026, it was decided that the Grid-India report on uniform criteria for harmonics measurement would be examined by all RPCs in coordination with RLDCs and other stakeholders, and the inputs would thereafter be considered by the Protection Sub-Group of NPC. Accordingly, the NPC Secretariat convened a meeting with RPCs and Grid-India on 04.06.2026, wherein the draft Guidelines were deliberated. Grid-India subsequently shared the revised Guidelines and informed that separate Guidelines for installation of harmonic filters for RE plants had also been submitted to CEA. The revised report was forwarded to the GM Division, CEA, and its recommendations are presently under consideration for incorporation in the draft Compliance Monitoring Guidelines.

2.27.2 Members noted the information.

2.28 Establishment of State-of- the-Art National Unified Network Management System (N-UNMS) in main & backup configuration integrating all the regional UNMSs (Agenda from CTU):

2.28.1 **MS, NPC** informed that in the 17th NPC Meeting held on 27.02.2026, CTUIL was advised to finalize and freeze the workflow module in coordination with the vendor and concerned stakeholders, incorporating the final comments already received. Accordingly, CTUIL convened a coordination meeting on 22.07.2026 with NPC, RPCs, RLDCs, POWERGRID and other stakeholders for finalization of the workflow, and the minutes were issued on 03.08.2026. POWERGRID has

confirmed that the finalized workflow will be developed and implemented within three months.

2.28.2 **MS, SRPC** highlighted that the deployment of PGCIL officials at NMT requires close attention. Presently it is being manned by OEM personnel. However, there is presently no clearly defined mechanism or dedicated team for resolving NMT-related issues. He emphasized the need to clearly define the responsibility and establish an appropriate team so that such issues are addressed promptly.

2.28.3 **Chairperson, CEA/NPC** suggested that unresolved NMT issues may be formally reported and taken up with **PowerGrid**, wherever required. CTUIL was advised to submit a letter to CEA detailing the issues so that the matter could be taken up at the appropriate level to PowerGrid.

2.28.4 The status of the communication audit was also discussed. It was informed that the audit activity had already commenced in some form, although certain aspects had been missed. The members agreed that the pending issues should be addressed and, if necessary, an alternative mechanism/model for undertaking the communication audit should be examined. The matter could also be taken up separately under the appropriate agenda.

2.28.5 **Decision of the NPC:**

i. **CTUIL shall submit a letter to CEA detailing the outstanding NMT-related issues, enabling the matter to be taken up with PowerGrid at the appropriate level.**

(Action: CTUIL)

2.29 Review of Status of Islanding schemes:

2.29.1 Briefing the agenda**, MS, NPC** informed that status of islanding schemes is being reviewed periodically by respective RPCs through OCC/PCM meetings. She further informed that the status of all islanding schemes under implementation was reviewed in a meeting held on 09.07.2026 under the chairmanship of Secretary, Power. She also informed that the SOP for the Islanding Scheme (attached at **Annexure-VII**) has been revised to incorporate RE generation into the Islanding Scheme and to address the operational feedback received from SRPC.

2.29.2 **Chairperson, CEA/NPC** suggested that the status of islanding schemes may be kept as a regular agenda item in the OCC/PCM meetings of RPCs. He further suggested that RPCs may periodically monitor and verify whether the already implemented islanding schemes are functional and available for operation.

2.29.3 **Decisions of the NPC:**

i. **The Revised SOP for Islanding Schemes was approved by the NPC forum.**

ii. **The status of islanding schemes may be kept as a regular agenda item in OCC/PCM meetings of RPCs. RPCs may periodically monitor and verify whether the already implemented islanding schemes are functional and available for operation.**

(Action: All RPCs)

2.30 Congestion Statement for RE entities (Agenda from SRPC):

2.30.1 MS, NPC informed in the 17th NPC Meeting held on 27.02.2026, it was decided that Congestion Statements shall include Renewable Energy (RE) entities in accordance with the prevailing CERC Regulations, and all RPCs will be adopting a uniform accounting practice. SRPC and NRPC have confirmed that RE entities will be included in their Congestion Statements henceforth, while WRPC is already following the practice. NERPC has reported that there are presently no ISGS RE entities in its region, making the provision not applicable at present.

2.30.2 Chairperson, CEA/NPC suggested that Congestion data shall be prepared with greater granularity, clearly distinguishing transmission/grid-related congestion from constraints attributable to the developer, generation conditions, connectivity status or other causes. The same will be discussed in RPC subcommittee meetings and major issues shall be highlighted to CEA.

2.30.3 Decision of the NPC:

i. Congestion data shall be prepared with greater granularity, clearly distinguishing transmission/grid-related congestion from constraints attributable to the developer, generation conditions, connectivity status or other causes. The same will be discussed in RPC subcommittee meetings and major issues shall be highlighted to CEA.

(Action: Grid- India)

2.31 Unified Real Time Dynamic State Measurement (URTDSM) project phase-II (Agenda from PowerGrid):

2.31.1 MS, NPC informed that in the 17th NPC Meeting held on 27.02.2026, Grid-India was tasked with identifying critical transmission lines for consideration of TBCB projects under Change in Law and RTM projects under Additional Capitalization, as applicable. Accordingly, the locations identified for PMU installation were shared with POWERGRID/CTUIL. The proposal was subsequently considered and approved in the 40th NCT Meeting held on 15.04.2026. Further, CTUIL informed that the URTDSM Phase-II Scheme was also placed before and approved by the 40th NCT Meeting.

2.31.2 Members noted the information.

2.32 Additional Agenda Items:

2.32.1 Scheduling Issue of "Power to be Sold Outside Long-Term PPA" from Generating Stations (Agenda from ERPC):

a. **MS, ERPC** briefed the agenda and informed that the power allocation from NTPC Farakka-III comprises 70% firm allocation, 15% unallocated capacity and 15% identified as "Power to be sold outside Long-Term PPA". NTPC subsequently entered into a bilateral PPA with GUVNL for the said 15% share. Since GUVNL already has an existing allocation of 6.948474%, its total entitlement from the generating station, including the additional 15% power, becomes 21.948474%.

b. He also informed that the matter was discussed in commercial subgroup of NPC and pre-meeting of NPC wherein it was decided that the power allocated from Govt. of India and Merchant bilateral power can be clubbed for Scheduling/Settlement purpose, if the tariff of both is same. For different tariff of Govt. of India allocation and merchant bilateral power, separate entity shall be created in scheduling software by Grid-India/RLDC for better settlement of the Energy accounts. Grid-India/RLDC may work out part load/SFC compensation methodology foe such cases.

c. It was discussed that the additional 15% power is outside the existing GoI allocation and is available for sale by the generating station under a separate bilateral arrangement. However, since the additional power is being supplied from the same generating station and generating unit, the issue is primarily regarding its treatment in scheduling and commercial settlement rather than separate physical operation of the generating unit.

d. **Director (Market Operation), Grid-India** suggested that, where the tariff applicable to both portions of power is the same, the GoI-allocated share and the additional power sold under the bilateral PPA may be clubbed for scheduling and commercial settlement. This would mean that the total power scheduled to GUVNL from the generating station may be considered together for operational purposes, without requiring separate scheduling treatment for the two portions.

e. **Chairperson, CEA/NPC** suggested that the treatment should depend on the tariff applicable to the two portions of power. He suggested that where the tariffs applicable to the GoI-allocated share and the additional bilateral PPA-based power are the same, the two portions may be clubbed for scheduling and commercial settlement. Where the tariffs are different, Grid-India may devise an appropriate mechanism to separately account for the respective portions while ensuring proper scheduling and commercial settlement.

f. **After detailed deliberations,** NPC forum agreed that, where the tariff applicable to the GoI-allocated share and the additional power sold under the bilateral PPA is the same, the two portions of power may be clubbed for scheduling and commercial settlement. Where the tariffs differ, an appropriate mechanism shall be devised by Grid-India for the scheduling and commercial settlement of the respective portions of power. The underlying allocation and bilateral PPA details shall remain identifiable in the relevant records wherever required.

g. <u>Decision of the NPC</u>:

i. Where the tariffs of the GoI-allocated share and bilateral PPA-based share are same, **the two shares may be clubbed for scheduling and settlement**. **Where the applicable tariffs differ, Grid-India shall devise an appropriate mechanism for separate scheduling and commercial settlement of the respective shares of power.**

(<u>Action</u>: All RPCs/Grid India)

2.32.2 Discussion on Change of Default Option in WBES from "Total Full Requisition" to "Full Surrender" and Request to Keep the Same on Hold Till Proper Discussion with Beneficiaries and Regulatory Clarity (Agenda from ERPC):

a. Briefing the agenda, **MS, ERPC** informed that, earlier, in case a beneficiary did not submit its requisition, the WBES defaulted to "Total Full Requisition", under which the beneficiary was considered for its full entitled share. The default option has subsequently been changed by Grid-India to "Full Surrender", i.e. zero requisition.

b. He also informed that the matter was discussed in commercial subgroup of NPC and pre-meeting of NPC wherein it was decided that the default option of "full surrender" maybe stopped and option of "total full requisition" may be continued in WBES and the matter may be placed before upcoming NPC meeting for further deliberation.

c. **Director (Market Operation), Grid-India** explained that under the earlier arrangement, beneficiaries could receive their full entitlement in the absence of a requisition. However, when the beneficiary subsequently reduced its requisition, particularly around 2:30 PM, the generating station could be required to operate below its Minimum Technical Level (MTL). This could increase operational requirements and associated costs. She further stated that submission of requisition is the responsibility of the beneficiary.

d. She, further informed that, from 1st April 2026, the revised process had been implemented after detailed discussions and practical hand-holding sessions with the concerned entities. Feedback received from the entities and RPCs had been incorporated in the scheduling process. The WBES software provides various options for submitting requisition, including file uploading, cube filling and block-wise filling, and additional manpower had also been deployed to assist the concerned entities. It was informed that the system had been functioning satisfactorily for the last five months and was in line with the applicable provisions of IEGC, 2023.

e. **MS, WRPC** did not agree with the reasoning given by Director (Market Operation), Grid-India regarding the satisfactory functioning of the option during the last five months. He pointed out that the beneficiaries are not satisfied with the existing option and are following the revised procedure only because they are required to do so and have no alternative. He emphasized that the fact that the procedure is being followed does not necessarily mean that the beneficiaries are satisfied with the existing arrangement.

f. **MS, SRPC** highlighted that, if "Full Surrender" is kept as the default option and a beneficiary fails to submit its requisition due to communication failure or any other reason, the beneficiary may lose access to its entitled power for that day. He therefore suggested that the implications of keeping "Full Surrender" as the default option should also be considered from the beneficiary's perspective.

g. **CMD, Grid-India** stated that when a beneficiary does not submit its requisition, the corresponding power becomes available for utilization by other market participants. He emphasized that beneficiaries should submit their actual requisition based on their requirement, so that the balance power can be made available to the market for utilization by others. He further clarified that "Full Surrender" remains available for beneficiaries who consciously wish to surrender their entitlement, and that the concern is primarily related to its use as the default option.

h. It was suggested that an alert provision may be incorporated in the scheduling software to automatically notify utilities if they have not submitted their requisition within the prescribed time. This would help reduce the possibility of inadvertent surrender of their entitlement while retaining the responsibility of the beneficiary to submit its requisition.

i. **After detailed deliberations**, NPC forum agreed with the view of Grid-India that the existing arrangement of "Full Surrender" as the default option may be continued, considering that the system was implemented after consultation with the concerned entities and has been functioning satisfactorily. At the same time, an alert provision shall be incorporated in the scheduling software to notify utilities if the requisition is not submitted within the prescribed time or any communication failure occurs.

j. <u>Decision of the NPC</u>:

i. The default option of "Full Surrender" (zero requisition) in WBES may be continued. However, concerns of stakeholder should be addressed through proper stakeholder consultation.

ii. An alert provision shall be incorporated in the scheduling software to automatically notify the nodal officers of utilities in case the requisition is not submitted within the prescribed time or any communication failure occurs.

(<u>Action</u>: Grid India)

2.32.3 <u>Review of FGD Installation in Consultation with Beneficiaries for Ongoing and Operational Category 'C' Thermal Power Projects of NTPC (Agenda from ERPC):</u>

a. Briefing the agenda, **MS, ERPC** informed that, as per the revised provisions of the MoEF&CC amendment dated 11.07.2025, Category 'C' thermal power plants are not required to comply with the prescribed SO_2 emission standards, subject to fulfilment of the applicable stack-height criteria. He further informed that the CAPEX incurred towards installation of FGD systems has already been borne by the constituents**,** while the recurring OPEX and additional auxiliary energy consumption associated with FGD operation impose an additional financial burden.

b. He also informed that the matter was discussed in commercial subgroup of NPC and pre-meeting of NPC, wherein it was decided that since the matter is policy-related and clarification from the Ministry of Power is already awaited and the cost-benefit analysis of operating the FGD system, including the potential revenue from

the sale of gypsum, has not yet been completed by NTPC. The matter may be placed in the upcoming NPC meeting for further deliberation/guidance.

c. **Chairperson, CEA/NPC** observed that the matter is primarily policy-related and falls outside the purview of RPCs. He suggested that, if the concerned States seek reimbursement/compensation towards recurring OPEX, they may approach the appropriate regulatory forum.

d. After detailed deliberations, NPC forum agreed with the view of the Chairperson, CEA/NPC that the matter is policy-related and falls outside the purview of RPCs. It was noted that the concerned States may approach the appropriate regulatory forum regarding recovery of recurring OPEX, as considered appropriate.

e. <u>Decision of the NPC</u>:

i. As the matter is policy-related and falls outside the purview of the RPCs, the concerned states may approach the appropriate regulatory forum for consideration of recovery of recurring OPEX associated with FGD operation.

(<u>Action</u>: Concerned States)

2.32.4 <u>Settlement of Start-up Power Drawl of Patratu Unit-2 as per the Energy Charge Rate (ECR) of the Station (Agenda from ERPC):</u>

a. Briefing the agenda, **MS, ERPC** informed that Patratu STPP Phase-I Unit-2 is under commissioning and that PVUNL/NTPC had proposed settlement of the start-up power drawl at the approved Energy Charge Rate (ECR) of the station, with reference to Unit-1, which has already achieved COD. He further explained that the ECR applicable to a COD-achieved unit cannot automatically be treated as the reference charge rate for a pre-COD unit in the absence of a specific regulatory provision.

b. He, further informed that in the commercial subgroup meeting of RPCs, it was decided that the deviation settlement for drawl of start-up power prior to CoD of the Generating unit shall be as per Regulation 8(9) of the CERC DSM Regulations, 2024 i.e. Weighted Average ACP of the Integrated Day Ahead Market segments of all Power Exchanges for the respective time block irrespective of CoD of the other units.

<u>Quote</u>

As per Regulation 8(9) of CERC DSM Regulations, 2024:

"*The charges for deviation for drawal of start-up power before the COD of a generating unit or for drawal of power to run the auxiliaries during the shut-down of a generating station shall be payable at the reference charge rate or contract rate or in the absence of reference charge rate or contract rate, the weighted average ACP of the Day Ahead Market segments of all Power Exchanges for the respective time block, as the case may be."*

<u>Unquote</u>

c. **Director (Market Operation), Grid-India** clarified that, prior to COD of the generating unit, start-up power drawn from the grid is settled at the Weighted Average ACP of the Integrated Day Ahead Market (IDAM) segments of all Power

Exchanges for the respective time block, irrespective of the COD status of other units of the generating station.

d. During the deliberation, it was further clarified that the start-up power is actually drawn from the grid and, therefore, where the applicable reference charge rate or contract rate is not available for the pre-COD unit, the settlement should be made in accordance with the methodology specified under Regulation 8(9), rather than by attributing the drawal to another generating unit of the station.

e. **After detailed deliberations,** NPC forum agreed that the drawal of start-up power prior to COD of the generating unit shall be settled in accordance with Regulation 8(9) of the CERC DSM Regulations, 2024. Accordingly, where the applicable reference charge rate or contract rate is not available, the Weighted Average ACP of the IDAM segments of all Power Exchanges for the respective time block shall be considered, irrespective of the COD status of other units of the generating station.

f. <u>Decision of the NPC</u>:

i. For drawl of start-up power prior to CoD of the Generating unit or in the absence of contract rate/reference rate shall be as per Regulation 8(9) of the CERC DSM Regulations, 2024 i.e. Weighted Average ACP of the Integrated Day Ahead Market segments of all Power Exchanges for the respective time block irrespective of CoD of the other units.

(<u>Action</u>: All RPCs)

ii. For Patratu STPP Phase-I Unit-2, deviation settlement for drawal of start-up power prior to CoD of the generating unit shall be as per Regulation 8(9) of the CERC DSM Regulations, 2024, i.e. at the Weighted Average ACP of the Integrated Day Ahead Market (I-DAM) segments of all Power Exchanges for the respective time block, irrespective of the CoD status of the other generating units.

(<u>Action</u>: ERPC)

2.32.5 <u>Issues Related to Compensation Statement for Operation Below 55% of Effective Capacity (Agenda from ERPC):</u>

a. Briefing the agenda, **MS, ERPC** that marginal variation below the 55% threshold due to decimal precision may result in an entire time block becoming eligible for additional compensation, even when SCUC/SCED had maintained the generating station at its technical minimum. The issue was therefore examined with a view to ensuring that compensation is not triggered merely due to such marginal computational variation.

b. **MS, SRPC** informed that as prevailing regulations, SCUC/SCED operations are intended to maintain generating stations at their technical minimum while ensuring secure and economical grid operation, so compensation for operation below 55% due to downward schedule of SCUC/SCED should be excluded while determining eligibility for compensation below 55% of effective capacity. This would ensure that compensation is not applicable to the generator for operation resulting from the

system dispatch requirement. He further explained, with reference to the analysis presented, that the impact of decimal adjustment on the compensation amount is marginal. Further by excluding the SCUC/SCED from Fuel Oil Consumption Compensation calculation, the compensation statement from energy terms to rupee terms is not needed.

c. **CMD, Grid India** informed that, as per the CERC-approved procedure for compensation towards degradation in Station Heat Rate, Auxiliary Energy Consumption and Secondary Fuel Oil Consumption due to part-load operation and multiple start/stop of generating units, where SCUC/SCED has maintained the generating station at its technical minimum, compensation statements should not be issued for such operation.

d. **After detailed deliberations,** NPC forum agreed that where SCUC/SCED down has been provided and the generating station nevertheless operates below 55% of effective capacity, the corresponding time block may be excluded from the calculation of compensation. Grid-India/RLDCs shall make the necessary modifications in the WBES software to exclude the time blocks in which downward schedules are given under SCUC/SCED, particularly where the generator is operating below 55% of its effective capacity due to rounding off issue of schedule figure.

e. **<u>Decision of the NPC</u>:**

i. The time block in which a downward schedule is issued under SCUC/SCED shall be excluded from the calculation of Secondary Fuel Oil (SFO) Consumption Compensation. This will be implemented from 01.04.2024 i.e. date of implementation of the Procedure for Mechanism of Compensation for Degradation of Station Heat Rate, Auxiliary Energy Consumption and Secondary Fuel Oil Consumption due to Part-Load Operation and Multiple Start/Stop of the Units, approved by CERC vide Order dated 14.07.2025.

(<u>Action:</u> All RPCs)

ii. Grid-India/RLDCs shall make the necessary modifications in the WBES software to exclude the time blocks in which downward schedules are given under SCUC/SCED, particularly where the generator is below 55% of its effective capacity due to rounding off issue of schedule figure.

(<u>Action:</u> Grid-India)

2.33 Status of Agenda items:

Agenda items	Decision/Deliberations in the 18th NPC Meeting
2.33.1 Agenda of operational issues of DISCOMs at RPC level	RPCs to continue reviewing these common agenda items at RPC level to ensure regular monitoring and resolution of operational issues of DISCOMs. **Members noted.**
2.33.2 Report of the Committee to Evolve a Mechanism for Ensuring Thermal Generation at Technical Minimum Level for Grid Stability and Renewable Energy Integration	RPCs to monitor the implementation of recommendation of the Report of the Committee as required. **Members noted.**
2.33.3 List of substations and transmission elements to be covered for protection audit in cycle of five (5) years.	All RPCs informed that the matter is being examined regularly in the Protection Sub-Committee meetings. NPC forum noted that the review should continue so that the identified substations and relevant State amendments are appropriately covered under the protection audit cycle. **Members noted.**
2.33.4 Automatic Demand Management System (ADMS) (Agenda from Grid India)	Members noted that complete ADMS functionality is presently not available and emphasized the need for proactive measures to ensure system resilience and maintain system discipline. **Accordingly, it was decided to convene a meeting under Member (GO&D), CEA with all States for a State-wise review of ADMS and system conditions.**
2.33.5 Sustained High Frequency in Indian power system during solar hours) (Agenda from Grid India)	RPCs confirmed that they regularly monitored the High/Low Frequency in their subcommittee meetings and accordingly, corrective action are discussed. **Members noted.**
2.33.6 Modification in REA Format/Computation for 55%-SFC Compensation (Agenda from SRPC)	All RPCs informed that the 55% Secondary Fuel Oil Consumption (SFC) compensation is being computed on a cumulative basis, considering both scheduled and actual generation data below 55% for the purpose of SFC compensation calculation and SFC of generating stations are being reviewed on a quarterly basis in the Commercial Sub-Committee meetings. **Members noted.**

Agenda items	Decision/Deliberations in the 18th NPC Meeting
2.33.7 Ramping impact on states due to bulk collective purchase by industries (Agenda from ERPC)	ERPC may take up the matter with the concerned SERC. **ERPC noted.**
2.33.8 Five (5) minute Interface Energy Meters along with AMR system for PAN India (for all Five regions) (Agenda from CTU)	CTUIL informed that they have expedited the procurement, examination and finalization process thereafter to ensure timely implementation. **Members noted.**
2.33.9 Frequent outages of HVDC Champa-Kurukshetra and its impact on Indian power system (Agenda from Grid India)	It was decided that the HVDC Champa–Kurukshetra matter shall continue to be monitored in coordination with POWERGRID. NRPC and WRPC may continue regular monitoring of the matter. **NRPC and WRPC noted.**
2.33.10 RE Generation Loss Events and performance of RE Plants (Agenda from Grid- India)	Committee constituted under CE (PSE&TD), CEA with members from CEA, RPCs, Grid-India, State Transco's, IIT Delhi & IIT Bombay for RE integration. Regarding formalization of RE compliance Monitoring Framework, SRPC has finalized the format. **Members noted.**

2.34 <u>Hosting of NPC meeting</u>:

2.34.1 MS, NPC informed that as per the roster finalized in the 5th NPC meeting, the next NPC meeting would be hosted by SRPC. The Committee agreed to the proposal.

2.34.2 <u>Decision of the NPC</u>:

i. The 19th NPC meeting will be hosted by SRPC. The date and venue will be finalized in consultation with NPC Secretariat.

(<u>Action</u>: SRPC)

The meeting concluded with a Vote of Thanks to Chairperson, CEA, all NPC members, and participants for their valuable contribution and active participation.

****

Annexure-A

List of Participants in the 18th meeting of National Power Committee (NPC) held on 18.09.2026 at Rajgir, Bihar.

Central Electricity Authority (CEA)

1. Sh. Ghanshyam Prasad, Chairperson, CEA/NPC
2. Sh. Hemant Jain, Member (GO&D), CEA
3. Sh. V. K. Singh, Member (PS), CEA
4. Smt. Rishika Sharan, Member Secretary, NPC
5. Sh. Satyendra Kumar Dotan, Director, NPC
6. Sh. Shishir Kumar Pradhan, Deputy Director, NPC
7. Sh. Saurabh Raj, Assistant Director, NPC
8. Smt. Bhawna Aggarwal, Assistant Director, NPC

Eastern Regional Power Committee (ERPC)

1. Sh. Ajay Yadav, Chairman, ERPC
2. Sh. Abdesh Kumar Singh, Chairman, TCC (ERPC)
3. Sh. K. B. Jagtap, Member Secretary
4. Sh. Nawal Kishor Choudhary, MD, BSPTCL
5. Sh. Indra Kumar Mehra, Director
6. Sh. R. K. Meena, Director
7. Sh. P. P. Jena, Deputy Director
8. Sh. Bitan Sekhar Roy, Deputy Director
9. Sh. Anup Das, Deputy Director
10. Sh. Abhinab Basu, Executive Engineer, BSPTCL
11. Sh. Saswat Ranjan Swain, Assistant Director
12. Sh. Kunal Saurav, Assistant Director

Northern Regional Power Committee (NRPC)

1. Sh. Sanjeev Kumar Sood, Chairperson, TCC (NRPC)
2. Smt. Rishika Sharan, Member Secretary
3. Sh. Praveen Jangra, Executive Engineer
4. Sh. Reeturaj Pandey, Executive Engineer

Southern Regional Power Committee (SRPC)

1. Smt. G.K. Kanchana, Chairperson, TCC (SRPC)
2. Sh. Asit Singh, Member Secretary
3. Smt. N.S. Malini, Superintending Engineer
4. Smt. Anusha Das J, Executive Engineer

Western Regional Power Committee (WRPC)

1. Sh. Deepak Kumar, Member Secretary

2. Sh. P. D. Lone, Director

North- Eastern Regional Power Committee (NERPC)

1. Sh. B. Lyngkhoi, Member Secretary
2. Sh. D. K. Bauri, Director
3. Sh. Vikash Shankar, Assistant Director
4. Sh. Dinesh Kumar Singh, Assistant Director

Grid Controller of India Limited (Grid-India)

1. Sh. Samir Chandra Saxena, CMD
2. Smt. S. Usha, Director (Market Operation)
3. Sh. Venkateshen M, GM
4. Sh. Ankur Gulati, DGM
5. Sh. Aman Gautam, Chief Manager

Central Transmission Utility of India Limited (CTUIL)

1. Sh. Kailash Kumar Gupta, COO
2. Smt. Nutan Mishra, CGM

Power Grid Corporation of India Limited (PGCIL)

1. Sh. A.K. Pandey, CGM
2. Sh. S.K. Singh, CGM

****

Annexure-I_18th NPC

STANDARD OPERATING PROCEDURE ON DIVERSION OF REGIONAL SPARES (TRANSFORMERS AND REACTORS)

August 2026

NATIONAL POWER COMMITTEE

1. Background & Objective

POWERGRID procures and maintains regional spares transformers and reactors to ensure the continuity of power supply and grid stability in the event of a contingency, such as the sudden failure of an in-service transformer or reactor. The primary purpose of these spares is to meet contingencies/emergencies within ISTS substations of the region. Regional spares are primarily sanctioned for use in Inter-State Transmission System (ISTS) substations. However, diversion of such spares to a State Transmission Utility (STU) may be permitted only under exceptional circumstances, based on the criticality of the requirement and subject to expeditious replenishment by the Borrower.

These Guidelines sets out the framework, eligibility, processes, roles, responsibilities, and conditions under which regional spares- transformers and reactors-maintained by POWERGRID may be diverted to eligible utilities. These Guidelines seeks to balance the need to extend emergency support to constituents with the responsibility of ensuring adequate spare availability for the ISTS network.

2. Scope & Applicability

2.1. These Guidelines applies exclusively to transformers and reactors approved by the respective Regional Power Committee (RPC) as *Regional Spares* for use in Inter-State Transmission System (ISTS) substations within the region. These spares are procured, owned, and maintained by POWERGRID to ensure operational continuity of the ISTS network during contingencies. Diversion may be considered only in case of failure of existing in-use equipment and where diversion is essential for grid security and reliability. The concerned RPC shall evaluate each request on the basis of technical justification, system requirements, and the merits of the case. All diversions may be executed strictly on a replenishment basis and may not amount to sale or transfer of ownership of the equipment.

2.2. Eligible Beneficiaries: Diversion of Regional Spares may be considered for the following **eligible beneficiaries** (hereinafter referred as Borrower) within the same Region, subject to the provisions of this SOP:

i. **ISTS Substations excluding Private Transmission Service Providers (TSPs)**

ii. **State Transmission Utility (STU) Substations.**

iii. **Private Transmission Service Providers (TSPs) operating Inter-State Transmission System (ISTS) assets as decided by concerned RPC on case-to-case basis.**

iv. **Any other utility specifically approved by the concerned RPC under exceptional circumstances.**

2.3. General Conditions Applicable to All Eligible Beneficiaries: Diversion of Regional Spare Transformers and Reactors to any eligible beneficiary shall be considered only under exceptional circumstances and shall be subject to the following conditions:

i. The failed equipment forms part of an operational ISTS asset or critical InSTS affecting ISTS

ii. The contingency materially affects grid security, reliability, power evacuation, transfer capability or continuity of transmission services;

iii. The concerned TSP demonstrates that no suitable spare equipment is available within its own inventory;

iv. The diversion is approved by the concerned RPC after considering the merits of the case.

The diversion of Regional Spares serves as a facilitative measure to support system security, operational reliability, continuity of power supply, and other critical grid requirements. The concerned RPC shall consider each request on its merits, with due regard to the availability of Regional Spares, technical justification, and the larger interest of ensuring reliable, secure, and resilient operation of the regional grid.

3. Ownership and Custody of Equipment

3.1. Ownership: Ownership of all Regional Spare Transformers and Reactors shall remain vested with POWERGRID at all times. Diversion of equipment shall not:

i. Constitute sale of equipment;
ii. Transfer ownership rights;
iii. Create any leasehold, mortgage, charge, lien, encumbrance, or proprietary interest in favor of the Borrower.

3.2. Custody of Equipment: The Borrower shall act only as custodian of the diverted equipment during the diversion period. The Borrower shall not:

i. Transfer the equipment to any third party;
ii. Create any security interest on the equipment;
iii. Dispose of the equipment;
iv. Modify equipment specifications without prior approval of POWERGRID.

4. Roles and Responsibilities

4.1. Lender (POWERGRID): POWERGRID may ensure that the regional spares- Transformers and Reactors- are maintained in operationally ready condition and available for deployment during contingencies. POWERGRID may:

i. Maintain a central inventory of all Regional Spares with technical particulars and locations.

ii. Implement the diversion only after RPC or its sub-forum's approval, as the case may be, and in accordance with this SOP.

iii. Record every approved diversion in the central register, including date of diversion, borrower, and approved return timeline.

iv. Monitor adherence to approved diversion timelines and report deviations to the respective RPC Secretariat.

4.2. Borrower: The Borrower may be responsible for safe custody and operation of the diverted Regional Spare during its possession. The Borrower may:

i. Submit a formal diversion request to the respective RPC Secretariat with required technical and contingency details.

ii. Jointly verify the equipment condition at POWERGRID substation prior to MoU signing.

iii. Bear all expenses associated with transportation (both ways), transit insurance, erection, testing, commissioning, and related statutory charges, as applicable, and any incidental expenditure or loss to POWERGRID.

iv. Ensure site readiness and compatibility of the spare equipment before diversion.

v. Furnish a valid Bank Guarantee equal to the prevailing cost of the equipment, effective till 45 days after return or replenishment is completed.

vi. Maintain and operate the equipment in accordance with applicable technical standards and POWERGRID's guidelines.

vii. Return or replenish the equipment in healthy condition within the approved timeframe and bear any repair or replacement cost arising from damage or failure.

viii. After returning of equipment, all tests may be jointly performed at substation (specified by POWERGRID) to ascertain healthiness. In case of any deviation, POWERGRID may take up the repair of equipment and cost of the repair may be borne by the Borrower.

4.3. RPC Secretariat: The concerned RPC Secretariat may facilitate deliberation of the diversion proposal in the RPC or its sub-forum and place the Borrower's request before the members for decision. It may record all decisions, including timelines for return or replenishment. RPC Secretariat may communicate the decision of the forum to borrower and Powergrid at the earliest decision in RPC or its sub-forum meeting.

4.4. Reporting Requirement: The Borrower shall submit periodic reports regarding the diverted equipment. The reporting framework shall include:

i. Monthly operational status report;
ii. Health condition report;
iii. Details of outages, defects, failures, repairs, or maintenance undertaken;
iv. Progress of procurement and replenishment activities;
v. Expected return schedule.

POWERGRID may place the status of all diverted equipment before RPC or its sub-forum at monthly intervals. Failure to submit reports may be treated as non-compliance under the SOP.

5. Procedure for Diversion

5.1. Submission of Request: The Borrower may submit a written request to the concerned RPC Secretariat, specifying:

i. The nature of contingency or failure necessitating diversion, including details of affected substation and equipment.

ii. Technical parameters of the failed equipment and the matching requirement from the Regional Spare pool.

iii. A detailed action plan and proposed timeline for return or replenishment of the diverted equipment.

5.2. Evaluation and Approval: The RPC or its sub-forum may evaluate the request on merit, considering:

i. The severity and genuineness of the contingency.

ii. Availability of the Regional Spare and its necessity for ISTS grid reliability.

iii. Impact on overall system stability and adequacy of remaining spares.

The decision of the RPC or its sub-forum will be final and binding on all concerned entities. Upon approval, the forum may record the diversion details and the agreed period of utilization in its proceedings.

5.3. Utilization Restriction: The diverted equipment shall be utilized strictly for the purpose, substation, and contingency approved by RPC. The Borrower shall not:

i. Shift the equipment to another location;
ii. Use the equipment for any project not approved by RPC or its sub-forum;
iii. Further lend, lease, transfer, or assign the equipment to any third party;
iv. Utilize the equipment for commissioning of new assets unless specifically approved by RPC.
v. Any deviation shall require prior approval of RPC or its sub-forum.
vi. Violation of this clause may result in immediate recall of the equipment and invocation of applicable penalties.

5.4. Execution of Memorandum of Understanding (MoU)

i. Following the approval of diversion by the respective RPC or its sub-forum, the Borrower and POWERGRID may execute a Memorandum of Understanding

ii. (MoU) within thirty (30) days from the date of RPC or its sub-forum. *For the purpose of these Guidelines, date of communication by RPC secretariat of the decisions of the forum to* Borrower *and Powergrid as defined in para 4.3 shall be treated as the date of RPC or its sub-forum approval, as the case may be.*

iii. The MoU may specify all terms and conditions of diversion, including equipment details, responsibilities of both parties, financial implications, Bank Guarantee (BG) requirements,

maintenance and reporting obligations, timelines for return/replenishment, and applicable penalties for default.

5.5. Condition Assessment and Testing

i. **Inspection before Diversion:** Before diversion, a joint inspection of the equipment shall be carried out by POWERGRID and the Borrower at the designated POWERGRID substation. The physical condition and test results shall be documented and signed jointly.

ii. **Inspection after Return:** Upon return, the equipment shall undergo testing at the Borrower /POWERGRID station to ascertain its healthiness. Any deviation, defect, or damage observed during inspection shall be rectified at the Borrower's cost. Where repair or refurbishment is necessary, the Borrower shall carry it out through the OEM or other approved agency as per POWERGRID specifications.

iii. **Replacement Equipment Specification:** Where replenishment is required, the replacement equipment shall:

a) Be of equivalent or higher rating;
b) Conform to current POWERGRID specifications;
c) Meet applicable BIS, IEC and CEA standards;
d) Be procured from approved manufacturers/vendors;
e) Be accepted only after inspection and testing by POWERGRID.

POWERGRID would have the right to determine technical acceptability of the replacement equipment.

Any issue including diversion, replenishment, return of Regional Spares, or technical acceptance of replacement equipment shall be resolved through the concerned RPC and its sub-forum, as applicable.

6. General Conditions of Diversion

6.1. Timeframe for Diversion and Return

i. The Borrower should take the physical handover of the equipment from the designated POWERGRID substation within forty-five (45) days from the date of execution of the MoU.

ii. Failure to take the physical handover of the equipment within the ninety-days (90) days from RPC or its sub-forum approval, as applicable, may be treated as revocation the diversion approval.

iii. The maximum diversion period for a Regional Spare Transformer or Reactor shall normally be 30 months from the Zero Date of Diversion with approval of RPC. The Borrower may seek an extension by submitting a reasoned request to the concerned RPC. Based on the technical justification and merits of the case, the concerned RPC may approve an extension for a period not exceeding 12 months.

iv. The Borrower may ensure return or replenishment of the diverted equipment within this period as per the action plan approved by the RPC or its sub-forum, as applicable, and the provisions of the MoU.

v. Any request for extension of the diversion period beyond thirty (30) months or delay in taking the physical handover of the equipment may require prior approval of the respective RPC or its sub-forum, as applicable, supported by written justification.

vi. On completion of the diversion period, the Borrower should return the equipment in healthy condition to POWERGRID to POWERGRID's technical specifications.

vii. The "Zero Date of Diversion" shall be the date recorded in the joint handover certificate signed by representatives of POWERGRID and the Borrower *at the time of physical transfer from the designated POWERGRID substation or storage location.*

viii. The "Date of Return" shall be the date recorded in the joint handover certificate signed by representatives of POWERGRID and the Borrower *after successful healthiness checking, at the time of physical transfer at the designated POWERGRID substation or storage location.*

ix. Force Majeure shall not absolve the Borrower of its obligation to restore, replace, or return the diverted equipment. The equipment shall be returned to POWERGRID in good working condition in accordance with this SOP and POWERGRID's applicable technical specifications.

6.2. Early Recall

i. RPC Forum may recall any diverted equipment at any time before the expiry of the approved period if required in the interest of grid security or system reliability.

ii. The Borrower shall return the equipment within 90 days upon receipt of such recall notice, and RPC Secretariat shall be intimated accordingly.

iii. This overrules any other provision in the SOP and equipment has to be returned by Borrower within 90 days during recall by RPC forum.

6.3. Financial Provisions: Diversion of Regional Spares may be carried out on a cost-neutral basis, ensuring that POWERGRID neither incurs financial loss nor earns additional revenue on account of such diversion. The diversion should not result in any change in the Yearly Transmission Charges recoverable by POWEGRID as per the approved tariff against the diverted asset and financial adjustments, if any, may be settled within the regional pool mechanism as approved by the RPC forum. The Borrower may bear all direct and incidental costs, including transportation, loading/unloading, insurance, erection, testing, and commissioning charges. The Borrower, may be fully liable for any loss, damage, theft, or deterioration of the equipment during the diversion period. Insurance coverage may be obtained in the joint name of POWERGRID and the Borrower with POWERGRID designated as the primary beneficiary.

In line with these principles, the financial treatment for diversion may be as follows:

i. **ISTS Substations excluding Private Transmission Service Providers (TSPs):** Diversion to any ISTS substation, should be without financial liability to Powergrid/DIC. Such diversion should not affect the regional tariff or cost-sharing framework.

ii. **STU Substations and Private Transmission Service Providers (TSPs):** For diversions to STU substations/ Private Transmission Service Providers (TSPs) operating Inter-State Transmission System (ISTS) assets, the equivalent Yearly Transmission Charge (YTC) of the diverted asset on pro-rate basis, along with any applicable penalty, may be credited to the Regional ISTS Pool for the diverted period.

For this purpose, POWERGRID may raise bilateral bills to the borrower to recover the equivalent YTC of the diverted asset on pro-rate basis, along with any applicable penalty. The YTC may be computed in accordance with the applicable Tariff Order, prevailing Tariff Regulations, Sharing Regulations, or any other rules or regulations notified by CERC and all provisions relating to due dates, late payment surcharge, interest, or other billing conditions may likewise be governed by the applicable rules or regulations. The amount so recovered may be adjusted in the Regional ISTS Pool through the Second Bill mechanism under sharing regulations, and the corresponding credit shall be passed on to the DICs of the Region in the same Second Bill.

6.4. Bank Guarantee (BG) requirements:

i. Borrower may furnish a valid Bank Guarantee equal to the prevailing cost of the equipment, effective till 45 days after return or replenishment is completed.

ii. The BG may be invoked by POWERGRID to recover any financial loss or liability arising from events such as failure to return or replenish the equipment within the agreed timeframe, or failure to repair, refurbish, or replace the equipment in the event of damage, failure, or loss during transit, erection, or operation.

6.5. Penalty and Default:

i. If the Borrower fails to return or replenish the diverted equipment within the agreed timeframe, which may not exceed 30 months and additional extension of 12 months as approved by RPC, if any, a penalty of 15% per annum of the approved Yearly Transmission Charge (YTC) of the diverted asset may be levied on a pro-rata basis for the delayed duration.

ii. The penalty amount may be credited to the Regional Component of ISTS charges for the corresponding period. In case of continued default or non-replenishment, POWERGRID may report the matter to the RPC forum for further decision, which may include encashment of the Bank Guarantee and/or regulatory intervention.

6.6. Record-Keeping and Monitoring: POWERGRID may maintain a centralized and up-to-date register of all diversions and furnish the information to RPC, containing the following information:

i. Borrower entity name and category.

ii. Location of Installation by the Borrower

iii. Equipment details (type, rating, make, serial number).

iv. Date of diversion and expected return date.

v. Physical and test condition at dispatch and upon return.

vi. Financial treatment and applicable YTC adjustments.

vii. Status of replenishment or replacement.

7. **Review and Amendment:** These SOP may be reviewed from time to time to incorporate operational experience, regulatory updates, or changes in system requirements.

8. **Power to Relax:** RPC forum may relax any of the provisions of these SOP on its own or on an application made before it by the affected party.

****

SOP FOR CERTIFICATION OF TRANSMISSION SYSTEM AVAILABILITY OF INTRA-STATE LINES (DEEMED ISTS/NATURAL ISTS) CARRYING INTERSTATE POWER.

1. Objective

This Standard Operating Procedure (SOP) aims to establish a uniform methodology for certification of transmission system availability of Intra-State lines (Deemed ISTS/Natural ISTS) carrying interstate power certified as ISTS.

2. Scope and Eligibility

This SOP shall apply to:

I. Deemed ISTS lines:

a) State Transmission Utilities (STUs) and private transmission licensees whose Intra State transmission lines have been certified as ISTS by concerned RPCs for period from May, 2015 to till October 2020 as per the approved Procedure of respective RPC and approved by CERC. Any case referred by CERC will be taken up.

b) State Transmission Utilities (STUs) and private transmission licensees whose Intra State transmission lines have been approved as Inter-State Transmission System (ISTS) by Hon'ble CERC through a Petition Order issued during the period from November 2020 to March 2024.

c) State Transmission Utilities (STUs) and private transmission licensees whose Intra State transmission lines have been certified as Inter-State Transmission System (ISTS) in accordance with Regulation 93 of the Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2024, for cases from April 2024 to March 2029.

II. Natural ISTS lines: State Transmission Utilities (STUs) and private transmission licensees having natural ISTS lines.

3. Roles and Responsibilities

3.1 <u>For cases pertaining to the period upto October 2020</u>.

I. State Transmission Utility / Transmission Licensee

For the applicable period under Intra-State lines (Deemed ISTS/Natural ISTS) carrying interstate power certified as ISTS, the STU/Transmission Licensee shall:

- Submit monthly outage details along with availability percentage to concerned RPC for outage verification.
- Outage details shall be submitted to concerned SLDC for verification with a copy to RPC.
- Provide supporting documents as required by SLDC.

II. State Load Despatch Centre (SLDC)

SLDC shall:

- Verify outage duration and reason submitted by STU/ transmission licensee and forward to concerned RPC within 15 days.

III. Regional Power Committees (RPCs)

RPC shall:

- Certify transmission system availability as per CERC (Tariff) Regulations (as **applicable).**

3.2 <u>For cases pertaining to the period from November 2020 onwards</u>

I. State Transmission Utility / Transmission Licensee

For the applicable period under Intra-State lines (Deemed ISTS/Natural ISTS) carrying interstate power certified as ISTS, the STU/Transmission Licensee shall:

- Submit monthly outage details along with availability percentage to concerned RLDC for outage verification with a copy to RPC.
- Wherever, assets are not under jurisdiction of RLDC, outage details shall be submitted to concerned SLDC for verification with a copy to RLDC/RPC.
- Provide supporting documents as required by RLDC/SLDC.

II. State Load Despatch Centre (SLDC)

SLDC shall:

- Verify outage duration and reason submitted by STU/ transmission licensee and forward to concerned RLDC within 15 days.

III. Regional Load Despatch Centre (RLDC)

RLDC shall:

- Verify outage duration and reason submitted by STU/ transmission licensee and forward to concerned RPC within 15 days.
- Wherever, assets are not under jurisdiction of RLDC, RLDC shall complete vetting of outage verification done by SLDC and forward to concerned RPC within 07 days.

IV. Regional Power Committees (RPCs)

RPC shall:

- Certify transmission system availability as per CERC (Tariff) Regulations (as **applicable).**

4. Format:

Prescribed format as annexed, shall be used by STU/ transmission licensee for submission of outage data to RLDC/SLDC.

Annexure

CODE	EVENT NO.	ELEMENT NAME	OUTAGE	RESTORATION	DURATION OF OUTAGE ATTRIBUTABLE TO				RLDC CODE	Classification/ Category Code	REASON OF OUTAGE	RLDC Remarks
			DATE TIME (Hrs Min)	DATE TIME Hrs Min	Licensee	OTHERS Natural calamity/ Militanc	System constraint	Deemed Available				
					@ (T)	# (U)	& (C)	* (D)				
					Hrs	Hrs	Hrs	Hrs:				

Annexure Availability Computations as per applicable CERC Regulation.

****

Standard Operating Procedure (SOP)

Submission of Information by Regional Entities for Energy Accounting by RPCs

1. Introduction

The Regional Power Committee (RPC) Secretariats are responsible for preparation of energy accounts, including Regional Energy Accounts (REA) and Deviation Settlement Accounts (DSM), based on schedule data, metering data, and other such data.

The preparation of accurate energy accounts requires, in addition to time-block-wise schedule and metering data, certain underlying technical, connectivity, operational and commercial parameters of the generating stations, Energy Storage Systems (ESS) and other entities. Such parameters, inter alia, determine the applicable accounting configuration, capacity and connectivity considered for accounting, beneficiary-wise allocation, applicable tariff/contract or reference rate, and other parameters relevant for determination of energy and deviation accounts.

As per the provisions of the Indian Electricity Grid Code (IEGC), 2023 or amendment(s) thereof:

- Regulation 20 mandates submission of key technical details of generating stations by the generating company to RLDC and RPC prior to issuance of notice of trial run;
- Regulation 25 provides that trial run certificate is issued by RLDC, and a copy is provided to the concerned RPC;
- Regulation 26 mandates submission of requisite certificates prior to declaration of Commercial Operation Date (COD) by the generating company to RLDC and concerned RPC; and
- Regulation 27 mandates a generating station to inform the Date of Commercial Operation to the concerned RPC.

Further, the CERC (Deviation Settlement Mechanism and Related Matters) Regulations, 2024, as amended from time to time, prescribe the manner of determination of the applicable **Contract Rate / Reference Charge Rate** that may require **tariff** adopted or approved by the Appropriate Commission under the applicable provisions of the Electricity Act, 2003.

Similarly, the CERC (Sharing of Inter-State Transmission Charges and Losses) Regulations, 2020, as amended from time to time, provide for determination of transmission deviation, inter alia, with reference to the net metered ex-bus injection or drawal vis-à-vis the GNA and T-GNA, as applicable. Accordingly, relevant connectivity, GNA/T-GNA, metering and associated technical parameters are also required for appropriate accounting, wherever applicable.

A uniform mechanism for submission of such information to the RPC Secretariat is therefore necessary to facilitate its systematic availability and use in preparation of energy accounts.

Accordingly, this SOP establishes a standardized mechanism for submission of technical, commercial and other accounting-relevant information by the concerned entities to the RPC Secretariat, including the information required at the stages of trial run, declaration of COD and commencement of commercial operation, as well as information arising from subsequent changes in the technical configuration, connectivity, metering arrangement or commercial arrangements of the entity.

The formats prescribed under this SOP are intended to provide a structured and standardized means of furnishing such information to the RPC Secretariat for the purpose of energy accounting. The submission under this SOP is supplementary to, and does not replace, any

submission or compliance required under the prevailing CERC regulations, IEGC, detailed procedures, RLDC/NLDC procedures, CTU/STU procedures or any other applicable regulatory or statutory instrument.

2. Scope

This SOP shall apply to all entities required to submit data for the purpose of energy accounting, including:

a) Regional entity Generating Station (Thermal, Hydro, Renewable);

b) Regional entity Energy Storage System (ESS);

c) Qualified Coordinating Agencies (QCA);

d) Regional Load Despatch Centre (RLDC).

3. Submission of Data and Responsibilities

3.1 Responsibilities of Generating Station/ ESS

The generating station or unit thereof or ESS may submit all required data to concerned RPC Secretariat in accordance with the provisions of IEGC and amendment thereof and this SOP. It may ensure that all submissions are complete, accurate, and updated as per actual configuration and commercial arrangements and ensure that submissions are certified by an authorized signatory, as applicable under relevant Act(s)/ rule(s)/ regulation(s).

3.1.1 Prior to Trial Run

The generating station or unit thereof or ESS may submit following information to the concerned RPC secretariat, in **FORM-EA-01,** prior to issuing notice for trial run by Generating Station/ ESS:

- Name of the **Generating Station/ ESS;** Name of the entity and Registered office address along with Copy of Company Registration in case of an SPV;
- Key technical-cum commercial details of generating station/ unit/ ESS;
- Intimation for Connectivity by CTU or STU, as the case may be in CONN-INT-IC Format- or equivalent);
- Copy of Approved metering scheme along with SLD;
- Summary of PPA / commercial arrangements along with copy of PPA/ PSA/ equivalent, if applicable;
- Contact person(s) details such as Name, Designation, Landline Telephone No, Mobile No., E-mail address, Postal address for energy accounting related communications;
- Designated E-mail address of Head of Station/ CEO, as the case may be.

3.1.2 Prior to Declaration of Commercial Operation

The generating station or unit thereof or ESS may submit following information/ certificates to the concerned RPC secretariat prior to declaration of commercial operation:

- Requisite certificates as specified under provisions of Regulation 26.1(a), 26.2(a), or 26.4(a) of IEGC, 2023 or amendment thereof. The certificates shall be signed by the authorized signatory not below the rank of CMD or CEO or MD of the generating company and shall be submitted to the Member Secretary of the concerned RPC before the declaration of COD;
- Date of successful trial run.

3.1.3 Declaration of Commercial Operation

The generating station or unit thereof or ESS shall communicate intimation of declaration of commercial operation of unit or station, as the case may be, to the concerned RPC secretariat on declaration of commercial operation.

3.1.4 Post Declaration of Commercial Operation

A generating station or unit thereof or ESS may promptly submit updated information to concerned RPC Secretariat upon occurrence of any change in technical or commercial parameters submitted prior to trial run, including but not limited to:

- Change in installed capacity or unit configuration;
- Addition of new units/ elements, or integration with energy storage systems;
- Change in Normative Auxiliary Power Consumption;
- Change in connectivity details;
- Change in metering configuration;
- Change in PPA, PPA Rate, beneficiaries/ allocation, etc.

Updated information may be submitted in **FORM-EA-01**. Changes in Contract Rate/ Reference Charge Rate may be implemented prospectively only.

3.2 Responsibilities of Bulk Consumer

The following requisite information may be submitted to the concerned RPC secretariat, in **FORM-EA-02,** prior to commencement of scheduling of power:

- Name of the entity and communication address along with Copy of Company Registration;
- Intimation for Connectivity by CTU, as the case may be in CONN-INT-IC Format or equivalent);
- Copy of Approved metering scheme along with SLD;
- Contact person(s) details such as Name, Designation, Landline Telephone No, Mobile No., E-mail address, Postal address for energy accounting related communications; and
- Designated E-mail address of Head of Entity/ CEO, as the case may be.

3.3 Responsibilities of QCA

The following requisite information may be submitted to the concerned RPC secretariat prior to commencement of scheduling of power under QCA:

- Name of the QCA and communication address along with Copy of Company Registration;
- Contact person(s) details such as Name, Designation, Landline Telephone No, Mobile No., E-mail address, Postal address for energy accounting related communications;
- Designated E-mail address of Head of Entity/ CEO, as the case may be;

- Furnish copy of QCA registration with concerned RLDC; and
- Pooling/ De-pooling details of generating stations/ ESS.

3.4 Responsibilities of concerned RLDC

The requisite information may be submitted to the concerned RPC secretariat as under:

a) RLDC shall furnish a copy of the trial run certificate of a generating station or unit thereof or ESS in accordance with provisions of Regulation 25 of IEGC to the concerned RPC Secretariat within 3 days of issuance of trial run certificate by the concerned RLDC or as per amended provisions of IEGC;

b) RLDC may inform of any change in pooling/ de-pooling under QCA.

3.5 Responsibilities of CTU/ STU

The requisite information may be submitted to the concerned RPC secretariat as under:

- Copy of Intimation for Connectivity by CTU or STU, as the case may be in CONN-INT-IC Format- or equivalent);
- Intimation for Operationalization of Connectivity/ GNA;

3.6 Responsibilities of RPC Secretariat

The RPC Secretariat may:

a) Keep a record of information submitted by entities for energy accounting;

b) Utilize the submitted data as the basis for preparation of energy accounts, including Regional Energy Account, Statement of Charges for Deviation, Regional Ancillary and SCUC Account, Regional Transmission Deviation Account, etc.;

c) Record instances of non-submission, delayed submission, or incomplete submission of data;

d) Where required, report persistent non-compliance to appropriate authorities in accordance with applicable regulations;

4 Mode of Submission

a) All submissions may be made in the prescribed formats as specified in this SOP and amendment thereof or as specified by the concerned RPC secretariat;

b) Submissions may be made to Member Secretary of the concerned RPC at the registered office address as well as through designated e-mail as given below:

RPC	Office Address	Designated e-mail address
ERPC	Eastern Regional Power Committee 14, Golf Club Rd, near RCGC, Golf Gardens Tollygunge, Kolkata- 700033	mserpc-power@nic.in
NERPC	North Eastern Regional Power Committee Jowai Rd, Umpling Shillong- 793006	ms-nerpc@gov.in
NRPC	Northern Regional Power Committee 18-A, Qutab Institutional Area,	ms-nrpc@nic.in

	Shaheed Jeet Singh Marg, Katwaria Sarai New Delhi-110016	
SRPC	Southern Regional Power Committee No.29, Race Course Cross Road Bengaluru-560009	mssrpc-ka@nic.in
WRPC	Western Regional Power Committee Plot No- F-3, MIDC Area, Marol, opp. SEEPZ Central Road, Andheri (East), Mumbai-400093	ms-wrpc@nic.in

FORM-EA-01

Technical and Commercial Parameters of Generator/ ESS

From: (Name of Generating Station) (Name of Company)

To: _____ Regional Power Committee

Dated: dd/mm/yyyy

S. No.	Description		Information
	Section I — General / Entity Information		
1.	Name of Entity		
2.	Name of Generating Station (or) ESS		
3.	Technology of Generating Station (or) ESS (Thermal/ Gas/ Hydro- RoR, Pondage or Storage/ Solar/ Wind, etc.)		
4.	Correspondence Address		
5.	Company Registration details, where applicable		
6.	Contact details of Head of Station (or) CEO	Name & Designation	
		E-mail address	
7.	Contact details of coordinating official	Name & Designation	
		Mobile Number, Landline Telephone Number	
		E-mail address	
	Section II — Technical Parameters		
8.	Total Installed Capacity (MW and MWh, as applicable) (or) Hybrid/ RTC capacity, as applicable		
9.	Pumping Power Requirement		
10.	Overload Capacity, if applicable		
11.	Unit-wise capacity (or) technology-wise capacity (e.g. 2 x 500 MW) (or) (Solar-100 MW, Wind-200 MW, etc.)		
12.	Co-location Status (Yes/ No); Specify associated Generating Station if co-located		
13.	Extra elements such as emission control system, IESS, etc.		
14.	Normative Auxiliary consumption (%)		
15.	Normative Auxiliary energy consumption for emission control system (%)		
16.	Capacity under Trial Run		
17.	Location(s)/ Point(s) of Connection to the ISTS		
18.	Connectivity Quantum/ GNA (MW)		
19.	Connectivity Intimation letter by CTU (attach copy)		

S. No.	Description		Information
20.	Black-start Facility availability (Yes/No)		
21.	Hydro generator details, if applicable	Design Head (m) (MDDL) (m), if applicable	
22.		Full reservoir level (FRL) (m)	
23.		Minimum draw down level (m)	
24.		Water released at Design Head (m3/ sec)	
	Section III — Metering & Energy Accounting Configuration		
25.	Approved Metering Scheme (attach SLD)		
26.	Metering Scheme implemented (attach SLD and meter details)		
27.	Tariff (in ₹/ kWh) as determined or adopted or approved by Commission u/s 62 (or) u/s 63 (or) u/s 86(1)(b) of the Act, if applicable; Attach copy of Appropriate Commission tariff order		
28.	Details of PPA or equivalent, if Tariff is adopted by Commission u/s 63; Attach copy of PPA(s) or equivalent, if applicable		
29.	QCA details, if applicable		
30.	Any Other Information		

Signature of Authorized Signatory
(With Stamp)
Name :
Designation :
Organization/ Company:

FORM-EA-02

Technical and Commercial Parameters of Bulk Consumer

From: (Name of Entity) (Name of Company)

To: _____ Regional Power Committee

Dated: dd/mm/yyyy

S. No.	Description		Information
1.	Name of Entity		
2.	Registered Office (or) Correspondence Address		
3.	Company Registration details, where applicable		
4.	Contact details of Head of Station (or) CEO	Name & Designation	
		E-mail address	
5.	Contact details of coordinating official	Name & Designation	
		Mobile Number, Landline Telephone Number	
		E-mail address	
6.	Location(s)/ Point(s) of Connection to the ISTS		
7.	Connectivity Quantum (MW)		
8.	Connectivity Intimation letter by CTU (attach copy)		
9.	GNA granted by CTU (MW), if any (attach copy)		
10.	Metering Scheme (attach SLD)		
11.	Any Other Information		

*Strike off whichever if not applicable

Signature of Authorized Signatory
(With Stamp)
Name :
Designation :
Organization/ Company:

2026

DRAFT TECHNICAL SPECIFICATIONS OF MPLS-TP FOR ISTS COMMUNICATION SYSTEM

TABLE OF CONTENT

Section 1 9
1 Introduction 9
1.1 General Network Characteristics 10
1.1.1 Description 10
1.1.2 General Systems Requirements 10
1.1.2.1 System Maintainability 11
1.1.2.2 System Manageability & Security 11
1.1.3 General Equipment Characteristics 12
1.1.3.1 Revision Levels and Modifications 12
1.1.3.2 Equipment Capacities 13
1.1.3.3 Alternate Routing, MPLS and Protection Schemes 13
1.1.3.4 Equipment Lifespan 14
1.1.3.5 Software Upgrades 14
1.1.4 Optical Fibre Characteristics 14
1.2 Survey of existing ISTS communication Network 14
1.3 Integration requirement with MPLS IP equipment 15
1.4 Migration Methodology 15
1.5 Interoperability between different OEMs 16
1.5.1 Executive Summary 16
1.5.2 Scope & Objectives 16
1.6 MPLS-TP Equipment for Aggregation & Access Network 19
1.6.1 MPLS-TP System 19
1.6.1.1 Functional Requirement 20
1.6.1.2 Equipment Requirement 21
1.6.1.3 Technical specification 21
1.6.1.3.1 Standard requirement 21
1.6.1.3.2 Layer-2 Switching Features 22
1.6.1.3.3 VLAN Features 22
1.6.1.3.4 Port trucking / Link Aggregation 23
1.6.1.3.5 Forwarding Support 23
1.6.1.3.6 MAC Address Learning / Limiting 23
1.6.1.3.7 The MPLS-TP Equipment shall support IEEE 802.1Q Tagging 24
1.6.1.3.8 Q-in-Q or IEEE 802.1ad mode Requirements 25
1.6.1.3.9 LSP Mode Requirements 26
1.6.1.3.10 Quality of Service Requirements 26
1.6.1.3.11 Classification/Prioritization 27
1.6.1.3.12 Mapping 27
1.6.1.3.13 Marking/Policing/Shaping 27
1.6.1.3.14 Rate Limiting 28
1.6.1.3.15 Queuing 28

1.6.1.3.16 Scheduling 28
1.6.1.3.17 Protection Mechanism 29
1.6.1.3.18 Circuit Emulation Protocols 30
1.6.1.3.19 Network Synchronization Requirements 30
1.6.1.3.20 MPLS-TP STANDARDS 31
1.7 OAM Requirements 32
1.7.1 Pluggable Optics 35
1.7.1.1 Amplifier Solution for Packet Links 35
1.7.1.1.1 Optical Amplifiers 35
1.7.1.1.2 Optical Link Performance Requirements 36
1.7.1.1.3 Link Budget Calculations 36
1.7.1.2 Management 37
1.8 Patch Cords 37
1.9 Power Supply 38
1.10 Cabinet 38
1.11 Inside Plant 38
1.12 Safety 38
1.13 Ambient Conditions 39
1.14 Electromagnetic Compatibility 39
1.15 Mechanical Construction 39
1.15.1 Summary of applicable standards 40
1.15.1.1 Immunity 40
1.15.1.2 Emission 40
1.15.1.3 Safety 40
1.15.1.4 Mechanical Test – Transport (IEC60721-3-2 class 2M1) 40
1.15.1.5 ETS/EN 40
1.16 Testing & Acceptance – FAT & SAT 40
1.16.1 Factory Acceptance Test (FAT) 41
1.16.2 Site Acceptance Test (SAT) 41
1.16.3 Test plan Compliance 41
Section 2 42
2.1 Applicable Standards 42
2.2 TMN Architecture 42
2.3 Management Functions 46
2.3.1 Configuration Management 46
2.3.2 Fault Management 47
2.3.3 Performance Management 48
2.3.4 Security Management 49
2.3.5 Inventory Management 51
2.3.6 Software Management 51
2.4 Data/ Communication Channel Requirement and Integration 52
2.5 Craft Terminal 53
2.6 Redundancy Requirements 54
2.7 Hardware Requirements 54
2.7.1 Server, Workstation and Craft Terminal 54

2.7.2 Local / Remote Operator Consoles 55
2.7.3 Power Supplies 55
2.8 General Software/ Firmware Requirements 55
2.8.1 Operating System Software 56
2.8.2 Applications Software 56
2.8.3 Software Utilities 56
2.8.4 Revisions, Upgrades, Maintainability 56
2.8.4.1 Versions 56
2.8.4.2 Program Rewrites 56
2.8.4.3 Maintainability 56
2.8.4.4 Standards Compliance 57
2.8.5 Database(s) 57
2.8.5.1 Structure and Inclusions 57
2.8.5.2 Data Retention 57
2.9 Help 57
Abbreviations: 58

ACKNOWLEDGEMENT

The Joint committee (JC) acknowledges the valuable cooperation extended by NPC, CEA, all RPCs, CTU, GRID-INDIA, POWERGRID, CSPTCL(Chhattisgarh), KSEB(Kerala), RVPNL(Rajasthan) and WBSETCL (West Bengal) for giving their essential inputs to finalize the recommendations for assessing the feasibility, integration & roll-out of MPLS in ISTS (Inter State Transmission System) Communication System, as per Terms of Reference (TOR) of the Joint Committee.

The JC also expresses its gratitude to MPLS OEMs/Service providers for their valuable inputs and suggestions in the preparations of this TS.

PREFACE

The Joint Committee (JC) to discuss and recommend on the introduction of MPLS technology in ISTS Communication system has been constituted by NPC vide their letter ref. no. CEA-GO-15-14/1/2021-NPC Division/304-347 dtd. 14.09.2023. The report of JC is approved in 16th NPC meeting dtd. 04.07.2025 wherein JC has recommended the "Introduction of MPLS Technology in the ISTS Communication System".

Further, as recommended in JC Report

"*…….the upcoming/future ISTS nodes shall be provided with MPLS TP equipment and suitably integrated with the evolved ISTS MPLS TP Network with proper configuration on Regional/ National UNMS*"

"*For the upcoming nodes of IPP/RE/Bulk consumers etc. MPLS TP/ MPLS IP can be adopted and integrated with the evolved ISTS MPLS TP Network with proper configuration on Regional/ National UNMS*"

Further, NPC extended the mandate to formulate the TS of MPLS technology. The NPC, CEA JC report on Introduction of MPLS Technology in ISTS Communication System prepared in April'2025 has recommended the MPLS TP technology for ISTS nodes as mentioned above. Accordingly, JC has done the meetings with MPLS TP OEMs to finalize the TS of MPLS-TP technology for ISTS nodes. The draft MPLS-TP TS was discussed in 10th JC meeting dtd. 18.02.2026 and has been modified as per suggestion and discussion in the meeting. Now, the MPLS-TP TS is being represented for the approval of all JC members.

Committee Members

CEA has nominated following personnel for the Joint-Committee from CEA, all RPCs, CTU, GRID-INDIA, POWERGRID, CSPTCL-Chhattisgarh, KSEB-Kerala, RVPNL-Rajasthan and WBSETCL-West Bengal.

Chief Engineer, DPT, CEA	Shri Vivek Goel	Member
Chief Engineer, ET&I, CEA	Shri Surata Ram	Member
Chief Engineer, GM, CEA	Shri Chandra Prakash	Member
Superintending Engineer, SRPC	Shri Meka Ramakrishna	Member
Superintending Engineer, WRPC	Shri P.D. Lone	Member
Representative from ERPC	#	Member
Superintending Engineer, NRPC	Shri Anzum Parwej	Member
Superintending Engineer, NERPC	Shri S M Aimol	Member
Director, PCD, CEA/Assistant Director, PCD, CEA	Shri Len J. B./ Shri Prateek Srivastava	Member
Director, NPC, CEA, Deputy Director, NPC, CEA	Shri Satyendra Kumar Doan/ Shri Himanshu Lal	Member
Chief General Manager, SRLDC	Shri T R Ganesh	Member
Chief General Manager, NERLDC	Shri S P Barnwal	Member
General Manager, WRLDC	Shri S. K. Saha	Member
Sr. Deputy General Manager, ERLDC	Shri L Muralikrishna	Member
Deputy General Manager, NRLDC	Shri Ankur Gulati	Member
Deputy General Manager, POWERGRID	Ms. Shyama Kumari	Member
Add. Chief Engineer, WBSETCL	Shri Biswajit Madhu	Member
Superintending Engineer RVPN	Shri Manish Athaiya	Member
Executive Engineer, KSEBL	Shree Rafeeque K P	Member
*Superintending Engineer, CSPTCL	Shi K K Yadav Shri Ashish Rai	Member
Sr. General Manager, CTUIL	Shri H.S. Kaushal	Member Convener

*CSPTCL has submitted their nomination for MPLS JC to NPC-CEA vide letter dtd. 22.04.2024.
Nomination not received.

Shiv Kumar Gupta/ @(H. S. Kaushal)
Sr. DGM/ Sr. GM,
CTU
Member-Convener, JC

P. D. Lone
Superintending Engineer,
WRPC
Member, JC

Satyendra Kumar Dotan
Director,
NPC, CEA
Member, JC

N S Malini/@(Len J. B.)/ @(Meka Ramakrishna)
SE (P&C)/ Director/ SE,
SRPC
Member, JC

Anzum Parwej
Superintending Engineer,
NRPC
Member, JC

Harish Rathour/ @(T. R. Ganesh)
Chief GM,
SRLDC
Member, JC

L. Muralikrishna
Sr. DGM,
ERLDC
Member, JC

Alik Dey/ @(S. M. Aimol)
Dy. Director/SE,
NERPC
Member, JC

S. P. Barnwal
Senior GM,
NERLDC
Member, JC

Navodit Hyanki/ @(Gaurav Awal)/ @(Shyama Kumari)
Sr. DGM/ DGM,
POWERGRID
Member, JC

S K Maharana/ @(Len J. B.)
Chief Engineer/ Director,
PCD, CEA
Member, JC

Pramod Singh/ @(S Chandrakar)/ @(S. K. Saha)
GM,
WRLDC
Member, JC

Biswajit Madhu
Addl. Chief Engineer,
WBSETCL
Member, JC

Manish Athaiya
SE,
RVPN
Member, JC

K. K. Yadav
Superintending Engineer,
CSPTCL
Member, JC

Rafeeque K. P.
Executive Engineer,
KSEBL
Member, JC

Ankur Gulati
DGM,
NRLDC
Member, JC

Vivek Goel
Chief Engineer,
DPT, CEA
Member, JC

Surata Ram
Chief engineer,
ET&I, CEA
Member, JC

@:- The original JC members nominated by NPC have been changed due to superannuation/transfer etc. The alternate concerned member has signed the TS.

Section 1

NETWORK CONFIGURATION & EQUIPMENT CHARACTERISTICS

1 Introduction

This section describes the communication network configuration and characteristics of the Fibre Optic Terminal Equipment (FOTE) with MPLS-TP technology along with the Amplifier Solutions and other associated subsystems. A Network Management System (Telecommunications Management Network, TMN) is required for the management of all MPLS-TP Equipment and Amplifier Solution to be supplied under the project (TMN & NMS are interchangeably used in this specifications). The TMN shall be integrated with the UNMS (Unified Network Management System) of the Employer using the standard North Bound Interfaces.

Equipment must comply with the MTCTE essentials requirements for required equipment and must comply with latest essential requirements and amendment if any. The equipment must attain the MTCTE certificate for the equipment offered.

The OEM/ MPLS vendor/ SI shall ensure that the supplied equipment has been tested as per relevant contemporary Indian or International Security Standards e.g. IT and IT related elements against ISO/IEC 15408 standards, for Information Security Management System against ISO 27001/2, Power Control Systems – Security Requirements against IS16335, Cyber Security for Industrial Control Systems against IEC 62443-4 etc. from an authorized and certified agency/lab. These mentioned standards shall be current with all amendments, if any and in case a standard is superseded, the new standard as on date of bid opening shall be applicable.

The OEM/ MPLS vendor shall also ensure that the equipment supplied has all the contemporary security related features and features related to communication security as prescribed under relevant security standards. A list of features, equipment, software etc. supplied and implemented in the project shall be given for use by the Employer. The supplied Equipment/System shall be accompanied by a certificate from a certification body accredited to assess devices and process for conformances to IEC 62443-4 standards during design and manufacture.

The OEM/ MPLS vendor shall get the Employer's network audited from a security point of view once every year from a CERT-In Empaneled Cyber Security Auditor. The audit of the network shall be carried out once in a financial year. Network forensics, Network hardening, Vulnerability Assessment, Network penetration test, Risk assessment, Actions to fix problems and to prevent such problems from reoccurring etc. shall be covered under network audit. OEM/ MPLS vendor shall implement the recommendations/remedial actions suggested by the Auditor after audit for any upgrade/ Patch update for the system.

The OEM/ MPLS vendor shall also be responsible for providing patches/updates for the products supplied under the project.

The OEM/ MPLS vendor is encouraged to propose equipment with a higher hardware configuration better suited to meet the performance and requirements of the OEM's standard products as long as the minimum equipment characteristic requirements of this specification are met.

The equipment supplied shall comply with Cyber Security requirements. The IA/OEM shall ensure that the equipment shall comply with cyber security guidelines/regulations, other relevant guidelines/ standards and their amendments issued on a time-to-time basis by GOI/DoT/CEA/CERT-In. The OEM/IA shall reconfigure the equipment or provide security patches, updated versions of the software to comply the above requirements time to time. In case any new equipment is required to meet the security related requirements, the same shall be provided by the IA.

1.1 General Network Characteristics

1.1.1 Description

The ISTS fiber optic network consists of a Backbone network providing connectivity among ISTS, STU, ISGS, RE, IPP, Bulk Consumer nodes etc. The Existing Access & Aggregation network is SDH & is required to be augmented by installing new MPLS-TP equipment over separate pairs of fiber.

The MPLS-TP equipment shall be designed to operate in electrical high-voltage environment and shall be suitable for installations in substations with harsh climate and high electromagnetic interference. It shall be highly reliable and provide secure communications for real-time communication such as voice, SCADA, Teleprotection, data including IP/Ethernet and status/control signals. It shall comply with the latest ITU-T & IETF recommendations and ETSI standards and be able to be interconnected with legacy multiplex and other telecommunication equipment.

The MPLS-TP equipment platform shall support packet and TDM transport. Packet services, such as MEF CE 2.0 services, L3 VPNs and L2 VPN, can be transported using MPLS-TP giving the service provider the freedom to choose the most appropriate technology. New MPLS-TP equipment must support native TDM & circuit emulation and facilitate users to build a packet network parallel to the existing legacy TDM networks.

1.1.2 General Systems Requirements

The OEM/ MPLS vendor is encouraged to offer standard products and designs. However, the OEM/ MPLS vendor must conform to the specification requirements and provide any additional equipment necessary to meet the requirements stated herein.

1.1.2.1 System Maintainability

All NEs (MPLS-TP & Amplifiers) provided by the supplier must be managed on the NMS.

The proposed system must provide several ways to limit service interruption: Error prevention, Fault tolerance, Error elimination and Error prediction. The "zero downtime upgrade" capacity must be detailed and illustrated by examples taken from live systems implemented by OEMs. The proposed system must guarantee 99.9% communication channel availability as per CERC Communication regulations 2017. Once a failure or degradation of performance is detected in the communications system, its cause shall be promptly isolated and detected by NMS to facilitate performance testing, efficient diagnosis and corrective resolution. The system shall permit in-service diagnostic testing to be executed both locally and from remote locations, manually and initiated under TMN control. Such testing shall not affect the functional operation of the system.

Preventive and problem-oriented maintenance of the communications system shall be performed using diagnostics tools such as TMN and test equipment's (Optical power meter, communication analyzer, BER meter, Optical attenuator, Ethernet Analyzer). They shall support complete maintenance of all system elements and shall permit the diagnosis of any fault without requiring additional test equipment. The IA/ MPLS vendor shall provide specialized training in coordination with OEM required to operate the above diagnostics tools to the user/TSP/RLDC/RPC/CTU. For all redundant systems, disconnecting and repair of any failed device shall not interrupt the operation of the system.

1.1.2.2 System Manageability & Security

The proposed system shall be provided with tools/applications for its management. Manageability shall include a centralized provisioning interface, a centralized monitoring/management interface and provision to integrate (using APIs, NBIs) the system management into a higher-level management system.

The supervisory system of the equipment shall be capable of monitoring all cards and interfaces which are available in the equipment.

The proposed system shall support various authentication methods (username/ password, TACACS/RADIUS etc.), system and operation logging, user management by user profiles (user classes) offering them different operation/management capability sets (for example: provisioning, reporting, configuration management, etc.), logging their actions, interception from inside and outside.

Cyber Security:

- CEA cyber security guidelines 2021 and amendments thereafter.
- Detailed cybersecurity architecture based on ITU-T X.805.
- Role-based access control (RBAC) as per IEC 62351-8.
- Authentication, Authorization and Accounting (AAA).
- Secure management protocols: SNMPv3, SSHv2.
- AES-256 GCM for authentication and encryption.
- AES 128-CMAC or AES-256-CMAC authentication.
- Audit logging, vulnerability management, disaster recovery.
- Cybersecurity certifications: ISO27000, IEC62443 series.
- Rate limiters for different traffic types.
- IPsec/MACsec Encryption must be supported for the equipment management.

Note: IA may list and modify detailed cyber security requirements after approval of Scheme as per network configuration & Site requirements in conformance with CEA Cyber Security Guidelines/ Regulations and their amendments issued from time to time.

1.1.3 General Equipment Characteristics

All applicable requirements stated in this section shall equally apply to the TMN equipment.

1.1.3.1 Revision Levels and Modifications

All hardware, firmware and software delivered as part of the communications network shall be field proven and at the most current revision level. All modifications and changes necessary to meet this requirement shall be completed prior to the acceptance of Equipment/ Link/ Network by the MPLS vendor/ OEM.

All field modifications required to update the hardware, firmware and software to the latest revision level occurring after the above specified testing, shall be fully disclosed, documented.

All field modifications of the hardware, firmware and software that are required to meet installation and/or performance specifications, shall be fully documented as part of the deliverables, both as a separate field modification record and as corrected equipment/configuration documentation.

Version Management procedure of the software shall be described. This information shall include the current version and the schedule of updates in the past and estimate in the future. OEM has to submit an annual report mentioning all the software, their version, updates etc. running on its network to IA.

1.1.3.2 Equipment Capacities

The Equipment provided shall be capable of optimizing multiple FOTE at each node and traffic of multiple existing FOTE could be routed through this new equipment after complete installation/ Testing as per requirement. Equipment supplied shall be sized and equipped with sufficient capacity (to be defined by IA during final scheme planning/ architecture) to support the circuit, channelization and configuration requirements, including spares. The Implementing Agency shall also be responsible for ensuring that sufficient equipped capacity exists to support all alternate routing and redundant equipment requirements defined herein. In the case of multiple FOTE existence at any station, the IA/ MPLS vendor shall also optimize the quantity of new MPLS FOTE requirement.

Each subsystem supplied shall be sized (to be equipped as specified) to support full subsystem expansion.

The IA shall size and equip the system to include all channelization and channel cards required to support the required Data communications channelization for TMN subsystems.

1.1.3.3 Alternate Routing, MPLS and Protection Schemes

The Implementing Agency(s) shall ensure that there shall be no single point of failure of Network due to equipment failure i.e. the failure of one Network Element shall not prevent the use of any other Equipment that has not failed. IA/OEM must state details about redundancy (1+1 Power Supplier, FANs) mechanism, wherever asked/ specified, of the proposed system at system level, subsystem level and board level.

Other protection schemes supported by the proposed equipment shall also be described in the DRS. In case the equipment offered by the IA/OEM does not support the specified minimum protection methods, the IA/OEM shall have to provide all additional equipment needed to provide same level of flexibility, redundancy and functionality. The Implementing Agency shall provide details of protection scheme(s) implemented in the network maintaining 2+2 redundancy (i.e. 2 channels to main control centre and 2 channels to backup control centre) for all the services used for Grid Operation.

Advanced redundancy features:

- Hitless switching
- Dual homing/ revertive & non-revertive switching
- Symmetrical TX/RX switching
- Redundancy on optical level
- 1+1 at STM Rate (STM-1/4/16) as applicable
- 1:1 for MPLS-TP 1optical interfaces (1g/10g/40g/100g) (optical interfaces to be decided

during detailed engineering)

1.1.3.4 Equipment Lifespan

All equipment to be supplied under the subject package shall have a minimum expected life of Ten (10) years from the date of final acceptance. The Implementing Agency shall ensure the availability of spare parts and cards/ items from the OEM for a minimum period of ten (10) years from operational acceptance.

1.1.3.5 Software Upgrades

The Implementing Agency shall provide software upgrades and patches, if any, for the proposed equipment, free of cost, till maintenance period specified in contract. The Implementing Agency shall also provide detailed procedure before applying any upgrade (hardware or Software) in the Network.

1.1.4 Optical Fibre Characteristics

The OPGW/Approach Cables have been installed on various transmission lines and comprise primarily of DWSM (G.652 D) fibers.

In case the MPLS vendor/ OEM needs any other details/ characteristics of the fibre(s) to finalize their solution, they may collect during survey of communication network.

The link budget calculations and equipment design shall be based on the specific fibre parameters as per survey done by the implementing agency/ OEM.

1.2 Survey of existing ISTS communication Network

Implementing Agency shall perform the survey for proposed segment of ISTS communication network on which MPLS-TP has to be established.

The survey includes but is not limited to the below mentioned items. The MPLS vendor/ OEM may also survey other items required for successful implementation of MPLS-TP network in coordination with implementing agency.

- Identify and check required no of Spare Fibers available for parallel operation of MPLS and SDH channels.
- Space for installation of FOTE/equipment rack in substation/Kiosk/ repeater etc. The IA may utilize the existing rack space if available in coordination with station owner for better optimization of resources.
- Required Power Supply/power cables etc. for FOTE/equipment.

- Link budget calculation for the existing OPGW for additional repeater assessment (if any). However, effort should be made to avoid any additional repeater with amplifier solutions.
- Integration requirement (Interfaces/patch cords/cables etc.) with legacy equipment.
- Required services to be integrated in upcoming MPLS-TP node and also required Interfaces/ cables for the same.
- IA shall provide the detail of existing network i.e. existing FOTE, OPGW detail, required power supply availability, space availability, etc.

1.3 Integration requirement with MPLS IP equipment

The proposed MPLS-TP FOTE at ISTS node should support required interfaces for integration (at service level) with MPLS-IP nodes installed at IPP/ Bulk Consumer/ RE GENCOs/ GENCOs/ stations etc. The MPLS vendor/ OEM shall also provide methodology for integration with MPLS-IP nodes.

1.4 Migration Methodology

Prerequisites:

1. Existing SDH Equipment and Network.
   - Identification of nodes in cluster to be integrated with MPLS-TP.
   - Availability of minimum two SDH Ports with SFP compliant with ITU-T G.957 at Point of Interconnection.
2. MPLS-TP Equipment at Point of Interconnection.
   - MPLS-TP Equipment should support Circuit Emulation with SDH & E1 interfaces in same Chassis with common Back plane, Clock, Controller/Processor to Enables availability of total backplane capacity as mappings are done through back plane Bus.
   - In built Cross Connect to translate and map frames from SDH to MPLT-TP and vice versa.
   - Should support both Passthrough and Drop Insert TDM (E1/Ethernet). MPLS TP FOTE should be able to support integration of services RS232, FXS, FXO, 4W E&M.
3. New Equipment's (MPLS-TP).
   - Support MPLS-TP, E-1 & Ethernet Interfaces to integrate all the power system services i.e. SCADA data, PMU, VoIP, tele protection, AMR, telemetering, AGC,

Video conferencing, ICCP, PDC, etc.

Migration as applicable:

1. Integration of existing Equipment with New MPLS-TP Equipment will be through SDH SFP in both equipment.
2. SDH Level.
   - Through STM Level SFP's.
   - Pass Through (Point to Point).
3. MPLS-TP Level.
   - Backbone (Optical) Level.
   - Services Level.
   - Pass Through (Point to Point).
   - Drop Insert (Point to Multi Point).
   - Services Level- Traffic integration.

1.5 Interoperability between different OEMs

This section defines technical, operational and security specifications required to ensure seamless interoperability of MPLS-TP equipment across multi-vendor networks, with a strong alignment to IETF and ITU-T standards.

1.5.1 Executive Summary

- Ensures standards-based, deterministic and reliable MPLS-TP behaviour across vendors.
- Supports carrier-grade networks, sub-50 ms protection and simplified operations.

1.5.2 Scope & Objectives

1. Scope Covers

- PE/P routers, NMS, EMS, OSS.
- OEM/IA shall supply and install the MPLS-TP equipment so that the new MPLS-TP equipment shall communicate/interoperate seamlessly with the existing equipment throughout during its operational life.

2. Objectives Include

- Full technical interoperability.
- Consistent operations & management among OEMs.
- Carrier-grade network for reliability (high availability), performance, scalability, security.
- Lower integration risk and vendor lock-in.

3. Standards Compliance

Key Compliance Principles:

- No proprietary extensions.
- Backward Compatibility: Vendors must ensure full backward compatibility with existing standards-compliant MPLS-TP implementations. New releases or platforms must interoperate without requiring upgrades to legacy nodes. All mandatory behaviours (label processing, OAM, APS, protection models) must conform to published IETF/ITU-T specifications, with no proprietary deviations.

4. Data Plane Requirements

Label Space & Allocation:

- Clear coordination on label distribution, service identifiers and QoS parameters is required to avoid misrouting or service degradation.
- Global label range: 16–1,048,575.
- Static allocation allowed.

Pseudo wire Requirements:

- **Ethernet PW:** Control word, VLAN preservation.
- **TDM PW:** CESoP/CESoPSN/SAToP/MEF-8/MEF-3 with jitter buffer, clocking, CAS support

5.Control & Management Plane

Primary Management:

- Primary Management should support Open Configuration to support interoperability.

6. OAM Requirements

Mandatory OAM:

- CC, CV, LM, DM with defined intervals and accuracy.
- Full defect hierarchy (dLOCV, dLDI).
- Alarm severity levels and RCA mechanisms.

7. Security Requirements

Authentication & Authorization:

- Local/ RADIUS/ TACACS+/ X.509 certs.
- Strong password & rotation policies.

8.Interoperability Testing Framework

Test Environment:

- Multi-topology: P2P, ring, dual-homed.
- Availability of Testing Tools: Ixia/Spirent, Wireshark, BER testers, oscilloscopes.

Test Categories:

- Basic Connectivity (LSP/PW establishment)
- OAM Tests (CC/CV accuracy, LM/DM)
- Protection Switching (fiber cut simulation, revertive tests)

Test Documentation:

- Includes test configs, packet captures, screenshots, logs, results.

9. Operational Requirements

Mandatory Documentation: ICS, commissioning guides, security hardening.
Software Lifecycle: 10-year support, 10-year of spare part, Hardware & Software patch availability.

10. Compliance Verification

- Self-certification (90 days initial).
- Compliance matrix with evidence for each requirement.

The following shall be confirmed by the OEMs to resolve interoperability issues:

- Interoperability with existing SDH/Legacy (STM4, STM 16, STM 1) at service level
- Interoperability with other make MPLS-TP equipment
- All existing and upcoming vendors/OEMs shall ensure full compliance with the MPLS TP interoperability requirements defined in the applicable IETF and ITU T standards and implement interoperability by coordinating with each other and shall be capable of implementing seamless multivendor interoperability without imposing any commercial implications or additional costs on the user."

11. Interface Compatibility

UNI/NNI interfaces should support standardized encapsulation, VLAN tagging and label formats. Optical interfaces (SFP/XFP) must be interoperable in terms of wavelength, power levels and connector types. (Optical Interfaces SFP/XFP must be compliant to ITU-T G.957, IEEE 802.3).

12. Synchronization

SyncE/ IEEE 1588v2 must be supported and interoperable for timing consistency.

13. Testing & Certification

Interoperability testing (IOT) and certification between OEMs (existing and new) should be conducted before deployment. At present the existing network is SDH and new MPLS-TP OEM to coordinate with existing OEM.

The protocols/standards should not be OEM specific. The OEMs are required to share requisite technical data i.e. Label range, protocols, standards, encryption algorithms etc. with other OEMs who are also providing/going to provide FOTE for power system applications to ensure seamless functioning of communication system.

Sharing of Requisite technical data for integration with UNMS:

OEM to ensure interoperability of their MPLS-TP FOTE with MPLS-TP FOTE of other OEMs and also integration with UNMS upwardly through standard North Bound Interface (NBI). OEM/Vendor shall be obliged to provide/share all necessary documentations such as NBI Guide/MIB/IDL/WSDL/API files/ etc., to facilitate centralized supervision, centralized inventory management, centralized provisioning of bandwidth/services, availability computation, monitoring of events and alarm handling etc. of supplied TMN/NEs through UNMS. The interface shall support all functionalities such as NE Inventory, Hardware Inventory – Shelf/Slot/Card/SFP/Port, Topology, Protections, Alarms, Performance- real time & periodic, Performance KPI parameters (E-1, STM, Ethernet), Remote Configuration, Cross Connects, Trails & Circuits, Services Provisioning (NE), E-1, STM, Ethernet, TX & RX Trace, loop back and details are published in the NBI guide for the configuration parameters.

Integration with U-NMS shall be in the scope of U-NMS provider. However, necessary support for integration of supplied NMS with U-NMS shall be provided by the contractor as required, which may be during implementation stage/AMC period.

The following support shall be provided by the Contractor for integration of the supplied equipment with UNMS:

- Enabling & activating NBI license in their NMS/TMN and providing NBI login access along with User credentials
- Assist in verifying NBI Connectivity with UNMS vendor for the successful communication and retrieval of data.
- Assist in troubleshooting (if required) for NBI connectivity along with UNMS vendor for the communication and retrieval of data.

1.6 MPLS-TP Equipment for Aggregation & Access Network

1.6.1 MPLS-TP System

The product/ solution with low footprint & power efficient shall be offered for the access/ aggregation layer. All optical interfaces (Line & client both) shall support Bi-directional and be pluggable. Also, IA reserves the right to use third party pluggable & interfaces and shall not have any kind of restriction from OEM/Vendor for the offered equipment. The system shall support circuit emulation MPLS-TP (MPLS-Transport Profile).

Equipment shall provide the following:

- OAM functions to detect and isolate faults (Like SDH/ SONET).
- Sub-50ms protection and restoration.
- Ring & mesh architecture.
- End-to-end QoS.

1.6.1.1 Functional Requirement

The offered MPLS-TP platform must be a reliable packet-based network based upon circuit-based transport networking. The architecture of the MPLS-TP platform must be defined as per the IETF RFC 5921, 6215 and other relevant standards. The requirements for MPLS-TP forwarding, OAM and network survivability must be as per RFC 5654, 5860 and other relevant standards.

1. The switching fabric plane shall be bidirectional and non-blocking. The Equipment's shall support a wire speed L2 switching capabilities under full load condition. The platform shall support enterprise services like Ethernet E-Line & E-LAN, E-Tree and E-Access services and aggregate & hand over the traffic to next higher Metro Ethernet network Core Layer.
2. The management of the MPLS-TP networks must be separable from its client networks so that the same means of management can be used regardless of the client. The management functions of MPLS-TP must include fault management, configuration management, performance monitoring and security management.
3. The purpose of the management function must be to provide control and monitoring of the MPLS transport profile protocol mechanisms and procedures. The requirements for the network management functionality must be as per RFC5950 & RFC5951.
4. MPLS-TP platform must mandatorily run BFD (Bidirectional Forwarding Detection) protocol to provide OAM functionality. It should have resiliency to ensure minimal interruption to traffic when a failure occurs within the system or network.
5. Additionally, the communication system shall also support the following:
   (a) Distance protection through Digital Protection Couplers.
   (b) Differential protection.
   (c) Data transport supporting Network Management channels.
   (d) The connectivity envisaged between RTUs/SAS and Control Centre in Wide Area Network (WAN) on TCP-IP using IEC 60870-5-104 protocol.
   (e) The equipment shall support digital VOIP subscriber & gateway functionality (SIP-Session Initiation Protocol) by connecting an integrated/external VOIP gateway.
   (f) Management: Remote management system with IP/Ethernet interface.

(g) To prevent personal injury form emerging laser light in the case of the fiber break, equipment shall support automatic laser shutdown (als) function according to ITU-T G.958 and ITU-T G.644.

(h) MACsec (IEEE 802.1AE) encryption shall also be supported by the equipment.

1.6.1.2 Equipment Requirement

1. Equipment sub rack must be suitable to install in 19-inch and 21-inch rack (IA may modify as per site requirement).
2. The supplier shall confirm that their solution supports insert, replace and remove of modules while the equipment is powered up without affecting traffic and damaging any module.
3. All NEs and cards provided by supplier must be managed on the same NMS.

1.6.1.3 Technical specification

1.6.1.3.1 Standard requirement

1. All equipment must comply with the Generic requirements mentioned in TEC/GR/TX/CEN-004/03/MAR-17 for MPLS-TP based carrier Ethernet switch for Aggregation & Access Network Applications.
2. All Equipment (100G & 10G) shall support amplifiers solution (best available amplifier solution may be taken to avoid any new repeater in the network, Detailed Amplifier requirement to be finalized by IA as per network requirement). The Equipment shall support Ethernet PW (Pseudo Wire) as specified by relevant IETF standards.
3. Equipment shall support minimum number (≥ 2K) of statically configured LSPs. The MPLS-TP Equipment has UNI (User Network Interface) and NNI (Network Node Interfaces). The MPLS-TP Equipment shall support UNI or NNI mode of operation on all the ports.
4. Optical Ethernet interfaces shall be configured as Client or Aggregate interfaces based on requirement.
5. All Equipment must be able to transport jumbo frame of upto 9198 Bytes.
6. The equipment shall support IPv4 and IPv6 traffic transparently at data plane.
7. All Equipment shall be able to function in terminal mode, hub, & mesh and ring topologies.

8. The equipment shall provide managed multi-service integration viz., voice, video and data.
9. All equipment shall be fully compliant to MEF 9, MEF 14 or CE2.0 & MEF3.0 standards.
10. It shall support built in power diagnostics feature to monitor optical SFP/XFP ports, system diagnostics to detect hardware failures.

1.6.1.3.2 Layer-2 Switching Features

1. It shall support ingress and egress bandwidth profile per User to Network Interface (UNI).
2. Equipment shall support Ethernet functions VLAN (IEEE 802.1Q), Q-in-Q (IEEE 802.1ad), VLAN manipulation: stack/switch/strip, IGMP snooping (V1/V2/V3), Link aggregation (IEEE 802.3ad) and allow the configuration of a link bundling.
3. The proposed network shall support disabling LACP on an 802.3ad link aggregate and relying on static configuration.
4. The proposed network shall support static MAC FIB entries as part of policy forwarding.
5. Equipment shall support Link Layer Discovery Protocol as per IEEE standards.
6. The equipment shall support enterprise services like Ethernet E-Line & E-LAN services and aggregate the traffic and hand over the same to the next higher Metro Ethernet network Core Layer.
7. Service multiplexing: A single MPLS-TP Equipment port shall support multiple Ethernet Services handover from one port through ENNI.

1.6.1.3.3 VLAN Features

1. The MPLS-TP Equipment shall support creation of VLAN among ports of different types as well as on all ports of the interface cards.
2. It shall support VLAN bridging (for outer tag) as per IEEE 802.1ad and user isolation per outer VLAN tag. The user isolation shall be configurable on a per port basis.
3. The MPLS-TP Equipment shall support VLAN ingress filtering to prevent VLAN leakage & VLAN tag overlapping allowing some ports to be member of more than one VLAN.

4. The proposed network shall support VLAN ID Translation (not tunnelling/stacking), i.e., translating VLAN ID received from one node to a different (network) VLAN ID at originating E-UNI and translating back to customer VLAN ID at terminating E-UNI.
5. The proposed network shall support the configuration of IEEE 802.1d user priority bits or DEI to MPLS-TP PW EXP bit mapping when performing MPLS-TP encapsulation. The proposed network shall be able to write the EXP bits based on the outcome of this mapping.

1.6.1.3.4 Port trucking / Link Aggregation

1. The MPLS-TP Equipment shall allow Link Aggregation as per IEEE 802.3 ad to allow link resilience.
2. Supports load balancing over Aggregated Links.
3. Static/LACP LAG on client ports shall be configured in all equipment.
4. The proposed network shall support disabling LACP on an 802.3ad link aggregate and relying on static configuration.

1.6.1.3.5 Forwarding Support

1. The MPLS-TP Equipment shall support to override the MPLS-TP Equipment port MAC address.
2. It shall also support VPLS, VPWS instance.

1.6.1.3.6 MAC Address Learning / Limiting

1. The MPLS-TP Equipment shall support L2 Learning parameters: Sources learning per Port/VPLS/VLAN/Source address.
2. The MPLS-TP Equipment shall support to set per port/VPLS instance dynamic MAC learning.
3. The MPLS-TP Equipment shall support to limit the number of source MAC addresses learnt from bridge port/VPLS instance in order to prevent MAC address flooding DoS attack. This limit is configurable per bridged port.
4. The MPLS-TP Equipment shall support dropping of Frames with new source MAC-addresses exceeding the configured value.
5. The MPLS-TP Equipment shall support per VLAN MAC learning to ensure MAC

addresses are learnt only from a VLAN perspective and automatic/manual disabling of MAC addresses learning for the VLAN where there are less than two ports in that VLAN.

6. The MPLS-TP Equipment shall support MAC limiting per Ethernet flow point (EFP) or bridge domain.
7. The MPLS-TP Equipment shall support MAC address limitation and aging.
8. All static entries shall NOT be aged.
9. The MPLS-TP Equipment shall support Hardware based aging of MAC Address Table entries.
10. The MPLS-TP Equipment shall support to enable L2 Aging on every port.
11. The MPLS-TP Equipment shall support MAC address learning disabling.
12. The MPLS-TP Equipment shall support to filter and discard all Ethernet frames received on bridged ports in the upstream direction with a specific MAC destination address (DA).
13. The MPLS-TP Equipment shall support list of allowable MAC destination address.
14. The MPLS-TP Equipment shall filter the MAC address from bridge port X if the same MAC address appears in the learning table pointing to bridge port Y (port X and port Y on the same the MPLS-TP Equipment and same VLAN), except in the cases where the aggregation network forwards according to MAC Learning table.
15. The MPLS-TP Equipment shall support unique MAC address per device to prevent spoofing and provide traceability.
16. The MPLS-TP Equipment shall have the capability to prioritize BPDUs (Bridge Protocol Data Unit) in the data plane (by providing dedicated queues) and in the control plane (by providing dedicated CPU queues for BPDUs).
17. The MPLS-TP Equipment shall have the capability to drop BPDUs regardless of the BPDU content. This function is configurable on a per port basis.

1.6.1.3.7 The MPLS-TP Equipment shall support IEEE 802.1Q Tagging

1. Tagged only, this is an IEEE 802.1Q trunk.
2. Untagged.
3. Hybrid tagged and untagged frames.
4. The MPLS-TP equipment shall support the following additional IEEE 802.1Q features:

I. Tag insertion, removal and swapping.
II. Capability of insertion and removal of second tag.
III. Encapsulation translation and rewrites Push, Pop and translate for IEEE 802.1Q or QinQ/IEEE 802.1ad tags.
IV. Local VLAN and ports cross-connect and multipoint or point-to-multipoint with Hierarchical Virtual Private LAN service (H-VPLS bridge topologies with pseudo-wires) or locally defined bridge domains.
V. The MPLS-TP Equipment shall allow configuring all 4K VID (VLAN Identifier) on all ports and at the same time supporting all 4K VLANs simultaneously. The user/operator shall be able to reuse the same VLAN-ID on a different port on the same. The MPLS-TP Equipment and terminate it into a different PW/VLAN.
VI. The MPLS-TP Equipment shall accept untagged and C-tagged frames through an IEEE 802.1Q port.

1.6.1.3.8 Q-in-Q or IEEE 802.1ad mode Requirements

1. The MPLS-TP Equipment's shall perform classification and service delineation based on outer Q tag and outer IEEE 802.1p bits. (i.e. ignore inner tag).
   - It shall support VLAN stacking as per IEEE 802.1ad.
   - It shall have minimum of 4094 S-VIDs (Stacked VLAN-IDs). VIDs "0".
   - It shall allow only S-tagged frame in '.1ad' ingress ports. It shall be possible to map the traffic to any PW based on SVLAN tag. It shall be possible to keep or pop the SVLAN tag before forwarding it to the PW.
   - It shall be possible to set the priority bits in the S-VLAN priority based on the PCP bits of C-tag of the incoming packet in '.1ad' mode.
   - Preferably the proposed network shall have UNI (User Network Interface) and NNI (Network Node Interface). Typically, UNI would be configured in 802.1Q mode or Q-in-Q mode and NNI shall be in MPLS-TP(P2P) or VPLS/H-VPLS (MP2MP) mode.

     In order to simplify the operation of the product it is intended that no restriction be placed on UNI and NNI ports and all the ports shall be capable to support any mode of operation.

1.6.1.3.9 LSP Mode Requirements

1. The MPLS-TP Equipment shall support LSP Mode Scalability Options i.e. Virtual Private LAN Service (VPLS).
   - Support Packet Transport Network solution using PW service tunnel.
   - TDM and Ethernet traffic shall be emulated into Pseudo-wires and PW label is added for service identification.
   - End-to-end transport path LSP shall be created based on MPLS-TP standard and multiple.
   - The Service tunnels shall support per LSP queuing/scheduling i.e. the ability to assign and guarantee per LSP per class bandwidth profiles (CIR, EIR, CBS and EBS).

1.6.1.3.10 Quality of Service Requirements

1. The MPLS-TP Equipment shall support VLAN CoS (Class of Service) preservation.
2. The MPLS-TP Equipment shall support VLAN CoS differentiation: It shall be possible to configure the classification of the traffic according to the service, VLAN, IEEE 802.1p bits or TOS (Type of Service)/DSCP (Differentiated Services Code Point) bits.
3. The MPLS-TP Equipment shall support creation of VLAN or Flow with DSCP parameters per service for data, video and O&M traffic for service differentiation.
4. Equipment shall support in-built feature of measurement of performance bounds for each flow in terms of throughput, loss, delay and delay variation, according to their respective defined service classes as per Y.1731.
5. The MPLS-TP Equipment shall support 16, 32, 64,128,256 and 512 k bytes burst sizes.
6. The MPLS-TP Equipment shall support wire speed forwarding on all interfaces and all packet sizes even with classification and QoS activated on all interfaces.
7. The MPLS-TP Equipment shall support bandwidth management reports and statistics.
8. The Edge the MPLS-TP Equipment shall support 8 class of service per flow.
9. Equipment shall support Hierarchical QoS (HQoS) and advanced queuing with support for >= 8 hardware queues per port, Priority mapping tables, VLAN QoS with

CoS handling.

1.6.1.3.11 Classification/Prioritization

1. The MPLS-TP Equipment shall support classification of ingress traffic for a specific service based on the following mapping:
    - IEEE 802.1P Mapping - it shall be possible to reserve parts of the link bandwidth for frames with particular IEEE 802.1p values
    - Customer IEEE 802.1p priority
    - Multiprotocol Label Switching (MPLS) Label Stack Entry: "EXP" Field Renamed to "Traffic Class" Field as per RFC 5462
    - Source MAC address
    - Destination MAC address
    - VLAN ID
    - IEEE 802.1Q
    - Default queue for non-matching traffic
2. The MPLS-TP Equipment shall aggregate incoming traffic into Traffic Classes by following characteristics:
    - Incoming port (Logical and Physical)
    - Source/ destination MAC
    - Link layer priority information as per IEEE 802.1p
    - The solution should support color-aware and color-blind policing

1.6.1.3.12 Mapping

1. The MPLS-TP Equipment shall support mapping of DSCP/VLAN/Port to MPLS labels.
2. Mapping of IEEE 802.1p and IP TOS bits into MPLS EXP bits.
3. Mapping of IEEE 802.1q VLAN tags into MPLS labels.
4. Aggregate incoming traffic into Traffic Classes by MPLS Label EXP bits (E-LSP).

1.6.1.3.13 Marking/Policing/Shaping

1. The MPLS-TP Equipment shall support the following Marking/Policing/Shaping requirements:
    - 8 level Priority marking as per IEEE 802.1p

- Broadcast/Multicast suppression
- Bandwidth management policies
- Trust the colour of the incoming packet
- Differentiated Service Two-Rate, Three-Color Marker with Efficient Handling of in-Profile Traffic
- Shaping of Burst Traffic

1.6.1.3.14 Rate Limiting

1. The Equipment shall support Rate limiting of bandwidth and per class (or flow).
2. Configuration of user bandwidth shall be supported, in steps of
   - Mbps for 1-1000Mbps
   - 100 Mbps granularity for 1-10Gbps or 100 Gbps (as required)
3. It shall support defining Committed Information Rate (CIR) and an Excess Information Rate (EIR) for each flow in steps of 1Mbps.
4. The MPLS-TP Equipment shall support flow-based rate limiting method based on per source address, destination address or both.

1.6.1.3.15 Queuing

1. The MPLS-TP Equipment shall support the following queuing:
   - SPQ – Strict Priority Queuing.
   - WFQ – Weighted fair Queuing.
   - No of queues per flow treatment of traffic.
   - Per service ingress queues are defined on the basis of Peak/Excess burst Size (PBS/EBS), Committed Burst Size (CBS), Peak/Excess Information Rate (PIR/EIR) and committed Information rate (CIR).
   - Per service egress queues have distinct parameters defining its operations like Peak/Excess burst Size (PBS/EBS), Committed Burst Size (CBS), Peak/Excess Information Rate (PIR/EIR) and committed Information rate (CIR).
   - Alternate priority routing traffic necessary to keep from starving other priority queues.

1.6.1.3.16 Scheduling

1. The MPLS-TP Equipment shall support scheduling of queues to strict priority with

2 or more priority levels.

2. The MPLS-TP Equipment shall support the following congestion avoidance mechanisms.
   - Weighted Round Robin (WRR).
   - WRED.
   - Strict Priority (SP).

3. The MPLS-TP Equipment shall support configuring the scheduling as per the
   - Per Hop Behaviour (PHB).
   - Physical port or logical port basis.
   - Up to 8 forwarding class queues can be configured on a per service basis each with its own CIR, PIR, CBS, PBS and Forwarding Class attribute.
   - At least three level dropping precedence levels in each queue.
   - The solution should support Broadcast Storm Control (BSC)

1.6.1.3.17 Protection Mechanism

1. The MPLS-TP Equipment shall support linear protection (1:1 & 1+1) as specified in ITU-T Rec. G.8131.1 or G.8131.2. (SNCP, MSP 1+1) and relevant RFC standards.
2. For all the modes of protection, the MPLS-TP Equipment shall support protection switching within **50ms** of expiration of any manually selected hold-off time (with both SF/SD scenario) and shall support all operator commands (Forced Switching [FS], manual Switching [MS], lockout of protection).
3. The MPLS-TP Equipment shall support protection switching within 50ms and Forced switching as analogous to SDH systems.
4. The MPLS-TP Equipment shall support protection switching triggered by fault detection, such as loss of signal, loss of frame, signal degrade (BER becomes worse than the predetermined threshold) and so on.
5. The MPLS-TP Equipment shall have Forced switching activated by administrative events, such as fibre rerouting, fibre replacement, etc.
6. The MPLS-TP Equipment shall have Ethernet ring protection for both S-VID and B-VID as per G.8032.
7. The MPLS-TP Equipment shall have MPLS-TP Linear Protection support as per

IETF standards or Ethernet/MPLS SNC based protection as per ITU-T standards.

8. Protected services must failover to the backup path based on complete failure of the primary path and based on partial traffic loss (signal degrade).

1.6.1.3.18 Circuit Emulation Protocols

1. The MPLS-TP Equipment shall support PW using Time Division Multiplexing (TDM) over Packet (SAToP) or MEF8.
2. The equipment shall support E1/channelized STM-1/4/16 circuit emulation mechanism and it shall support Circuit Emulation Services over MPLS as per Pseudo Wire Emulation Edge-to-Edge (PWE3) standard to aggregate the TDM PW from the edge and access (Carrier Ethernet Network (CEN).

1.6.1.3.19 Network Synchronization Requirements

1. The MPLS-TP Equipment shall be able to synchronize with an external NavIC (with failback option to GPS) based time reference clock.
2. It also supports Synchronous clock selection algorithm based on the following parameters:
   - Quality of Signal.
   - Signal fail.
   - Priority.
   - External Commands.
3. It shall have feature of SyncE as per ITU-T G.8261, G.6282 and G.8264 or IEEE 1588v2.
4. The MPLS-TP Equipment shall support Network Time Protocol (NTP) for synchronizing with a central NTP server.
5. The MPLS-TP Equipment shall have feature of timing and synchronization aspects of Packet Networks based on SyncE as per G.8261. The MPLS-TP Equipment shall support timing characteristics of a synchronization slave clock as per G.8262.
6. The MPLS-TP Equipment shall have feature to provide a timing-output interface at 2048 kHz for external synchronization. The output shall conform to ITU-T Rec. G.812, as applicable.
7. The MPLS-TP equipment shall have enhanced synchronization features:
   - PTP Transparent Clock (G.8273.3).

- PTP Clocks: Ordinary/Boundary/Transparent.
- ToD (Time of day).
- 1-PPS (One Pulse per second) output interface.
- G.8265.1 Profile (Frequency Synchronization).
- SyncE Synchronous Ethernet from all built-in and plug-in GbE, 10GbE ports.
- ITU-T Ethernet Synchronous Message Channel (ESMC).
    a) Stratum 3E timing
    b) TDM line clock: E1/T1 and STM/OC ports
    c) External clock input and output (2 Mbps / 2 MHz)
- GPS sync for event recording.
- PTP gateway between Telecom and Power profiles.

1.6.1.3.20 MPLS-TP STANDARDS

1. It shall support the creation of L2VPN solutions using statically configured PWs and tunnels as per RFC 4664.
2. The MPLS-TP Equipment shall have feature of MPLS-TP requirements as per RFC 5654 or ITU Y.SUP4.
3. The MPLS-TP Equipment shall have the Architecture of MPLS-TP Layer Network as per ITU-T G.8110.1v2 or equivalent IETF standards.
4. The MPLS-TP Equipment shall have the Interfaces for the MPLS-TP Hierarchy as per ITU-T G.8112 or equivalent IETF standards.
5. The MPLS-TP Equipment shall have the Characteristics of MPLS-TP Network Equipment Functional Blocks as per ITU-T G.8121v2 or equivalent IETF standards.
6. The MPLS-TP Equipment shall have the feature of MPLS-TP General Framework as per RFC 5921 or ITU G.8110.1
7. The MPLS-TP Equipment shall have MPLS-TP survivability framework as per RFC 6372 or ITU G.8131/G.8132
8. The MPLS-TP Equipment shall have MPLS-TP Data plane Architecture as per RFC5960 or ITU Y.SUP4
9. The MPLS-TP Equipment shall have MPLS Generic Associated Channel (GAL/G-ACH) as per RFC 5586 or ITU G.8113.1/G.8113.2
10. The MPLS-TP Equipment shall have the feature of Definition of ACH TLV Structure

as per draft-ietf-mpls-tp-ach-tlv-02 or ITU G.8113.1/G.8113.2

11. shall have the feature of Pseudowire Status for Static Pseudowires as per RFC 6478
12. shall have the feature of MPLS On-Demand Connectivity Verification and Route Tracing as per RFC 6426 or ITU G.8113.1/G.8113.2
13. MPLS-TP Equipment shall have the feature of Proactive Connectivity Verification, Continuity Check and Remote Defect Indication for the MPLS Transport Profile as per ITU G.8113.1/G.8113.2
14. The MPLS-TP Equipment shall be connection-oriented packet switching model with traffic engineering capabilities that allow deterministic control of the use of network resources. It shall support traffic engineered point to point (P2P).
15. The Edge MPLS-TP Equipment shall support packet transport network solution by using PW service tunnel and MPLS-TP transport technology. TDM and Ethernet traffic are emulated into Pseudo-wires and PW label is added for service identification. End-to-end transport path LSP is created based on MPLS-TP standard (ongoing) and multiple PWs are transported over the same LSP end-to-end in both directions.
16. In order to support traffic engineered point-to-point MPLS-TP circuits, it shall have all the MPLS-TP specific requirements specified in the RFCs (RFC 3031, 3032, 3443, 5586, 5860, 5960, 6370, 6426, 6428). No explicit support for control plane protocols is required. NMS Support shall be mandatory.
17. It shall be possible to rate limit the traffic in MPLS-TP tunnels at minimum 10 Mbps granularity. MPLS-TP tunnels shall have per E-LSP Queuing as defined in RFC 3270.
18. In order to support traffic-engineered Pseudo Wire Emulations (PWE) over MPLS-TP, the system shall be compliant to the following RFCs (RFC 4448, 5659, 5994). The compliance for these RFCs is required to the extent of supporting MPLS-TP and PWE. No explicit support for control plane protocols is required. NMS support shall be mandatory.
19. The MPLS-TP Equipment shall comply with RFC 6378, RFC 6669, RFC 7213, ITU-T G.8151 for interoperability between different OEM's Equipment.

1.7 OAM Requirements

The proposed network shall support a full suite of OAM features and functionality to easily monitor, administer and troubleshoot all the services.

The proposed network shall support OAM framework as defined in RFC 6371 and requirements defined in RFC 5860. The system shall support OAM for:

- Detection & recovery of Path Defects
- Diagnosis of a Broken Path
- Preferably Service Level Agreement Measurement for Jitter, Packet Loss and Latency.
- Frequency of OAM Execution
- Inter-working for Fault Notification
- Detection of Denial-of-Service Attacks
- LSP/PW ping & trace route
- Preferably SNMP traps.
- Mac Pinging – Continuity Check
- Trace-route
- Loop-back Connectivity check
- Ethernet –Local Management Interface (E-LMI)
- Ethernet LMI to CFM (802.1ag) interworking
- 802.3ah to CFM (802.1ag) interworking
- Maintenance End Points (MEP) on switch ports
- Maintenance Intermediate Points (MIP)
- Connectivity Fault Management over 802.1ad links
- SNMP traps
- Preferably the System shall support Link Layer OAM (802.3ah) with following functionalities
- OAM discoveries
- Link Monitoring
- Remote Loopback
- Remote Fault Indication
- OAM should inform the management system / third part application about the status of service, connection per box basis and per user basis. Details information should be available like ingress and egress value, connection ID, port ID.

- There shall be a mechanism to measure delay, jitter and round-trip delay, packet loss and frame loss end-to-end for a given flow. The system should synchronize the counters on both ends.
- There shall be a mechanism to fetch delay, jitter and round-trip delay, packet loss and frame loss for unicast & multicast.
- The exchange of OAM packets should be end-to-end with provision to count number of times connections were down. It should identify the status of link.
- OAM should provide mechanism for trace-route to help operator to trace the path from ingress to egress network element with details of intermediate element.
- OAM packet should be isolated to user's data packet and it should be given highest priority.
- OAM packet should have attributes pertaining to ingress and egress filter.
- OAM should run per connection basis. The connection can be made using VLAN, Port, or other attributes.
- The solution shall support debugging through Event Logs, Alarm Logs, Performance logs, debug files in Equipment.
- Selective debugging of data plane aspects shall be supported including logging of individual ACL rules, FIB events, etc. Configuration management: backup/restore of configuration from a remote system using standard protocols like FTP, or TFTP. All of these functions shall be able to be performed through in-band interfaces and OOB management Ethernet port.
- SNMP v1, v2c and v3 shall be supported
- Equipment should support HTTPs for GUI access
- Intensive OAM processing shall be supported on per LSP/PW basis (GAL/GAch for every LSP/PW)
- Sub-50ms PG (protection group) processing needs to be implemented on per LSP/PW basis
- Continuity Check messages
- Remote defect Indication
- Route tracing
- The proposed network shall support 802.1ag Connectivity Fault Management standard

- The proposed network shall discard customer frames that contain unassigned customer VLANs on 802.1q port (including untagged customer frames)
- The proposed network shall support counters for number of broadcasts, unicast, multicast and unknown unicast frames flooded per VLAN
- The proposed network shall support MPLS-TP OAM requirements per RFC 6428
- The proposed network shall support the MPLS-TP OAM bundled with MPLS-TP tunnel for the monitoring and the protection
- The MPLS-TP OAM or Bidirectional Forward Detection (BFD) packet sending interval should be user configurable

1.7.1 Pluggable Optics

The optical transceivers shall interconnect the nodes using fibre optical infrastructure. The transceivers shall support single mode fibre cables and operate at 1310nm or 1550nm.

1. The Tuneable 10G Pluggable for all type of MPLS-TP Equipment must support span loss of minimum 22dB without any amplification.
2. All pluggable optics shall be used in NNI & UNI ports of MPLS-TP equipment.
3. Bi-Directional XFP/ SFP+ shall be supported with 10G (NNI & UNI) interfaces of all MPLS-TP equipment.
4. 1G, 10G pluggable supporting up to 40 Km, 80 km, 120 km, 180 km, 220km distance with or without amplifier (pre and post) solution.

1.7.1.1 Amplifier Solution for Packet Links

1.7.1.1.1 Optical Amplifiers

Transmit power amplifier and/or a combination of transmit power amplifier & receiver preamplifier shall be offered to meet the link budget requirements stated in 'Optical Link Performance Requirements'. Amplifier Solution shall be located with the equipment.

The Optical amplifiers shall meet the alarm requirements and shall be fully manageable from TMN. It should be possible to monitor the optical parameters and also handle alarms of the optical amplifier from the TMN. The MPLS OEM/ Vendor shall provide detailed specifications of Optical Amplifiers used in the Amplifier Solution.

Link Solution supporting difference span losses in the proposed link shall be in the form of 'Set'. The 'Set' consists of all necessary amplifiers, pluggable Optics for equipment, Patch cords, power cables, Communication/ DCN cable accessories and any other items as per TS, for one end of the link i.e. implementing agency shall order two (02) sets for implementation of one (01) link.

1.7.1.1.2 Optical Link Performance Requirements

The Link performance for ES, SES and BBER for the fibre optic links shall correspond to National Network as defined in ITU-T G.826, G.828, M.2101, RFC 2544 and Y.1564.

1.7.1.1.3 Link Budget Calculations

The fibre optic link budget calculations shall be calculated based upon the following criteria:

1. Fibre attenuation: The fibre attenuation shall be taken to be the guaranteed maximum fibre attenuation i.e. 0.21 dB/Km @1550nm and 0.35 dB/km @1310nm.
2. Splice loss: Minimum 0.05 dB per splice. One splice shall be considered for every 3 kms.
3. Connector losses: Losses due to connectors shall be considered as minimum 1.0 dB per link.
4. Equipment Parameters: The equipment parameters to be considered for link budget calculations shall be the guaranteed "End of Life (EOL)" parameters. In case, the End of Life parameters are not specified for the MPLS-TP equipment, an End of Life Margin of at least 2 dB shall be considered and a similar margin shall be considered for optical amplifiers.
5. Optical path Penalty: An optical path penalty of at least 1 dB shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp.
6. Maintenance Margin: A maintenance margin of at least 2.5 dB/100Km shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc.
7. Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered
   Dispersion: The fibre dispersion shall be as per G.652 fibre dispersion.

8. Bit Error Rate: The link budget calculations shall be done for a minimum BER of 10^{-10} for 1G and 10^{-12} for 10G.

The bidders shall determine the total link loss based on the above parameters and shall submit the system design (including link budget calculations) for each category of fibre optic link during detailed engineering by IA.

For finalizing the FOTE system design & BOQ, above methodology shall be adopted taking into account fiber attenuation, dispersion and splice loss determined during the detailed engineering by IA.

1.7.1.2 Management

The MPLS-TP system shall support the In-Band & Out-Band management communication channel. The management function of MPLS-TP includes fault management, configuration management, performance monitoring and security management. The management function must provide control and monitoring of the MPLS transport profile protocol mechanisms and procedures. The requirements for the network management functionality must be as per RFC5951.

- Fully manageable via SNMP (v3)
- Fully manageable via GUI
- Serial port
- SSH, Telnet via Ethernet
- GbE Interface in-bands
- Account Security
- Two types of privileges: Operator (read only) and Administrator (read and write)
- Radius Client and 802.1x Authentication
- Upload/Download NE configuration ▪ TFTP ▪ SFTP
- Syslog, NTP

1.8 Patch Cords

The OEM/ MPLS vendor shall provide (i.e. supply and install) connectorized FODP-to-equipment and equipment-to-equipment jumpers (patch-cords) for each equipment with two installed spares. The Implementing Agency shall be required to provide armored patch-cords at some of the locations prone to rat cuts as identified during survey/ or mentioned while finalization of BoQ. Fiber jumpers should be of sufficient length to provide at least 0.5m of service loops when connected for their intended purpose. The Implementing Agency shall provide patch cords of appropriate length for interconnection amongst equipment ports and with FODP for proper

routing inside the cabinet and to maintain aesthetics. Implementing Agency shall assess the requirement of various lengths of patch cords during survey and keep sufficient quantity of various length of patch cords to cater for any changes during Installation. The Patch cords shall comply with the Comply with the TEC No. TEC/GR/TX/OFJ-01/05/NOV-09 and latest release and amendments.

1.9 Power Supply

The equipment shall operate from a nominal -48VDC (-15% / +20%) battery and 220v AC as per requirement specified after detailed engineering. The equipment shall support dual power feed (1+1 hardware protection) i.e. that two power sources can be connected directly to the equipment (two connection points) without any common circuitry which can add a point of failure. The operating voltage should be - 48V (Positive grounded).

The equipment shall supervise the power source and provide corresponding alarm in case of loss of either power source. Necessary surge protection shall be provided to filter all surges.

1.10 Cabinet

1. Equipment cabinet must comply with ETSI 300 119 RACK Dimensions (2200mm x 600mm x 600mm) and must be supply with power distribution panel.
2. The rack shall have a DCDB(PDP) with sufficient number of MCBs to support installation of minimum of 3 equipment's/Sub-racks.
3. Dust and moisture protection shall meet or exceed IP41 standards.
4. Rack should be equipped with a fiber management tray or fiber tray rack mount to organize and access patch cord ports.

1.11 Inside Plant

For the purposes of the specification, Inside Plant shall include cabling, wiring etc. Equipment and material components of the Inside Plant are part of this procurement.

1.12 Safety

The equipment shall be safe to use and shall comply with EN 60950-1. Laser Safety according to IEC 60825-2 and IEC60255-27.

1.13 Ambient Conditions

Storage and transport:

Temperature range: - 25°C ... +70°C

Humidity: max. 95% (no condensation)

Operation:

Temperature range: - 10°C … +55°C

Humidity: max. 95% (no condensation)

1.14 Electromagnetic Compatibility

The equipment shall comply with the EN 55022 class A, EN 61000-6-2, EN 61850-3 and shall be in conformance with CE.

1.15 Mechanical Construction

The equipment shall be available as a 19" shelf to be mounted in a 19" rack or 19" cabinet. It shall be of robust design. All connectors shall be accessible from the front and comply with international specifications. Equipment Sub Racks shall be steel/aluminium fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint. All equipment racks, enclosures and equipment, including distribution frames, shall be clearly labelled with unique identifiers. Dust and moisture protection shall be as per the IP41 specification, or better standard. The equipment cabinet shall be built in such a way that it prevents the entry of all type of rodents.

The IA/OEM is required to provide and install all additional necessary indoor and outdoor cable raceways. Signal cabling and power cabling shall require separate cable raceways. Signal and power cabling shall not share the same raceways and shall be installed as far apart as is practical. Adequate shielding shall be provided as required. Especially, all the F.O. patch chords from FODP to FOTE cabinet shall be enclosed with minimum of 1" flexible standard steel hose.

The IA/OEM shall be required to provide protection from lightning and transient voltages for all wideband communications equipment. Suitable surge voltage protection device shall be installed in all panels.

1.15.1 Summary of applicable standards

The equipment shall conform to the following standard:

1.15.1.1 Immunity

- IEC/EN 61000-4-5 Immunity against voltage surges, DC terminals. Level 2KV, others 1KV.
- IEC/EN 61000-4-6 Immunity against radio frequency voltage conducted in Power terminals, level 10V/m
- IEC/EN 61000-4-17 ripple on DC input port Immunity
- IEC/EN 61000-4-18 Damped Oscillatory wave Immunity
- IEC/EN 61000-4-29 Immunity against short voltage dips, interruption and voltage variations

1.15.1.2 Emission

- EN 55022 (CISPR-22) conducted emission, Level Class B
- EN 55022 (CISPR-22) radiated emission, Level Class B

1.15.1.3 Safety

- IEC/ EN 60950-1 Information technology equipment safety.
- IEC60255-27 Measuring relays and protection equipment product safety requirement.

1.15.1.4 Mechanical Test – Transport (IEC60721-3-2 class 2M1)

- Vibration 5-9Hz displacement amplitude IEC60068-2-6 +/- 0.3mm (sinusoidal) 9-200Hz displacement amplitude 1m./sec sq.

  OR
- Shock response spectrum Type L IEC60068-2-27 40m/sec sq peak acceleration.

  OR
- Free fall height of fall IEC60068-2-32 0.25m.

1.15.1.5 ETS/EN

- **EN 60825-2:** Laser Safety.

1.16 Testing & Acceptance – FAT & SAT

1.16.1 Factory Acceptance Test (FAT)

Verify compliance of equipment with technical specifications before dispatch.

1.16.2 Site Acceptance Test (SAT)

Validate end-to-end performance after installation and integration.

1.16.3 Test plan Compliance

- All tests shall follow ITU-T, IETF RFC and TEC latest standards and amendments thereof.
- OEM shall provide list of tests to be done as per applicable standards, detailed test procedures and results. These tests i.e. FAT, SAT etc. will be conducted by IA.
- Implementing agency may add additional tests which are required to ensure the interoperability performance of the MPLS-TP equipment for Power system.

Section 2

TELECOMMUNICATIONS MANAGEMENT NETWORK

The Contractor shall provide a Telecommunications Management Network (TMN) System for operational support of the Equipment (MPLS-TP, Optical Amplifiers etc.) and associated subsystems. The contractor shall provide a centralized TMN System to monitor, configure and control all the Network Elements supplied under this Package. This TMN system shall assist the Employer in the overall management, operations and maintenance of the telecommunication resources including detection of degraded circuits and system performance, diagnosis of problems, implementation of remedial actions and the allocation or reallocation of telecommunications resources.

2.1 Applicable Standards

The TMN design concept, functional and informational architecture and physical architecture, shall be in compliance with ITU-T Recommendation M.3010.

2.2 TMN Architecture

1. The OEM/IA will propose TMN system in the Regional ISTS network such that all the management functions are available seamlessly across all the network elements (MPLS-TP, Optical Amplifiers etc.) supplied by the bidder under this package.
2. The TMN shall provide-
   a. Collection of Management data from all Network Elements (NEs) supplied under this package. The minimum monitoring and control requirements for the communication equipment as per this section.
   b. Processing of above management data by using a processor(s) located at Control Centres and additional intermediate station processors, wherever required.
   c. Invoking the TMN functions through local Workstations and remote workstations.
   d. IA may like to extend the environmental/ auxiliary alarm of associated devices at locations where FOTE are installed, if required. So necessary provision of Supervisory monitoring of following alarms will be available:

i. Intrusion Detection Alarms

ii. Power Failure

iii. Fire and Smoke Detection

iv. Environmental Control (Temperature, Humidity etc.)

e. Communication channel support as specified in this section.

f. The offered TMN system shall be capable of integration with Centralized Network Management System (UNMS) upwardly through standard North bound interface (NBI) protocol such as SNMP/CORBA/XML/REST etc. as per standards TMF814/TMF 864/RFC standard/XML etc. The interface shall support all functionalities such as NE Inventory, Hardware Inventory – Shelf/Slot/Card/SFP/Port, Topology, Protections, Alarms, Performance- real time & periodic, Performance KPI parameters (E-1, STM, Ethernet), Remote Configuration, Cross Connects, Trails & Circuits, Services Provisioning (NE), E-1, STM, Ethernet, TX & RX Trace, loop back and details are published in the NBI guide for the configuration parameters. Integration with U-NMS shall be in the scope of OEM. However, necessary support for integration of supplied NMS/TMN with U-NMS shall be provided by the U-NMS provider as required, which may be during implementation stage/AMC period.

OEM shall be obliged to provide/share all necessary documentations such as NBI Guide/MIB/IDL/WSDL/API files/ etc., to facilitate centralized supervision, centralized inventory management, centralized provisioning of bandwidth/services, availability computation, monitoring of events and alarm handling etc. of supplied TMN/NEs through UNMS.

The following support shall be provided by the OEM for integration of the supplied equipment with UNMS:

- Enabling & activating NBI license in their EMS/NMS and providing NBI login access along with User credentials
- Assist in verifying NBI Connectivity with UNMS vendor for the successful communication and retrieval of data.
- Assist in troubleshooting (if required) for NBI connectivity along with UNMS vendor for the communication and retrieval of data.

g. The supplied TMN system shall be capable of handling all management functions for at least

300% of the final network elements supplied under this package, also the TMN system shall be capable of handling the fully expanded equipment. If the bidder is upgrading existing TMN system, the upgraded TMN system shall be capable of handling all management functions of fully expended equipment for at least additional 300% of the final network elements supplied under this package. The cost of license to meet these requirements shall be included in the network element cost. The IA/ MPLS Vendor shall submit the TMN architecture describing in detail the following subsystems/features:

i. Database used in TMN.
ii. Server/workstation, LAN, Peripherals and hardware
iii. Software and operating system
iv. Local / Remote Operator Consoles
v. Craft Terminals
vi. Data communication between NEs, Remote/Local Consoles and TMN Processor(s)
vii. Routers/ Switches
viii. Expansion Capabilities
ix. Redundancy Provisions
x. Response time details
xi. Detail Breakup listing all Hardware components, Physical architecture, Software(s) and licenses included in the TMN
xii. Compliance with DoT condition w.r.t storage of logs & necessary provision for their Online as well as offline both storage

h. In case any of the proprietary interface, protocol, system architecture etc supplied with TMN/ NMS etc, the contractor shall have to provide full support including manpower resources, licenses, documents etc for integration of network with third party orchestrator or OSS, GIS, whenever required during project execution, DLP or AMC.

i. All licenses shall be supplied at least for 10 years from the date of Operational acceptance or be perpetual

j. The IA shall have support from the OEM for the security updates/patches for 10 years from

Operational Acceptance.

3. General Operational and Functional Requirements

a) The TMN system shall be multi-user system and based on Graphical User Interface.

b) It should be possible to have a view of selected sub-networks/rings controlled by the TMN system as per requirements. By zooming-in, it shall be possible to drill down to module-level in each NE for configuration and fault management. The same shall be provided through user-friendly GUI commands.

c) The TMN system shall provide the complete view of the network elements and the interconnecting links. The TMN system shall have the ability to include the network elements and the links in the visual/graphical map of the domain. The visual maps shall display the elements and the links in different colour depending upon the status of the links. For example, green colour for healthy and amber/yellow colour for degraded condition and red for unhealthy condition may be used.

d) It shall provide the ability to drill down to the individual element, then to subsystem, then to card and then to port level configuration template from the domain-map by clicking on the icon of the network element.

e) It shall be possible to generate customized reports for various types of faults, performance history, security management etc. It shall be possible to generate reports at various client levels to facilitate monitoring of performance statistics in a pre-defined/ customized format. It shall be possible to generate and define the formats at any time, based on network needs.

f) The TMN shall support correlation (filtering and suppression) to avoid multiple alarms from a single source of failure within the sub-network. Single Alarm shall be provided for the events that are correlated and are due to a common cause.

g) It shall be possible to execute any schedulable administrative command i.e. NE backup, software download, performance, operator log-in/ log-out etc., at any time by attaching a time tag to the command and it shall be executed when the Network real time matches the time tag. It shall be possible to define both time and date. If no date is mentioned, the command shall be executed daily at the time mentioned.

h) The response time for query/command on any operator terminal, local or remote shall be

indicated by the vendor. For update on topological information on the terminals, the response time shall be indicated by the vendor. The response time shall, however, be reviewed depending upon total NE load and topology by Employer during testing.

2.3 Management Functions

The TMN shall support and provide the following Management functions:

1. Configuration Management
2. Fault Management
3. Performance Management
4. Security Management
5. Inventory Management
6. Software Management
7. Network planning

The equipment shall support the generic requirement of fault, configuration and performance requirements as per clause 6.1 of ITU-T G.872. The equipment shall support the management aspect of the optical network as specified in ITU-T G.874 and G.874.1. The functions mentioned below shall be available across the entire network on a seamless end-to-end basis comprising of all the network elements (MPLS-TP Optical amplifiers etc.) being procured under this package.

MPLS-TP Equipment shall support/include features that facilitate network planning at UNMS level. IA shall specify the required features for network planning during detailed engineering/tendering of MPLS-TP network.

2.3.1 Configuration Management

Configuration management is concerned with management, display, configuration, provisioning and control of the network configuration and shall be implemented in accordance with ITU-T Rec. G.874. Minimum specific requirements that shall be satisfied include the following:

a) Provide tools to establish, maintain, update, delete and retrieve the topology and configuration information and provide graphical maps depicting the configurations. It shall be possible to inspect and configure all the appropriate parameters of the Network

Elements through the Graphical User Interface.

b) Gather descriptive information about the current configuration of the equipment, provide operator displays and prepare reports.

c) Provide tools for planning, establishing and changing the static equipment configuration. Provide for changes to the equipment configuration in response to equipment failures, planned upgrades and operator requests to take equipment offline for testing.

d) Provide verification testing to support new equipment installation.

e) Provide tools & support for configuring end to end and to configure protection for each of them individually.

2.3.2 Fault Management

Fault management is concerned with detecting, diagnosing, bypassing, directing service restoral and reporting on all the network equipment, systems and links and shall be implemented in accordance with latest and relevant ITU-T standards. Minimum specific requirements that shall be satisfied include the following:

a) Display equipment status in a consistent fashion regardless of the source of the data on a graphical topological, map-type display. Status shall be displayed through the use of colours on links and nodes as well as through text. Alarm notification shall include type, occurrence, severity, probable cause and clearing.

b) Obtain status and detect faults through periodic polling, processing of unsolicited alarms and error events and periodic testing for connectivity. Each failure and clearance shall be time-stamped.

c) Maintain an alarm summary of unacknowledged alarm events on the management station display and maintain a log of all received alarms. The operator shall be able to acknowledge and clear alarms individually and as a group. The use of alarm correlation techniques is required to minimize the proliferation of alarms caused by a single, common event.

d) Bypass failures through the use of automatic failover to redundant equipment where possible and through operator-initiated actions where automatic failover is not possible. The criteria for failover shall be configurable.

e) Retrieving functions with filtering capabilities for historical alarms and events shall be provided. Frame Check Sequence (FCS) errors for Ethernet clients shall be provided.

f) Assigning alarm severity i.e. Critical, Major, Minor & Deferred.

g) Provision to create a customised entity under fault management window to monitor alarms of specific set of customers, set of links, geographical area etc.

2.3.3 Performance Management

Performance management is concerned with evaluation of the use of network equipment's and their capability to meet performance objectives and shall be implemented in accordance with latest and relevant ITU-T standards. Performance monitoring shall conform to ITU-T Rec. M-2100, M-2101, M-2120, G.821, G.826, G.828, G.829 and RFC 2544. The equipment shall support / OTU-k related performance requirements specified in ITU-T G.8113, G.8113.2, G.709, G.8201 and G.7710. The minimum specific requirements that shall be satisfied include the following:

a) Provide support for an operator to initiate, collect and terminate performance metrics under both normal and degraded conditions. For example, The BER of each link, together with other data measured at each node, shall be available on operator request. A suitable user interface shall be provided for generating report. The details for report format shall be finalised during detailed engineering. It shall be possible to set the performance thresholds from 1x10-5 to 1x10-15 through the TMN/LCT in a continuous manner in the specified BER range as above.

b) Provide tools for measuring the uptime of link/ location/ circuit trail end to end.

c) Provide tools to calculate availability of communication system as per availability guidelines.

d) Provide end to end latency of Ethernet links at circuit level.

e) There shall be provision for both, near end performance monitoring and far end performance monitoring at lambda level and circuit level.

f) Monitor point to point & end to end signal quality and history at individual wavelength level. Provide operator controls to monitor performance of specified events, measures and resources. Specifically provide displays to permit the operator to:

i. A suitable user interface shall be provided for generating above reports. The details for report format shall be finalised during detailed engineering. Select/deselect network equipment, events and threshold parameters to monitor

ii. Set monitoring start time and duration or end time

iii. Set monitoring sampling frequency

iv. Set/change threshold values on selected performance parameters

v. Generate alarm events when thresholds are exceeded.

vi. Monitor optical parameters (signal levels) of all optical interfaces and generate alarms. Set multiple thresholds on certain performance parameters of electrical and optical signals. Alarm categories include as a minimum a warning and a failure.

vii. Calculate selected statistical data to measure performance on selected equipment based on both current and historical performance data maintained in performance logs. Performance data provided is limited to what is available from the equipment Contractors.

viii. Provide graphical displays of point to point and end to end current performance parameter values. Provide tabular displays of current, peak and average values for performance parameters.

ix. Generate reports on a daily, weekly, monthly and yearly basis containing system statistics

2.3.4 Security Management

The TMN system shall provide adequate security to the data and for the access to the system as per the following details:

1. The TMN shall be provided with security features to limit access to monitoring and control capabilities to only authorized personnel. The authorizations and the privileges of the operators (Remote and Local) shall depend upon the Login and Password.

    a. Low level protection for read only access to faults and performance information.

    b. Medium level protection for access to configuration status and features.

    c. High level protection for control of access to change in the configuration and control

parameters.

2. Network management security features shall include operator authentication, command, menu-restriction and operator privileges. The TMN shall support multi-level passwords as below-

    a. TMN shall allow the System Administrator to define the level of access to the network capabilities or feature for each assigned password. TMN shall block the access to the operator in case of unauthorized commands being tried for five consecutive times. TMN shall also not allow the entry into the system in case wrong password is provided more than five consecutive times during the login.

    b. The system administrator shall be able to monitor and log all operator activities in the TMN and Local Craft Terminal.

    c. The dynamic password facility shall be provided in which the operator may change his password at any time.

3. All log-in and log-out attempts shall be logged in the security log file of the TMN system.

4. The network and the management system shall be protected against intentional or accidental abuse, unauthorized access and loss of communication.

5. The man-machine communication programs shall have the facility of restricting the use of certain commands or procedures to certain passwords and terminals.

6. The LCTs shall normally operate through the centralized TMN. Only in the case of failure of link between the LCT location and the TMN, the LCT should be able to supervise/monitor the local assigned to it.

7. It should be mandatory for the system to have a record of all logins, operation and maintenance command logs which shall include the actual command given, who gave the command, when was it given with date and time and from where for a period of at least twelve months after which a backup should be possible under system administrator command.

8. It shall be possible to define multiple domains for purposes of monitoring and control. It shall also be possible to make domain based on the circuit(s) of a particular customer. Means shall be provided to ensure only one authorized operator has access to change in the

configuration and control parameters for a selected domain of the network.

9. The system shall be able to back up programmes and data and restore the same to and from external storage media (e.g. tape, CD etc.). Anti-virus packages, if required, shall also be provided.

10. The DCN network shall transmit all management data encrypted. Encryption shall be done by 128-bit encryption key.

TMN System shall comply with Cyber Security requirements on security & remote access. The IA/OEM shall ensure that the TMN shall comply with cyber security guidelines/regulations, other relevant guidelines/ standards and their amendments issued on a time-to-time basis by GOI/DoT/CEA/CERT-In.

2.3.5 Inventory Management

Under inventory management functionality, the following shall be supported:

a. It shall indicate complete view of the network elements and interconnecting links. It shall indicate absence or presence of any physical module in hardware elements. It shall also indicate the usage of module i.e. how many ports are in use, which interface is in use and which are free to be used etc.

b. TMN shall be able to discover and keep the device information.

c. The inventory information shall be provided to Network Management Layer (NML) / Service Management Layer (SML) so that SML is able to create and activate a service to the customer automatically. This shall also assist SML in providing the network inventory to which SML shall add the customer identification and maintain this information in the database.

d. Generate report based on query e.g. module type, network element location etc. A suitable user interface shall be provided for generating report. The details for report format shall be finalised during detailed engineering.

2.3.6 Software Management

It shall be possible to carry out the following tasks under the software management function:

a. Loading of new system software.

b. Manage different versions of software.

c. Shall have the capability of managing multiple versions of software for individual elements. In this case, one software version should remain active and other versions should be passive.

d. Installation of software patches.

e. Examine contents of all system memory and disk memory.

f. At the time of downloading the software, the message shall be displayed that the software has been downloaded successfully or failed and at what stage.

g. The operator terminals (local & remote) shall not allow loading of any software without the terminal administrator's authorization.

h. It shall support FTP/TFTP for downloading of Software, configuration, patches etc. to the Network Element.

i. It shall enable operations like changing the system configuration, reconfiguration of input and output devices, loading a new software package, etc. Both automatic and manual reconfiguration capabilities should be available.

j. All commands which are executed over the TMN program or data shall be logged in a file (read only) and it shall be possible to retrieve the same on demand whenever required using Man-Machine Commands. The file usage of up to 50%, 75% and 90% shall generate alerts in the server platform, of suitable category prompting the operator to initiate the backup operation.

k. It shall be possible through a single Man-Machine Command to obtain a list and the total number of equipment of a particular domain in a state (e.g. in-service, blocked etc.).

l. While working on system level commands, it shall be possible to log recent user operations and display the same through the GUI.

2.4 Data/ Communication Channel Requirement and Integration

The OEM shall provide Communication channel requirements as a part of TMN system and/or as part of network element supply. The OEM shall provide all required Equipment, interface

cards / devices, LAN, routers/ bridges, channel routing, cabling, wiring etc. and interfacing required for TMN data transport for all the supplied equipment and transport of data shall be in protected configuration.

The data transport network shall be designed with full protected configuration and with 100% hardware redundancy. The Data Communication Network shall be designed to ensure proper and effective use of encryption techniques/devices to protect confidentiality, authenticity and/integrity of information in line with DoT guidelines.

The OEM/IA shall describe in the proposal the TMN data transport proposed to be used by the bidder in detail including capacity requirements and various components/equipment proposed to be used. The OEM/IA shall also indicate the response times envisaged.

2.5 Craft Terminal

Each node on the network shall include provision for connecting a Local Craft Terminal, i.e. a portable (laptop) of any reputed make to support local commissioning and maintenance activities. It shall also be possible to perform maintenance activities on remote stations. Through the use of this Local Craft terminal, the operator shall be able to:

a. Change the configuration of the station

b. Perform tests

c. Get detailed fault information

d. Download configuration data, software upgrades

e. Upload alarm data and other system related data from the network element

f. Monitor performance parameter of optical ports.

The laptop computer shall be connected to an Ethernet interface, USB etc. available at network element. Laptop computers, each complete with necessary system & application software to support the functions listed below, shall be supplied.

i. There shall be a provision at each network element for connecting to a Local Craft Terminal (LCT). This feature shall be available for all network element equipment proposed by the Bidder. The Local Craft Terminal shall be connected through Ethernet interface, USB etc.

ii. The Local Craft Terminal software shall be executable on a laptop PC equipped with latest supported Microsoft Windows or Linux (or its variant) operating systems.

iii. It shall be possible, once connected to one Network Element, to access other network elements by way of addressing.

iv. The Local Craft Terminal shall provide Graphical User Interfaces that enables the user to interact with the embedded software in the network element in such a way that the user can:

   a. Inspect all data residing in the network element, being registers, files or database elements.

   b. Set all the appropriate data elements, as appropriate, within the network element.

v. The OEM shall state if there are any functionalities (or registers, files, or database elements) for which the Graphical User Interface of the Local Craft terminal cannot be used and the means by which such functionalities are then reached.

2.6 Redundancy Requirements

TMN system hardware shall be so designed that failure of a component shall not inhibit any of the functionality of the TMN Server of the control centres.

2.7 Hardware Requirements

2.7.1 Server, Workstation and Craft Terminal

The TMN hardware should be based on either UNIX/LINUX/SOLARIS or the latest supported windows server platform with Sun/HP/Siemens/IBM/DELL or any other equivalent make Servers and Workstations. The software should be user friendly. The sizing of the server/processor, RAM, number & type of interfaces, RAID/HDD etc. shall commensurate with the network size, number of con-current users, response time etc. The bidder shall provide details of hardware, software and server sizing calculations along with the bid. Servers and workstations shall have the necessary Disk drives for data backup and restoration. Servers along with associated hardware shall be rack mounted.

a) Workstation CPU enclosures shall be desktop type (Preferably All-in-one PC suitable for 24x7 NOC operations) and shall include available expansion slots except for the Craft Terminal which shall be a laptop. All the VDUs including that of server and

Workstations shall be not less than 23.8" Full HD colour LED panels. The minimum requirement for Desktop PC/ Terminal shall be as follows:

- Intel 14th Generation Core-i7 processor or higher
- Licensed MS Window with Anti-Virus provisioning
- 16GB DDR5 2333 MHz SDRAM or higher
- 512 GB SSD
- Min 23.8-inch Full HD LED monitor
- Ethernet 10/100 adapter with RJ-45 connector

b) Craft Terminal (Hardware & Software) shall be supplied along with associated items like cable, connectors, licensed software etc. The Craft Terminal (hardware) shall be a professional grade device from a prominent Laptop/ Computer manufacturer and shall be supplied along with latest licensed operating system (OS). The minimum requirement of each Craft Terminal shall be as follows:

- Intel 14th Generation Core-i7 processor or latest version
- Licensed MS Window with Anti-Virus provisioning
- 16GB DDR5 2333 MHz SDRAM or higher
- 512 GB SSD
- 14-inch or above (as specified by IA) Full HD LED (or Higher resolution)
- Ethernet 10/100 adapter with RJ-45 connector
- Minimum 6 hours Battery Life

2.7.2 Local / Remote Operator Consoles

The Contractor shall provide operator consoles sized and equipped to support the subsystem(s) furnished and in compliance with the specification. The console shall provide hardware interfacing for the TMN users to the software operating support systems. At a minimum, a console shall include a workstation and suitable interfaces to the TMN as stated above.

2.7.3 Power Supplies

The TMN system shall use 230-volt 50 Hz AC or -48volt DC for its operation.

2.8 General Software/ Firmware Requirements

Due to various alternative design approaches, it is neither intended nor possible to specify all software and firmware characteristics. It is the intent herein to provide design boundaries and guidelines that help to ensure a demonstrated, integrated program package that is maintainable and meets both hardware systems requirements and the customer's operational requirements.

The OEM/IA shall provide software upgrades and patches if any for the proposed TMN. The OEM/IA shall also provide detailed procedure to execute the upgrades.

2.8.1 Operating System Software

Operating system software shall be provided to control the execution of system programs, application programs, management devices, to allocate system resources and manage communications among the system processors. The Contractor shall make no modifications to the OEM's operating system, except as provided as USER installation parameters.

2.8.2 Applications Software

All applications software shall be written in a high-level programming language unless developed using industry proven application programs and development tools provided with the system. The Contractor shall make no modifications to the applications program except as provided as USER development tools.

2.8.3 Software Utilities

A utility shall be provided to convert all reports into standard PC application formats i.e. dbase, dxf, excel, ascii etc. as applicable.

2.8.4 Revisions, Upgrades, Maintainability

Software revisions, upgrades and maintainability is specified as follows:

2.8.4.1 Versions

All firmware and software delivered under this specification shall be the latest field proven.

2.8.4.2 Program Rewrites

All firmware provided shall support its fully equipped intended functional requirements without additional rewrite or programming.

2.8.4.3 Maintainability

Contractor shall supply a copy of installation version of software(s) including final database in External SSD Drive, if requested by Employer.

2.8.4.4 Standards Compliance

Software provided shall be compliant with national and international industry standards such as IEEE, ISO and OSF.

2.8.5 Database(s)

The IA shall develop all the databases for final wideband network following the global acronyms for all stations. Database(s) shall comply with the following:

2.8.5.1 Structure and Inclusions

A database shall be provided that contains all structure definitions and data for the integrated functional requirements of TMN system.

TMN operator Groups shall share the same virtual database. This means that they shall share the same database and database manager, whether or not physically separate databases are maintained.

2.8.5.2 Data Retention

Data retention shall be as per CEA Technical Standards for Communication System In Power System Operation, 2020.

User shall keep evidence of compliance on availability for the previous two calendar years plus the current year for all the interfaces which are in operation.

Historical data of ninety days shall be kept.

2.9 Help

All applications shall be supported by USER accessible HELP commands that shall assist the USER in the performance of its tasks. HELP commands for an application shall be available to the USER from within the active application and shall not interfere with the activities of the application.

Note: Implementing Agency may add necessary requirements to the above-mentioned Specifications during detail engineering as per network configuration and Site conditions.

Abbreviations:

1-PPS	One Pulse Per Second
ABI	Application Binary Interface
ACL	Access Control List
AES-128 CMAC	Advanced Encryption Standard 128-bit Cipher-based Message Authentication Code
AES-256 GCM	Advanced Encryption Standard 256-bit Galois/Counter Mode
AGC	Automatic Generation Control
AMC	Annual Maintenance Contract
AMR	Automatic Meter Reading
API	Application Programming Interface
APS	Automatic Protection Switching
BER	Bit Error Rate
BFD	Bidirectional Forwarding Detection
BOQ	Bill of Quantities
BPDU	Bridge Protocol Data Unit
BSC	Broadcast Storm Control
CBS	Committed Burst Size
CC	Continuity Check
CD	Compact Disc
CE	Carrier Ethernet
CEA	Central Electricity Authority
CEN	Carrier Ethernet Network
CERC	Central Electricity Regulatory Commission
CERT-In	Computer Emergency Response Team - India
CESoP	Circuit Emulation Service over Packet
CESoPSN	Circuit Emulation Service over Packet Switched Network
CFM	Connectivity Fault Management
CIR	Committed Information Rate
CORBA	Common Object Request Broker Architecture
CoS	Class of Service
CPU	Central Processing Unit
CTU	Central Transmission Utility
CV	Continuity Verification
DA	Destination Address
DC	Direct Current
DCDB(PDP)	DC Distribution Board (Power Distribution Panel)
DCN	Data Communication Network
DDR5	Double Data Rate 5
DEI	Drop Eligible Indicator
dLDI	Defect Loss of Defect Indication
dLOCV	Defect Loss of Continuity Verification
DLP	Data Loss Prevention
DM	Delay Measurement
DoT	Department of Telecommunications
DSCP	Differentiated Services Code Point

DWSM	Dry Water-Blocked Single Mode
EBS	Excess Burst Size
EFP	Ethernet Flow Point
EIR	Excess Information Rate
E-LAN	Ethernet- Local Area Network
E-LMI	Ethernet Local Management Interface
EMS	Element Management System
EN	European Norm
ENNI	External Network-to-Network Interface
EOL	End of Life
ESMC	Ethernet Synchronization Messaging Channel
ETSI	European Telecommunications Standards Institute
EXP bit	Experimental Bits
FAT	Factory Acceptance Test
FCS	Frame Check Sequence
FOTE	Fibre Optic Terminal Equipment
FTP	File Transfer Protocol
FXO	Foreign Exchange Office
FXS	Foreign Exchange Subscriber
GAL/G-ACH	Generic Associated Channel
GbE	Gigabit Ethernet
GENCO	Generating Company
GOI	Government of India
GPS	Global Positioning System
GR	Generic Requirements
HQoS	Hierarchical Quality of Service
IA	Implementing Agency
ICCP	Inter-Control Center Communications Protocol
ICS	Interface Compliance Statement
IDL	Interface Definition Language
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IOT	Internet of Things
IPP	Independent Power Producer
IS	Indian Standard
ISGS	Inter-State Generating Station
ISO	International Organization for Standardization
ISTS	Inter-State Transmission System
IT	Information Technology
ITU-T	International Telecommunication Union - Telecommunication Standardization Sector
L2VPN	Layer 2 Virtual Private Network
LACP	Link Aggregation Control Protocol
LAG	Link Aggregation Group

LAN	Local Area Network
LCT	Local Craft Terminal
LED	Light Emitting Diode
LM	Loss Measurement
LSP	Label Switched Path
MAC	Media Access Control
MAC FIB	Media Access Control Forwarding Information Base
MACsec	Media Access Control Security
MCB	Miniature Circuit Breaker
MEF	Metro Ethernet Forum
MEF CE	Metro Ethernet Forum Carrier Ethernet
MEP	Maintenance End Point
MIB	Management Information Base
MIP	Maintenance Intermediate Point
MPLS-TP	Multiprotocol Label Switching – Transport Profile
MSP	Multiplex Section Protection
MTCTE	Mandatory Testing and Certification of Telecom Equipment
NavIC	Navigation with Indian Constellation
NBI	North Bound Interface
NE	Network element
NML	Network Management Layer
NMS	Network Management System
NNI	Network-to-Network Interface
NOC	Network Operations Center
NTP	Network Time Protocol
OAM	Operations, Administration and Maintenance
OEM	Original Equipment Manufacturer
OOB	Out-of-Band Management
OSS	Operations Support System
P2P	Point-to-Point
PBS	Peak Burst Size
PC	Personal Computer
PCP bit	Priority Code Point bit
PDC	Phasor Data Concentrator
PE/P	Provider Edge / Provider Router
PHB	Per-Hop Behavior
PIR	Peak Information Rate
PMU	Phasor Measurement Unit
PW	Pseudo Wire
PWE	Pseudo Wire Emulation
Q-in-Q	Queuing in Queuing
QoS	Quality of Service
RADIUS	Remote Authentication Dial-In User Service
RAID/HDD	Redundant Array of Independent Disks/ Hard Disk Drive
RAM	Random Access Memory
RBAC	Role-Based Access Control

RE	Renewable Energy
REST	Representational State Transfer
RFC	Request for Comments
RLDC	Regional Load Dispatch Center
RPC	Regional Power Committee
RS232	Recommended Standard 232
SAS	Substation Automation System
SAT	Site Acceptance Test
SAToP	Structure-Agnostic Time Division over Packet
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy
SDRAM	Synchronous Dynamic Random-Access Memory
SFP	Small Form-factor Pluggable
SFTP	Secure File Transfer Protocol
SI	System Integrator
SIP	Session Initiation Protocol
SML	Service Management Layer
SNCP	Subnetwork Connection Protection
SNMP	Simple Network Management Protocol
SONET	Synchronous Optical Network
SPQ	Strict Priority Queuing
SSD	Solid State Drive
SSH	Secure Shell
STM	Synchronous Transport Module
STU	State Transmission Utility
SVLAN	Service Virtual LAN
TACACS	Terminal Access Controller Access-Control System
TCP-IP	Transmission Control Protocol / Internet Protocol
TDM	Time Division Multiplexing
TEC	Telecommunication Engineering Centre
TFTP	Trivial File Transfer Protocol
TMF	TeleManagement Forum
TMN	Telecommunication Management Network
ToD	Time of Day
ToS	Type of Service
TSP	Transmission Service Provider
TX/RX	Transmit/Receive
UNI	User Network Interface
UNMS	Unified Network Management System
USB	Universal Serial Bus
VDU	Visual Display Unit
VID	VLAN Identifier
VLAN	Virtual Local Area Network
VoIP	Voice Over Internet Protocol
VPLS	Virtual Private Local Area Network Service
VPN	Virtual Private Network

VPWS	Virtual Private Wire Service
WAN	Wide Area Network
WFQ	Weighted Fair Queuing
WRED	Weighted Random Early Detection
WRR	Weighted Round Robin
WSDL	Web Services Description Language
XFP	10 Gigabit Small Form-factor Pluggable
XML	Extensible Markup Language

सत्यमेव जयते

Annexure-V_18th NPC

Report of the Committee on Guidelines/ Procedure for Implementation of TWFL Technology





केविप्रा
cea

GOVERNMENT OF INDIA
MINISTRY OF POWER
CENTRAL ELECTRICITY AUTHORITY

September 2026

Index

1. Introduction 1

1.1 Background 1

1.2 Committee Constitution 1

1.3 Proceedings of the Committee 2

2. Take-away from NRPC Sub-Group Committee Report 4

3. Details of On-line TWFL Technology 6

3.1 Technical Details of On-line TWFL Technologies 6

3.2 Single ended TWFL Technology 6

3.3 Double ended TWFL Technology 7

3.4 System Architecture and Components of On-line TWFL Technology 8

3.5 Indigenous Availability of the Technology 9

4. Details of Off-line TWFL Technology 10

4.1 Technical Details of Off-line TWFL Technology 10

4.2 Indigenous Availability of the Technology 13

5. Comparative Assessment of On-line and Off-line TWFL Technology 14

5.1 Details of TWFL Technologies 14

5.2 Indigenous Availability of TWFL 16

5.3 Indicative Per Unit Cost of TWFL 18

5.4 Details of the Utilities where TWFL has been deployed 18

5.5 Effectiveness of the TWFL Product (based on feedback from respective customers) 19

5.6 Limitation of the TWFL Products 20

5.7 Applicability and Effectiveness on Long HVDC Transmission Lines 21

5.8 Effectiveness on Mixed Overhead and Underground Cable Configurations 22

5.9 TWFL Products Ability to Use Existing Substation GPS 23

5.10 Space, Power Supply, and Other Requirements for Substation Deployment 23

5.11 Consistency of Measurements 25

5.12 Effect of improper grounding or incorrect equipment connection during actual usage 25

5.13 Normal expected life span of the TWFL product 26

5.14 Integration of Different-Make Relays 26

5.15 Future developmental efforts w.r.t. Integrating the TWFL product with the Protection Relays 27

5.16 Effectiveness of On-line/ Off-line TWFL technologies for subsea cables 28

6. Guidelines/ Recommendations for TWFL Technology 29

6.1 Guidelines for Mandatorily Providing Off-line TWFL Devices 30

6.2 Guidelines for Mandatorily Providing On-line TWFL Devices: 30

6.3 General Guidelines to be followed for TWFL 30

List of Annexures

Annexure-I	:	Office Order on Constitution of Committee to Prepare Guidelines/Procedure for implementation of TWFL Technology
Annexure-II	:	Minutes of the First Meeting of the Committee to Prepare Guidelines/ Procedure for Implementation of TWFL Technology
Annexure-III	:	Minutes of the Second Meeting of the Committee to Prepare Guidelines/ Procedure for Implementation of TWFL Technology

List of Tables

Table 1: Comparison of Single-Ended vs. Double-Ended On-line TWFL configurations.....8
Table 2: OEMs offering On-line TWFL products available in the Indian market 9
Table 3: OEMs offering Off-line TWFL products in the Indian market 13
Table 4: Comprehensive comparison of TWFL technologies across OEMs 15
Table 5: Comprehensive comparison of Off-line and On-line TWFL technologies.....16
Table 6: Indigenous availability assessment of TWFL products 17
Table 7: Indicative per unit cost of TWFL products 18
Table 8: GE Vernova TWFL deployed Lines.....18
Table 9: GPS and time synchronization requirements by OEM and technology type.....23
Table 10: Expected lifespan and maintenance requirements for TWFL products 26

List of Abbreviations

ADC	:	Analog-to-Digital Converter
AI	:	Artificial Intelligence
AMC	:	Annual Maintenance Contracts
CEA	:	Central Electricity Authority
CTUIL	:	Central Transmission Utility of India Limited
EHV	:	Extra High Voltage
HVAC	:	High Voltage Alternating Current
HVDC	:	High Voltage Direct Current
ISTS	:	Inter-State Transmission System
MSETCL	:	Maharashtra State Electricity Transmission Company Limited
NER	:	North Eastern Region
NERPC	:	North Eastern Regional Power Committee
NRLDC	:	Northern Regional Load Dispatch Centre
NRPC	:	Northern Regional Power Committee
NPC	:	National Power Committee
OEM	:	Original Equipment Manufacturer
OPGW	:	Optical Ground Wire
PGCIL	:	Power Grid Corporation of India Limited
PSE&TD	:	Power Systems Engineering & Technology Division
SCADA	:	Supervisory Control and Data Acquisition
SOTF	:	Switch-On-To-Fault
TDR	:	Time Domain Reflectometry
ToR	:	Terms of Reference
TW	:	Travelling Waves
TWFL	:	Travelling Wave Fault Locator
UHV	:	Ultra High Voltage
UPS		Uninterruptible Power Supply

1. Introduction

1.1 Background

Reliable and fast identification of faults on transmission lines is essential for maintaining the security and reliability of the Power System and for reducing the time required for restoration of supply. At present, transmission line faults are primarily detected and located through conventional impedance-based distance protection systems. These systems estimate the apparent impedance between the relay location and the fault point and determine the fault location based on the measured electrical quantities. The accuracy of impedance-based fault location is influenced by the electrical characteristics of the fault and the transmission system. In particular, fault resistance and the associated changes in the electrical parameters of the line and fault path can affect the apparent impedance seen by the relay. Changes in the condition of line insulation, including deterioration of insulators, may also alter the electrical characteristics of the fault path and consequently affect the measured R, L and C parameters. Such variations may result in errors in fault-location estimation and may affect the performance of conventional impedance-based protection, particularly in cases involving high-resistance or developing faults. These limitations of impedance-based fault-location methods highlight the need for a more accurate and faster fault-location approach, for which Travelling Wave Fault Locator (TWFL) technology offers a significant technical advantage.

Travelling Wave Fault Locator (TWFL) technology are mainly of two types i.e. On-line TWFL and Off-line TWFL. These TWFL technologies follow a different principle for locating faults in comparison to conventional Impedance based Relay. On-line TWFL identifies and locates the fault by detecting the travelling-waves associated with high-frequency electro-magnetic transients that get generated during fault on the line. By analyzing the arrival time of travelling waves and their reflections, the location of the fault is calculated. In case of Off-line TWFL, a pulse is sent into the into de-energized lines and the time taken by reflected wave is measured to compute the distance of fault location. Thus, the method of TWFL technologies is based primarily on the propagation characteristics and time-domain behavior of the travelling wave rather than on the impedance measured at the relay location. The TWFL principle provides an important technical advantage for accurate fault location, particularly where the apparent impedance may be affected by fault or system conditions. Accordingly, TWFL can provide more accurate and rapid fault-location information and is less dependent on factors such as fault resistance and variations in apparent impedance, making it a technically superior approach to conventional impedance-based fault-location methods. Its application can improve the accuracy and speed of fault location, assist in faster restoration of transmission lines and provide additional information regarding developing or abnormal line conditions. In view of these advantages, it becomes pertinent to examine the suitability of TWFL for deployment on critical transmission lines for improving the overall reliability and operational efficiency of the transmission system.

1.2 Committee Constitution

In the 17th National Power Committee (NPC) meeting held on 27.02.2026 at Vizag, Andhra Pradesh, NRPC Sub-Group's Report on Implementation of TWFL was discusses, wherein it was decided that the matter merits bringing out a uniform National Policy Framework for TWFL,

and accordingly the matter was referred to PSE&TD Division of CEA to prepare suitable Guidelines/Procedure for implementation of TWFL on critical transmission lines at 220 kV and above, and at 132 kV and above in the North-Eastern Region.

In this context, to examine and prepare Guidelines/ Procedure for implementation of TWFL Technology, a Committee was constituted vide CEA letter dated 13.05.2026 (**Annexure-I**). The details of the Committee Members are given as under:

1	Sh. N.R.L.K. Prasad, Chief Engineer (PSE&TD Division), CEA	Chairperson
2	Sh. Om Kishor, EE, NRPC	Member
3	Sh. V. Muncha, Director, NERPC	Member
4	Sh. P. P. Chand, DGM, GRID INDIA Sh. Deepak Kumar, Dy. Manager, GRID INDIA	Member
5	Sh. Anurag, GM , Engg-SS, PGCIL	Member
6	Sh. Manoj Joshi, Superintending Engineer (ACI&P), MSETCL	Member
7	Sh. Pankaj Kumar Verma, Dy. Director (PSE&TD Division), CEA	Member Convener

The Terms of Reference (ToR) of the Committee are as under:

(a) To explore various On-line and Off-line fault locator technologies including TWFL.
(b) To assess the indigenous availability of the various Fault Locator Technologies.
(c) Cost comparison of various Fault Locator Technologies of Fault Locator.
(d) To prepare Guidelines/Procedure for implementation of Fault Locator Technologies on critical Transmission Lines for 220 kV and above (132 kV and above for NER) voltage levels.
(e) Any other relevant issues.

1.3 Proceedings of the Committee

The Committee conducted two meeting to deliberate on the matter. The first meeting was held on 25.05.2026. Owing to the evolving nature of the subject matter, the Committee invited various OEM's in the TWFL field for gaining valuable insights. In the meeting, TWFL technologies available with OEMs {M/s GE Vernova, M/s Taurus MK Srinivasan Systems Pvt. Ltd. [mentioned as Taurus-MKS in ensuing sections] and M/s Megger (India) Pvt Ltd [mentioned as Megger in ensuing sections]} including their technical features (On-line TWFL Technology vs Off-line TWFL Technology), indigenous availability, manufacturing capacity, cost, field experience and effectiveness were discussed. The integration of TWFL with the existing protection systems and other relevant technical issues were also discussed. NRPC Committee Report on TWFL implementation was also discussed in the meeting. The minutes of the first meeting are enclosed at **Annexure-II.**

Following the first meeting, technical and operational queries were formulated and forwarded to the OEMs, and the responses received regarding On-line and Off-line TWFL technologies were compiled and circulated to the Committee members. The second meeting was convened on 27.08.2026 to examine the responses received from the OEMs, deliberate on the deployment of TWFL technology (On-line/Off-line), and discuss the criteria for identification of critical transmission lines for deployment of TWFL. The minutes of the second meeting are enclosed at **Annexure-III**.

Based on the deliberations held, and all relevant information made available, the Report has been structured to address the following aspects:

- Takeaway from NRPC Sub-Group Committee Report on TWFL
- Details of On-line TWFL Technology
- Details of Off-line TWFL Technology
- Comparative Assessment of On-line and Off-line TWFL Technology
- Guidelines/Recommendations for TWFL Technology

Ensuing sections discuss the above in sufficient detail.

2. Take-away from NRPC Sub-Group Committee Report

(a) Brief Background

Based on a proposal of PGCIL placed before the 80th NRPC meeting for deployment of TWFL on critical transmission lines, NRPC constituted a Sub-Group comprising representatives from CEA, CTUIL, NRLDC and other stakeholders to assess the technology and identify critical transmission lines warranting TWFL installation. The Sub-Group examined the matter through detailed deliberations involving the concerned transmission and system operation stakeholders, including assessment of the technical features and field performance of TWFL. A physical visit was also undertaken to the 765/400 kV Meerut Substation on 19.09.2025 by a team comprising members from CEA, NRLDC, CTU and NRPC Secretariat to understand the functioning of TWFL and evaluate the benefits of its installation. However, it may be mentioned that the Sub-Group primarily focused on regional requirements and did not cover lower voltage levels, particularly 132 kV lines relevant to the North-Eastern Region.

(b) Operational and System Level Benefits

NRPC Sub-Group observed significant technical and operational advantages of TWFL in providing accurate fault-location information and reducing the time required for fault identification and restoration. Report mentioned that TWFL systems consistently achieve fault location accuracy within ±100–500 meters, even on long transmission lines exceeding 300 km, mixed overhead–underground lines, and lines with series compensation or shunt reactors. The technology can reduce the area and time required for physical patrolling and thereby support faster restoration of critical transmission lines. The deployment of TWFL therefore provides tangible operational benefits, including significant reduction in outage duration, improved system availability, enhanced reliability indices and reduced manual patrolling effort. Faster restoration directly contributes to grid security, particularly for lines evacuating renewable and nuclear power, where prolonged outages can lead to generation backing down and grid instability.

(c) Deliberations and Analysis

The field observations also provided a comparison with the fault-location indications obtained from conventional Main-1/Main-2 distance relays and those obtained from TWFL. In a number of cases, the conventional distance relay indications showed deviations of several kilometers from the actual fault location, with mismatches of approximately 6–20 km reported in some instances. Such deviations can result in a larger section of the transmission line having to be patrolled before the fault is identified and rectified. The Sub-Group therefore observed that more precise fault-location information can contribute to reduction in restoration time, particularly in the case of long transmission lines and lines located in difficult terrain. NRPC Report further explained that conventional distance relays are impedance-based and their fault-location indication depends on line impedance parameters and system conditions. In contrast, TWFL determines the fault location by detecting the arrival times of travelling waves at the line terminals and is inherently independent of line impedance parameters, fault resistance and power-flow conditions.

(d) Availability and Operational Cost

The NRPC report mentions that On-line TWFL devices manufactured by GE and Qualitrol are currently available in the Indian market. In addition, TWFL devices manufactured by SEL and Kehui are also available globally. Also, as per the report, the indicative cost of TWFL systems, including supply, installation, testing and commissioning, ranges approximately from ₹18 lakh for a single-line module to ₹100 lakh for an eight-line module. The actual cost may vary depending upon the number of transmission lines covered, system configuration and site-specific requirements. It is noted that NRPC report focused on On-line TWFL technology and does not mention about Off-line TWFL technology.

(e) Recommendation

The Sub-Group considered long lines, hilly-terrain lines, renewable and nuclear evacuation lines, and other operationally important corridors as suitable for priority consideration. It recommended a phased approach for implementation of TWFL, rather than immediate deployment on all transmission lines. Such an approach would enable the technology to be initially implemented on lines having higher operational criticality and greater restoration challenges, followed by wider deployment based on field experience, performance assessment and operational requirements.

Accordingly, For the first phase, the recommended criteria included:

(i) 220 kV, 400 kV and 765 kV transmission lines longer than 200 km;
(ii) 220 kV, 400 kV and 765 kV transmission lines used for evacuation of renewable and nuclear power having length more than 150 km;
(iii) 220 kV and above transmission lines located in hilly terrain; and
(iv) Inter-regional 220 kV and above transmission lines having length more than 150 km.

Based on the overall assessment, the Sub-Group highlighted the need for formulation of a national-level policy and detailed implementation guidelines for systematic deployment of TWFL Technology.

3. Details of On-line TWFL Technology

3.1 Technical Details of On-line TWFL Technologies

On-line Travelling Wave Fault Locator (TWFL) technology operates on the principle that a fault on a transmission line causes an abrupt collapse of voltage and surge in current, generating high-frequency electromagnetic transients known as "travelling waves." These waves propagate along the transmission line simultaneously in both directions from the point of fault, at velocities approaching the speed of light (approximately 3 x 10^5 km/s for overhead lines). The frequency content of these waves lies in the range of approximately 100 kHz to 500 kHz.

An On-line TWFL system continuously monitors the transmission line for such high-frequency transients during normal energized operation. When a fault occurs, the system at each end of the line records the precise GPS-synchronized timestamp at which the travelling wave front arrives. Using these two timestamps and the known total line length, the fault location is computed automatically without any manual intervention. A typical schematic of On-line Travelling Wave Fault Locator is shown in **Figure-1**.

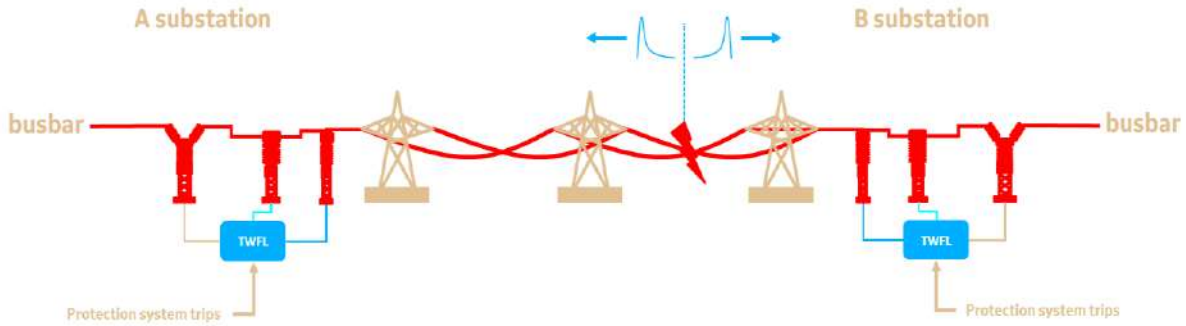


Figure 1: Typical schematic of On-line Travelling Wave Fault Locator

TWFL solution consists of the high-speed travelling-wave acquisition units, time-synchronization equipment, Central processing unit, communication interface and DR Manager software. The System is stated to provide typical fault location accuracy of less than 150 meters with automatic fault location capability and SCADA integration support.

There are two types of technologies exists in On-line TWFL. These area as follows.

1. Single ended TWFL technology
2. Double ended TWFL technology

3.2 Single ended TWFL Technology

In case of Single ended TWFL, the setup is installed only at one end. On the occurrence of a fault, TW travel in both the direction. The system uses the travelling wave received directly from the fault (TW reaching directly to the Setup) and reflections of TW from the remote end of the line (Other end Substation). Based on the timing of reaching of direct TW, reflected TW and length of the line, the distance of fault location is measured.

The principal advantage of single ended TWFL technology is that equipment is required only at one terminal. However, since the technology rely on the detection of the direct pulse and the reflected pulse from other end Substation, the reflected pulse gets attenuated and therefore, depending on the type of fault and the distance from the measurement point the accuracy of fault detection varies. The accuracy is generally lower than that of a double-ended system because the calculation relies on identification of reflected waves, which may become difficult under certain line and network conditions. Further, since single ended TWFL relies on the reflected pulses, therefore, depending on where the fault happened, it might have a superposition of the direct pulse and the reflected pulse, which leads to almost impossible to locate the fault. Further, non-linear lines (Hybrid lines or Railways) will have multiple reflections not related to the fault which invalidates its method for such conditions.

3.3 Double ended TWFL Technology

Double ended TWFL relies only on the arrival of the direct pulse generated by the event in each Substation end. In case of the Double ended TWFL, complete setup consisting of a central processing unit, acquisition unit, GPS receiver and DR Manager software is installed at both ends of the transmission line. The acquisition units capture high-frequency signals, while the GPS provides accurate time synchronization. Communication between the two Substations through an Ethernet link is necessary for exchange of travelling wave records required for double-ended fault calculation. A typical schematic diagram of Double ended TWFL technology is shown in **Figure-2**.

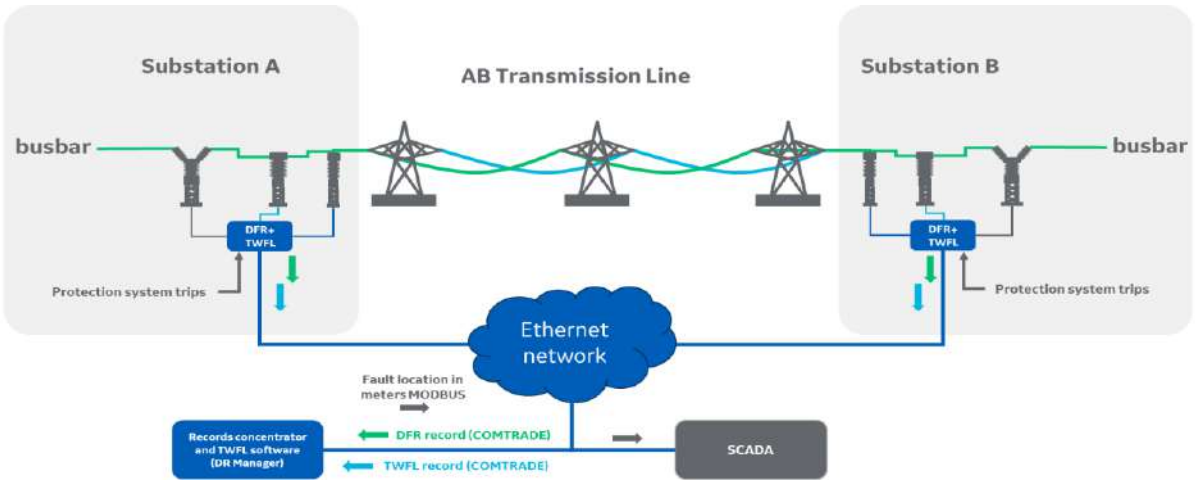


Figure 2: Typical schematic diagram of Double ended TWFL technology

The distance to fault can be calculated by following formula.

$$X_{\mathrm{Distance\,to\,fault}} = \frac{\mathrm{l+k\cdot c\cdot (ta-tb)}}{2}$$

Where $l-linelength$
$c-lightspeed$
$k-velocityfactor$

$ta–wavehead\ timestamp\ T_a$
$tb–wavehead\ timestamp\ T_b$

Simpler and more accurate algorithms can be applied using Double ended TWFL since the direct pulse is easier to identify than the reflected pulse. Some of the advantage of Double ended TWFL are as follows:

a) Double Ended TWFL is suitable for all type of applications.
b) Switch-On-To-Fault (SOTF) can only be located for all occasions by Double Ended Method.
c) Each mixed section generates (Over Head and Underground) a non-linearity in the line and reflections. In such case only Double ended TWFL is suitable.
d) Reflections can travel through all segments making it hard to automatically locate the fault with Single Ended.
e) Since Auto-Transformers impact generating reflections. Therefore, Double ended TWFL is more suitable technology.

A Comparison of Single-Ended vs. Double-Ended On-line TWFL configurations has been shown in **Table 1**.

Aspect	Single-Ended	Double-Ended (Preferred)
Equipment Location	One end only	Both ends of the line
Accuracy	Lower; depends on reflected pulse quality	Higher; relies on direct pulses only
GPS Synchronization	Not required	Mandatory (nanosecond precision, IRIG-B)
Communication	Not required	Required between both ends
Limitations	Reflected pulses may be attenuated on long/mixed lines; unreliable for short lines and T-connections	Requires dedicated communication; OPGW path may be affected during fault
Preferred Application	Basic / backup configuration	EHV/UHV systems; all critical applications

Table 1: Comparison of Single-Ended vs. Double-Ended On-line TWFL configurations

It is observed by the Committee that Double-ended methods are preferred over single-ended methods because they rely only on direct travelling wave pulses and provide better accuracy, whereas single-ended methods depend on reflected pulses which may become difficult to identify accurately.

3.4 System Architecture and Components of On-line TWFL Technology

The On-line TWFL system generally comprises the following core components:

- GPS Receiver: Provides precise time synchronization.
- Remote Data Acquisition Module: Samples high-frequency signals at 5 MHz (one acquisition every 200 nanoseconds). Monitors voltage analog signals (Phase A, B, C, Neutral) and various digital signals (Breaker operation, TRIP, Various Protection Operation Status Signals).

- Central Processing Unit: Interfaces with multiple Data Acquisition units. Communicates with SCADA via Modbus and IEC 60870-5-104 protocol.
- DR Manager Software: Software manages Disturbance Records from multiple devices. Communicates via TCP/IP.
- GPS Synchronization and Communication Requirements**:** Precise GPS synchronization is the critical enabling requirement for double-ended On-line TWFL. Communication links between both substations must be dedicated and isolated. However, public internet is not recommended for protection-grade applications. OPGW-based communication paths may be adversely affected during a fault event, therefore a dedicated and secure communication arrangement through an independent medium is strongly recommended.

3.5 Indigenous Availability of the Technology

As of now there are two manufacturers who are supplying On-line TWFL technology in India. These are as follows:

(a) GE Vernova
(b) Qualitrol

Both the above mentioned manufacturers are not manufacturing the Product in India. GE Vernova is manufacturing the product at GEV factories located in Brazil and UK. GE Vernova is manufacturing approximately 1500 RPV311 and RA333 per year globally while Qualitrol is manufacturing approximately 300 devices per year. The system is designed for an industrial service life around 15-20 years, provided that standard maintenance and operating conditions as recommended by the manufacturer. Both the above manufacturers are able to supply in India on the requirement of the Product.

Other suppliers of On-line TWFL technologies include (a) SEL (Schweitzer Engineering Laboratories), and (b) Kehui. However, they have limited India-specific deployment data.

A comparison of OEMs offering On-line TWFL products available in the Indian market have been shown in **Table 2**.

Manufacturer	Product / System	Manufacturing Location	Status in India
GE Vernova	RT430, RPV311, RA333, DR Manager	Brazil and UK	Widely deployed; 200+ lines in India
Qualitrol	TWS FL-8 / TWS FL-1	Not manufactured in India	Available through authorized channel partners

Table 2: OEMs offering On-line TWFL products available in the Indian market

4. Details of Off-line TWFL Technology

4.1 Technical Details of Off-line TWFL Technology

Off-line TWFL technology relies basically on Time Domain Reflectometry (TDR). It is like radar i.e. a pulse is sent into the into de-energized lines and the time taken by reflected wave is measured to compute the distance of fault location. The transmission line must be de-energized, isolated, and grounded at both ends before testing. A typical example of Off-line TWFL connection is given in **Figure-3**.

Every transmission line possesses distributed electrical parameters namely resistance (R), inductance (L), capacitance (C) and conductance (G). These parameters define the characteristic impedance and travelling wave propagation characteristics of the line. When a fast impulse is injected into a transmission line, a travelling wave propagates along the conductor at a velocity close to the speed of light. When the travelling wave front encounters any impedance discontinuity - an actual fault (open or short circuit, high resistance), a physical discontinuity (jumper, repair sleeve, joint), or an abnormality (corrosion, insulator degradation, vegetation contact) - a portion of the pulse energy is reflected back towards the injection terminal. The round-trip travel time of this reflected wave is measured precisely, and the distance to the discontinuity is computed using the known wave propagation velocity.

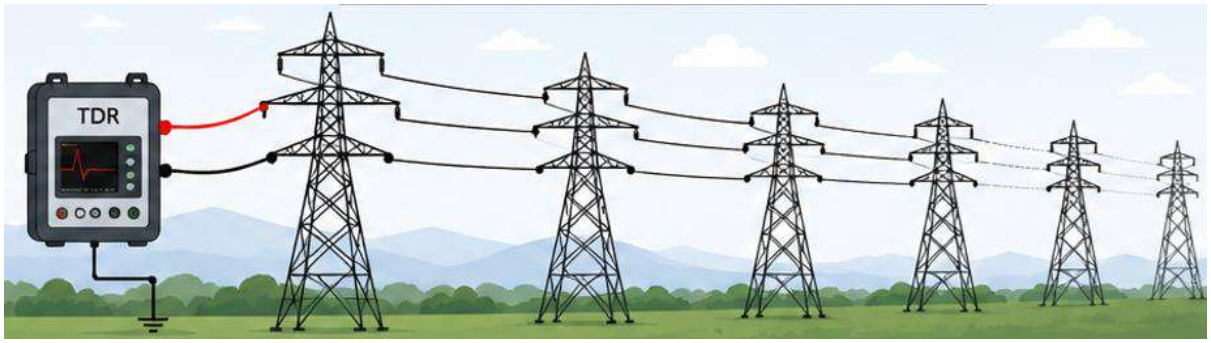


Figure-3: Off-line TWFL connection to Transmission Line

Typical impedance discontinuities include following:

(a) Broken conductors
(b) Conductor-to-earth faults
(c) Phase-to-phase faults
(d) Loose jumpers
(e) Corroded conductors
(f) Damaged insulators
(g) Tree encroachments
(h) Excessive sag
(i) Weak points developing along the line

In addition to determining fault distance, the Off-line TWFL analyzes the polarity, magnitude and waveform shape of the reflected travelling waves and therefore is capable of detecting

the nature of the fault like permanent open circuit, short circuit faults, high impedance fault and their location. Different types of defects produce unique travelling wave signatures:

• Open circuit faults generate positive reflections.
• Short circuit faults generate negative reflections.
• High resistance faults produce reduced amplitude reflections.
• Progressive insulation deterioration produces gradual signature variations.
• Tree encroachments and external objects alter line capacitance and generate identifiable travelling wave responses.

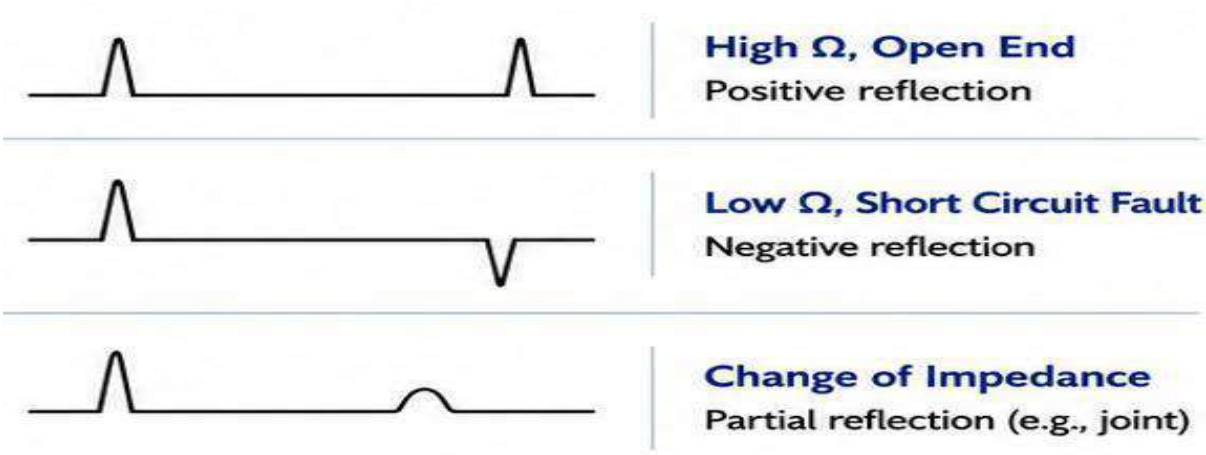


Figure 4: Pattern of Reflection of Pulse based on the Fault Condition

The system therefore provides not only fault location but also the fault characterization. Off-line TWFL technology.

Unlike On-line TWFL, Off-line TWFL systems are portable and can be deployed at any substation within a utility network. The standard deployment process involves:

(a) De-energization and isolation of the faulted line
(b) Transportation of the Off-line TWFL equipment to the relevant substation
(c) Connection via surge arrestor terminals using specially designed hot-sticks
(d) Grounding verification and safety checks
(e) Pulse injection and waveform acquisition
(f) Analysis and fault distance computation

The Off-line TWFL technology combines both fault location and line signature analysis functions within a single unit, thereby enabling not only fault identification during breakdown conditions but also predictive analysis of developing defects and insulation weaknesses.

The equipment in the Off-line TWFL technology includes onboard display, onboard analysis capability and graphical representation of test results. The System works on the principle of signature analysis, wherein reference signatures of transmission lines can be recorded during healthy conditions and subsequently compared with later measurements taken during periodic maintenance activities. By comparing the signatures over time, utilities can identify developing insulation weaknesses, loose connections and line irregularities before they evolve into major faults. The trend comparison allows utilities to understand the progression

of faults and deterioration in the transmission line system. The system is capable of identifying:

a) Existing faults
b) Developing faults
c) Weak insulation points
d) Defective insulator strings
e) Abnormal conductor conditions
f) Potential flashover locations

This enables utilities to adopt predictive and preventive maintenance practices.

As of now there are two OEMs supplying Off-line TWFL technology in India. These are as follows:

(a) Taurus-MKS
(b) Megger

The Taurus-MKS system injects a controlled high-voltage impulse of up to 20 kV into the de-energized transmission line and measures the reflected travelling waves returning from various discontinuities. The elapsed time between pulse injection and receipt of reflected travelling waves is measured with high precision. Based on travelling wave propagation characteristics, the distance to the discontinuity is calculated. The product can cover the line length up to 800 km. The claimed fault location accuracy of the system is within ±100 meters.

In case of Megger the solution injects test pulses of up to 1500 volts with operating frequencies ranging from approximately 100 kHz to 2 MHz. The System support testing and fault location for transmission line lengths of more than 1000 km. The claimed fault location accuracy of the system has been close to 20 meters.

Off-line TWFL has following advantages:

- Single-ended operation;
- No requirement for equipment at the remote end;
- No requirement for GPS synchronization;
- No dependence on communication links;
- No dependence on protection-relay operation;
- Portability;
- Possibility of use on multiple lines;
- Suitability for planned maintenance;
- Capability for line diagnostics and preventive maintenance; and
- Comparatively lower infrastructure requirement.

Its principal limitation is that the line must be in de-energized condition before the equipment is connected and the test pulse injected. Therefore, it is not capable of providing immediate automatic fault location on an energized line. The Committee also noted that operation during rainy conditions may sometimes become time-consuming because of difficulties associated with grounding.

4.2 Indigenous Availability of the Technology

Taurus-MKS, Off-line TWFL has designed, engineered and manufactured the product in India. The pulse generation system, travelling wave acquisition hardware, signal processing algorithms, diagnostic software and fault analysis techniques have been developed in house. The product is not based on any imported licensed technology and is fully supported from India. The company possesses indigenous capabilities for design, manufacturing, calibration, testing, commissioning, training and after-sales support. Manufacturing and servicing are carried out from the company's Bangalore facility. Taurus-MKS has an annual production capacity of approximately 400 units per annum. The manufacturing capacity can be further enhanced to 1000 units annually, based on utility requirements and project demand.

Megger is supplying TWFL technology through its Mumbai Office, with local technical support and service capabilities. While the technology and manufacturing are supported by Megger's global facilities in the UK, Germany, USA, Sweden, and India, the product is available for indigenous deployment and utility-scale applications across the country. Megger is capable of production of more than 200 units/year and plant capacity is available to meet more than 500 units.

A comparison of indigenous capability of Taurus-MKS and Megger is shown in **Table 3**.

Manufacturer	Product	Manufacturing Location	Indigenous Status
Taurus-MKS	Taurus-MKS EHT-1250 MAX-3 / MAX-4	Bangalore, India	Fully Indigenous (Make in India); in continuous development since 1989
Megger	Portable TDR-based Off-line TWFL System	UK, Germany, USA; Mumbai office in India	Partially Indigenous (local support and service)

Table 3: OEMs offering Off-line TWFL products in the Indian market

5. Comparative Assessment of On-line and Off-line TWFL Technology

5.1 Details of TWFL Technologies

TC-TWFL Committee sought the inputs from the OEMs of both the TWFL technologies. The Inputs w.r.t. details of TWFL Technologies are summarized in the **Table-4**.

Parameter	GE Vernova (On-line)	Qualitrol (On-line)	Megger (Off-line)	Taurus-MKS (Off-line)
Technology Type	On-line, Double-ended / Single-ended	On-line, Double-ended (auto) / Single-ended (manual)	Off-line, Portable, Single-ended (TDR)	Off-line, Portable, Single-ended (TDR+TW)
Sampling Rate	5 MHz (200 ns resolution)	Up to 20 MHz (12-bit ADC)	Not applicable (TDR pulse)	Not applicable (TDR pulse)
GPS/Time Sync Required	Yes - IRIG-B, sub-100 ns; existing GPS usable if compliant	Yes - own internal GPS module mandatory; existing substation GPS cannot be used	No GPS required	No GPS required
Claimed Accuracy	Typically <150 m;	+/- 60 m (double-ended automatic)	~ +/- 20 m	+/- 100 m (normal field conditions)
Line De-energization Required	No (operates on energized line)	No (operates on energized line)	Yes (line must be de-energized and isolated)	Yes (line must be fully de-energized and isolated)
Pulse Injection Voltage	N/A (passive monitoring)	N/A (passive monitoring)	Up to 1,500 V (peak); min 300 V/ 1500 V at 300 Ohm	Up to 20 kV impulse (high voltage for long EHV lines)
Power Supply	100-250 Vdc / 110-240 Vac (existing station auxiliary DC supply)	(AC/DC supply)	AC mains 230 V or external battery	Battery operated; upto 6 hours capacity
Space Requirement	RPV311: 3U 19-inch rack; RA333: 5U half-19-inch rack per line	3U high 19-inch rack chassis	Portable; no permanent installation	3 rugged waterproof cases (~25-30 kg each); no permanent installation

Parameter	GE Vernova (On-line)	Qualitrol (On-line)	Megger (Off-line)	Taurus-MKS (Off-line)
Diagnostic Capability	Fault location only	Fault location only (Grid Assist in development)	Fault location + signature analysis + diagnostics	Fault location + AI-assisted diagnostics + predictive maintenance
HVDC Applicability	Yes; globally deployed on HVDC	Yes; applicable	Not applicable (Off-line, not for energized HVDC)	Yes; deployed on Talcher-Kolar, Agra, Pugalur, Kurukshetra HVDC; BMTE Brazil (2,544 km)
Expected Lifespan	>20 years	15 years	8-12 years (with periodic maintenance)	>15 years (product in use since 1990)
Communication Required	Yes (dedicated, isolated network; TCP/IP)	Yes (dedicated network)	No	No

Table 4: Comprehensive comparison of TWFL technologies across OEMs

The Committee concluded that On-line TWFL is preferable for highly important transmission corridors where rapid restoration through automatic fault identification is required, whereas Off-line TWFL is particularly suitable where portability, multi-line utilization, diagnostics and lower infrastructure requirements are important. **Table-5** provides a comprehensive comparison of On-line and Off-line TWFL technologies as evaluated by the TC-TWFL Committee:

Parameter	On-line TWFL	Off-line TWFL
Operating condition	Energized line	De-energized line
Principle	Detects naturally generated fault travelling wave	Injects controlled pulse and analyses reflection
Fault-location operation	Automatic	Generally manual/non-automatic
Line shutdown	Not required	Required
External pulse	Not required	Required
Remote-end equipment	Required for double-ended system	Not required

Parameter	On-line TWFL	Off-line TWFL
GPS synchronization	Required for double-ended systems	Not required
Communication link	Required for double-ended system	Not required
Protection relay dependency	Can be integrated/interface with relay/DFR system	Not required
Portability	Permanently installed/configured	Portable
Multiple-line use	Generally configured for designated lines	One unit can serve multiple lines
Diagnostic capability	Primarily fault location	Fault location plus diagnostic/preventive maintenance capability
Restoration advantage	Very high because location can be obtained automatically after fault	Lower because equipment must be mobilized and line isolated
Infrastructure requirement	Relatively high	Relatively low

Table 5: Comprehensive comparison of Off-line and On-line TWFL technologies

5.2 Indigenous Availability of TWFL

W.r.t. Indigenous availability of the technology, the Committee has observed following:

(a) GE Vernova

GE Vernova stated that its TWFL equipment is manufactured at its factories in Brazil and the UK. The technology is available in India with local support. The stated annual manufacturing capacity is approximately 1500 RPV311 and RA333 units.

Thus, the technology is available for deployment in India but is not manufactured in India, based on the information furnished.

(b) Megger

Megger stated that its TWFL technology/ manufacturing is supported through its global facilities, including India, UK, Germany, USA and Sweden. Local technical support and service capability are available through Megger. The annual manufacturing capacity stated was more than 200 Units/ year, with plant capacity available to meet more than 500 units.

(c)Taurus-MKS

Taurus-MKS is observed to be completely indigenous. The product has been designed, developed, patented and manufactured entirely in India, with continuous development since 1989 through its in-house R&D facility.

The company has stated an annual manufacturing capacity of approximately 400 units, which can potentially be enhanced to approximately 1000 units/year depending upon demand.

(d) Qualitrol

Qualitrol has stated that its TWFL products are not manufactured in India, although they are available through authorized Indian channel partners and spares can be maintained locally.

Accordingly, from the perspective of indigenous manufacturing, Taurus-MKS provides the indigenous produced products, whereas the other products are internationally manufactured products available for deployment and support in India. A comparison of indigenous manufacturing capacity has been shown in **Table-6**.

OEM	Product Type	Indigenous Status	Details
Taurus-MKS	Off-line TWFL	manufactured in India	Designed, developed, patented, and manufactured entirely in India since 1989. Bangalore facility. DSIR-recognized in-house R&D. NSIC registered. Manufacturing capacity: 400 units/year (expandable to 1,000). Supports Make in India initiative.
Megger	Off-line TWFL	Not manufactured in India	Megger has presence in India with Mumbai office providing local technical support and service. Global manufacturing in UK, Germany, USA, Sweden. Local assembly and customization possibilities. Manufacturing capacity: 200+ units/year, expandable to 500+.
GE Vernova	On-line TWFL	Not manufactured in India	Manufactured at GE Vernova factories in Brazil and UK. Available in India through local sales channels. Global manufacturing capacity: approximately 1,500 RPV311 and RA333 units per year.
Qualitrol	On-line TWFL	Not manufactured in India	Not manufactured in India. Available through authorized channel partners who maintain spares stock. Global manufacturing capacity: approximately 300 devices per year.

Table 6: Indigenous availability assessment of TWFL products

5.3 Indicative Per Unit Cost of TWFL

The Cost of TWFL technologies of various OEMs is shown in **Table-7**.

Product/Technology	Type	Indicative Cost	Remarks
GE Vernova	On-line	Approx. ₹18 lakh for single-circuit/single-line module; approx. ₹1 crore for eight-line module*	Includes supply, installation, testing and commissioning as per NRPC presentation
Megger	Off-line	Approx. ₹45 lakh + taxes	HVAC; complete OLTS system
Taurus-MKS	Off-line	Approx. ₹55–65 lakh/set	HVAC, 66–800 kV; depends on configuration/ accessories
Qualitrol	On-line	Available in Indian currency through authorized channel partners; detailed quotation on request	Cost is scheme/ configuration dependent

Table 7: Indicative per unit cost of TWFL products

*The NRPC Sub-group indicated an approximate cost of ₹18 lakh for a single-circuit/single-line On-line module and approximately ₹1 crore for an eight-line module, inclusive of supply, installation, testing and commissioning for the cost of GE Vernova.

5.4 Details of the Utilities where TWFL has been deployed

GE Vernova:

GE Vernova reported a mature global installed base and stated that its equipment has been installed on more than 200 lines in India. Some of the lines where GE Vernova TWFL has been deployed are shown in **Table-8**.

Substation	Feeder/Line	Voltage
Meerut	Meerut–Bhiwani	765 kV
Meerut	Meerut-Moga	765 kV
Meerut	Meerut-Koteshwar- I/II	765 kV
Jeypore	Jeypore-Gukuwaka-I/II	400 kV
Ranchi	Ranchi-Sipat 2	400 kV

Table 8: GE Vernova TWFL deployed Lines

Megger:

Representative from Megger furnished following UPPTCL lines from Sarnath where their TWFL System has been deployed:

- Sarnath–Anpara L-5: approximately 158.341 km;
- Sarnath–Anpara L-6: approximately 262.267 km;
- Sarnath–Prayagraj: approximately 130 km;
- Sarnath–Gorakhpur: approximately 218 km; and
- Sarnath–Obra: approximately 145 km.

Taurus-MKS:

Taurus-MKS stated that its Off-line TWFL was first supplied in 1990 and has since been used by several Indian utilities, including PGCIL, APTRANSCO, TSTRANSCO, KPTCL, TANTRANSCO, KSEB, MPPTCL, UPPTCL, WBSETCL, DVC, HVPNL, and Adani Transmission.

Further, the technology has also been implemented by Nepal Electricity Authority, Bhutan Power Corporation and BMTE, Brazil.

Specific Indian examples include:

- 220 kV Kadarpur–Pali transmission line of HVPNL;
- 400 kV Allahabad–Singrouli Transmission Line-3 of Powergrid; and
- 132 kV Panyor Lower–Itanagar transmission line in Arunachal Pradesh.

Taurus-MKS also furnished examples from Arunachal Pradesh and Tripura, including lines in the range of approximately 30–95 km.

Taurus-MKS also reported application on major HVDC projects including:

- Talcher–Kolar HVDC;
- Agra HVDC;
- Pugalur HVDC; and
- Kurukshetra HVDC.

The technology was stated to have been used on these systems for more than 15 years.

Qualitrol:

Qualitrol has supplied its TWS systems to utilities internationally. The reference customers are Public Service New Mexico, CenterPoint Energy, Dominion Virginia, Eskom, Saudi Electricity Company, Svenska Kraftnät, and Scottish Power.

The furnished information indicates voltage levels from 66 kV to 500 kV, with automatic double-ended analysis capable of approximately ±60 m accuracy under good signal conditions.

5.5 Effectiveness of the TWFL Product (based on feedback from respective customers)

On-line TWFL

The NRPC field assessment provides strong evidence of the effectiveness of On-line TWFL technology in Indian transmission networks. The observed difference between On-line TWFL

fault-location indications and actual physical fault locations was generally within approximately one tower span or around 0.5 km. In comparison, conventional Main-1/Main-2 relay indications differed by approximately 6–20 km in some cases. The principal operational benefits identified were:

- reduction in outage duration;
- faster restoration;
- reduction in manual patrolling;
- improvement in system availability;
- improvement in reliability indices; and
- improved grid security.

These benefits are particularly relevant for renewable-energy evacuation corridors and transmission lines associated with nuclear generation, where prolonged outages may result in generation backing down and adverse system consequences.

Off-line TWFL

The OEM responses indicate successful field deployment of Off-line TWFL over several decades. Taurus-MKS reported successful use from 66 kV to 765 kV and under diverse terrain and environmental conditions, including forests, mountainous regions, coastal areas and long-distance transmission corridors. User feedback indicates:

- rapid identification of fault locations;
- reduction in fault-patrolling time;
- reduced outage duration;
- reduced manpower requirements;
- faster restoration;
- detection of developing faults;
- detection of insulator abnormalities;
- detection of tree encroachment and conductor defects; and
- support for preventive and predictive maintenance.

5.6 Limitation of the TWFL Products

(a) Limitations Regarding Line Length

- GE Vernova: Travelling wave amplitude decreases with increasing line length due to attenuation; however, this is mitigated by the 5 MHz high-resolution acquisition and sensitive detection algorithms.
- Megger: Suitable up to approximately 1,000 km; very long and complex networks may require synchronized measurements from both ends.
- Taurus-MKS: As line length increases, reflected signal amplitude decreases. This has been mitigated by high-voltage impulse injection (up to 20 kV) and sensitive signal acquisition electronics. The Technology is applicable up to 800 km (HVAC).
- Qualitrol: For cable sections, a maximum of approximately 50 km between measurement points is recommended due to higher attenuation in cables.

(b) Limitations Regarding Remote In-Feeds

Unlike conventional impedance-based methods, TWFL technologies are largely unaffected by remote in-feeds. The inputs provided by different OEMS w.r.t. Remote-in-Feeds are as follows:

- On-line TWFL (GE Vernova): Completely independent of system parameters including in-feed/out-feed, as fault location is computed from GPS-synchronized timestamps alone.
- Off-line TWFL (Megger): Remote in-feeds have minimal impact as measurements are performed on de-energized lines.
- Off-line TWFL (Taurus-MKS): Since the system operates on a de-energized line, the influence of remote in-feeds is completely eliminated.

(c) Limitations Regarding Intervening Joints / Jumpers

The inputs provided by different OEMS w.r.t. Intervening Joints / Jumpers are as follows:

- GE Vernova: Mixed lines with different propagation constants require precise configuration of propagation constant (K) values for each section in the DR Manager software.
- Megger: Cable joints, transition points, and impedance discontinuities generate additional reflected waves that may complicate wave interpretation; detailed line models and reference signatures are needed.
- Taurus-MKS: Intervening jumpers, taps, repairs, and joints generate identifiable reflections; AI-assisted diagnostic software distinguishes normal line features from fault-related reflections using baseline comparison.
- Qualitrol: Correct cable velocity factor must be configured. The System is capable for in two in-circuit teed lines. In a hybrid circuit where there is a combination of overhead line and underground cables, the travelling Wave System is limited to two junctions between overhead line and underground cable sections.

5.7 Applicability and Effectiveness on Long HVDC Transmission Lines

India operates several major High Voltage Direct Current (HVDC) transmission links, including the 800 kV HVDC systems which represent the highest voltage class of DC transmission infrastructure. The TC-TWFL Committee considered the applicability of TWFL technologies specifically to these systems.

(a) On-line TWFL on HVDC Lines

The RPV311/RA333 architecture of GE Vernova is fully optimized for HVDC applications. The 5 MHz sampling rate is designed to detect the extremely fast transients characteristic of HVDC transmission. GE Vernova TWFL systems have been deployed in HVDC applications globally, including a 2,411 km, 600 kV DC Porto Velho-Araraquara HVDC line in Brazil.

Similarly, Qualitrol has submitted that their System can be applied to HVDC transmission Line.

(b) Off-line TWFL on HVDC Lines

Taurus-MKS Systems has confirmed that travelling wave principles are independent of AC or DC operating mode, making Off-line TWFL applicable to both HVAC and HVDC systems. The

technology has been successfully deployed and utilized on the following major Indian HVDC projects:

- Talcher-Kolar HVDC Link
- Agra HVDC System
- Pugalur HVDC System
- Kurukshetra HVDC System (over 15 years of deployment)

Additionally, the technology has been deployed on the BMTE transmission network in Brazil, including corridors up to approximately 2,544 km through the Amazon region. Long HVDC corridors exhibit lower attenuation and fewer intermediate discontinuities compared to AC networks, which is advantageous for travelling wave analysis. Factors such as smoothing reactors, line terminations, filters, and converter station interfaces may influence travelling wave behavior and should be considered during system configuration.

Megger's TWFL solution is an Off-line testing and fault location technology and is not intended for continuous On-line travelling-wave monitoring of energized HVDC transmission systems. Therefore, its applicability and effectiveness for On-line fault location on long ±800 kV HVDC transmission lines are not established. The system is primarily designed for Off-line diagnostics and fault location of de-energized overhead lines and cable systems.

5.8 Effectiveness on Mixed Overhead and Underground Cable Configurations

Mixed overhead-line/underground-cable configurations present greater challenges than homogeneous overhead transmission lines. The principal reasons are:

- different travelling-wave propagation velocities;
- different characteristic impedances;
- frequency-dependent attenuation;
- reflections at overhead/cable transition points;
- reflections at cable joints;
- termination effects; and
- sheath/bonding arrangements.

The Committee specifically recognized these challenges and observed that proper line modelling and configuration are essential. Various Inputs provided by OEMs w.r.t. effectiveness on Mixed Overhead and Underground Cable Configurations are as follows:

GE Vernova: GE Vernova indicated that its software can define different propagation characteristics for different line sections. The technology was stated to be applicable to hybrid lines, subject to proper configuration.

Megger: Megger stated that its technology is applicable to overhead lines and underground cable systems and therefore can be applied to mixed networks. However, location accuracy may depend on the complexity of the network topology and the availability of detailed line and cable data.

Qualitrol: Qualitrol stated that its TWFL system can be used for cable and hybrid overhead/cable circuits. However, it recommends a maximum cable-section length of approximately 50 km between measurement points, beyond which attenuation of high-

frequency travelling-wave components can make automatic detection more difficult. Qualitrol infomred that present technology is limited to approximately two junctions between overhead and underground cable sections for reliable operation.

Taurus-MKS: Taurus-MKS adopts a more application-specific approach. In mixed networks, the overhead-line and underground-cable sections may be treated as separate diagnostic entities, with dedicated cable fault-location equipment used for the cable section.

The Committee notes that complex cable networks may require specialized or separate fault location solutions rather than a single TWFL arrangement.

5.9 TWFL Products Ability to Use Existing Substation GPS

GPS/time synchronization is important primarily for double-ended On-line TWFL systems. The Time Synchronization requirement of different OEMs is given in the **Table-9**.

OEM	Type	GPS / Time Synchronization Requirement
GE Vernova	On-line	Requires IRIG-B (004 even parity) standard with sub-100 nanosecond jitter performance. Existing substation GPS CAN be utilized provided it conforms to IRIG-B standard and has spare output ports meeting the nanosecond-level jitter performance. Generally, uses GPS equipment with fibre optic output ports. TWFL devices also include inbuilt GPS as standard.
Qualitrol	On-line	Uses its own internal GPS module to ensure 100 nanosecond accuracy. System cannot use existing substation GPS. The System must be deployed with its own dedicated GPS and antenna at each substation terminal.
Megger	Off-line	GPS synchronization NOT required for Off-line TDR-based operation. No dependency on GPS, communication channels, or satellite infrastructure.
Taurus-MKS	Off-line	GPS synchronization NOT required for fault location operation. System performs all measurements from a single end. If GPS is available in substation, it may optionally be utilized for event logging, test documentation, and asset management purposes only. No dependency on GPS for core measurement function.

Table 9: GPS and time synchronization requirements by OEM and technology type

The Committee noted that for Off-line TWFL, GPS synchronization is not required because the fault location is calculated from the round-trip travel time of the reflected pulse at the same terminal.

5.10 Space, Power Supply, and Other Requirements for Substation Deployment

(a) On-line TWFL

GE Vernova:
The GE Vernova equipment consists of:

- RT430 GPS receiver;
- RPV311 Central Processing Unit;
- RA333 acquisition unit; and

- DR Manager software.

The stated power requirements are:
- 100–250 V DC; or
- 110–240 V AC

The physical equipment comprises approximately:
- RPV311: 3U, 19-inch rack;
- RA333: 5U, half-19-inch width.

The stated operating temperature ranges are approximately -10°C to +50°C for RPV311 and -40°C to +55°C for RA333.

The System can use existing station DC supply, with DC preferred, and normally does not require a separate UPS arrangement.

In addition to physical equipment, an On-line double-ended system requires:
- Equipment at both line terminals;
- Communication path;
- Time synchronization;
- Configuration database;
- Suitable interfacing;
- Secure station network; and
- Engineering/configuration support.

Qualitrol

The travelling wave system comes in a 3U high 19 inch rack chassis.

(b) Off-line TWFL

Taurus-MKS

Off-line systems have substantially lower permanent infrastructure requirements. Taurus-MKS supplies a portable system in rugged carrying cases and the system can be moved between line bays. It does not require permanent control-room installation, dedicated communication, remote-end equipment or GPS synchronization. The unit is battery operated and can conduct approximately 5–6 line tests per charge.

The principal requirements are:
- access to the line terminal;
- safe line isolation;
- proper grounding;
- suitable connection accessories;
- trained operating personnel; and
- battery charging facility.

Megger
- Mains Supply: 230 V ±10%, 49–61 Hz, ≤70 VA.

- Off-line/ Portable Device -deployed at substation. Whenever fault occurs during that time the kit is used.
- Thus, the TWFL product is a portable Off-line diagnostic system that can be deployed on demand at substations without requiring dedicated infrastructure or continuous power backup arrangements.

  Thus, from the infrastructure perspective, Off-line TWFL has a significant advantage where a single portable unit is intended to serve several transmission lines.

5.11 Consistency of Measurements

For On-line systems, configuration management is particularly important. Changes in line topology, line parameters, addition of bays or conversion of overhead sections to cable sections should be reflected in the TWFL configuration database. However, if correctly configured with site-specific line parameters, the system provides consistent and reliable fault location results.

In case of Off-line TWFL, the OEM responses indicate that TWFL systems provide repeatable measurements when properly configured. Megger stated that its system provides repeatable and consistent measurements when the test setup, line parameters and operating conditions remain unchanged. Taurus-MKS reported highly repeatable results under repeated testing of the same transmission line under similar conditions. It also stated that laboratory tests involving thousands of triggers demonstrated repeatability. Minor variations may arise because of changes in moisture, contamination, vegetation contact or temporary line conditions.

The principal factors affecting repeatability are therefore:

- accuracy of line parameters;
- propagation velocity;
- equipment calibration;
- connection arrangement;
- grounding;
- electromagnetic noise;
- changes in line configuration; and
- changes in physical/environmental line conditions.

5.12 Effect of improper grounding or incorrect equipment connection during actual usage

Correct grounding and connection are essential, particularly for Off-line systems involving high-voltage pulse injection.

Megger's system incorporates ground-loop detection and safety interlocks. If improper grounding or incorrect connection is detected, pulse injection is inhibited and an alarm/indication is provided to the operator.

Taurus-MKS provides two independent high-current-capacity 10 mm^2 copper grounding cables. The system also incorporates internal grounding verification, which checks the grounding condition before testing. If inadequate grounding is detected, the operator is alerted before the test is initiated.

Improper grounding may otherwise result in:

- measurement errors;
- nuisance triggering;
- unreliable travelling-wave detection; or
- unsafe operating conditions.

The Committee also recorded utility feedback that grounding can become particularly difficult during rainy conditions, potentially increasing testing time. Accordingly, grounding verification and electrical safety interlocks should be mandatory requirements in the technical specification for Off-line TWFL systems.

5.13 Normal expected life span of the TWFL product

The OEM responses w.r.t. normal expected life span has been shown in **Table-10.**

OEM / Product	Type	Expected Lifespan	Maintenance Requirements
GE Vernova	On-line	>20 years	Standard preventive maintenance; software updates; firmware upgrades as recommended by OEM. Operating within specified temperature and power ranges.
Qualitrol	On-line	15 years	Periodic inspection, calibration, and software updates.
Megger	Off-line	8-12 years	Periodic calibration and preventive maintenance as per OEM schedule. Battery replacement as required.
Taurus-MKS	Off-line	>15 years	Normal usage with periodic calibration and routine preventive maintenance. Product has been in continuous use since 1990. Annual AMC, calibration, and 24x7 technical support available. Annual training provided.

Table 10: Expected lifespan and maintenance requirements for TWFL products

5.14 Integration of Different-Make Relays

On-line TWFL should preferably be manufacturer-agnostic with respect to the protection relays installed at the two ends of the line. The OEMs response indicate that TWFL can be manufacturer-agnostic, while interoperability depends on:

- communication architecture;
- data-exchange protocols;
- time synchronization;
- TWFL acquisition-system compatibility; and
- appropriate configuration/mapping of measurements.

Therefore, the use of different relay manufacturers at the two ends should not by itself constitute a barrier to implementation of On-line TWFL. However, the TWFL system should not depend unnecessarily on proprietary relay hardware or proprietary communication protocols. The technical specification should require the TWFL system to interface with

protection systems through open/standardized interfaces and to remain functional even where Main-1 and Main-2 relays are of different makes.

A key requirement for On-line TWFL deployment in Indian substations, where protection relays of multiple makes may be installed especially at the two ends of the line, is that the TWFL system should be compatible with relays from different manufacturers. In this respect inputs provided by OEMs are given as below:

- GE Vernova (On-line TWFL): The system is manufacturer-agnostic with respect to protection relays.
- Qualitrol (On-line TWFL): Protection relay type has no bearing on Qualitrol's Travelling Wave solution.
- Megger and Taurus-MKS (Off-line TWFL): Off-line systems do not interact with protection relays, synchronized measurements, or communication links. Issues of relay make compatibility are therefore not applicable in case of Off-line TWFL.

An important operational consideration noted by the Committee is that proper configuration management is necessary when using On-line TWFL. Any change in line topology, addition of a new line or bay, modification of line parameters, or change from overhead to cable sections would require corresponding updates to the TWFL system database and configuration. This must be managed as part of the substation asset management process.

5.15 Future developmental efforts w.r.t. Integrating the TWFL product with the Protection Relays

The TC-TWFL Committee examined the prospects for future integration of TWFL functionality directly into protection relays. OEM-specific development roadmaps are as follows:

GE Vernova:

GE Vernova acknowledges the fundamental challenge of the sampling rate mismatch as relays sample at 4–16 kHz, while TWFL requires 1–5 MHz to capture high-frequency transients.

Qualitrol:

Qualitrol reported development of a software solution called Grid Assist, intended to integrate protection-relay fault records with Qualitrol's Travelling Wave fault location system data and present combined information on a map-based application for fast and easy review.

Taurus-MKS:

Taurus-MKS has proposed integration of the proven Off-line TWFL technology with an On-line Continuous Transmission Line Monitoring and Health Monitoring System. A Proof of Concept (POC) was successfully demonstrated in 2016 in collaboration with PGCIL at Maithon Substation, on 220 kV and 400 kV transmission lines. The POC validated continuous online transmission line monitoring, health assessment, travelling-wave-based monitoring, fault detection, line signature acquisition, and identification of line abnormalities under live operating conditions. The proposed online monitoring system operates by continuously injecting controlled travelling-wave pulses through the PLCC (Power Line Carrier Communication) channel, enabling fault and transmission line abnormality detection within

approximately 2 to 3 milliseconds of occurrence. Taurus-MKS expressed willingness to further conduct a detailed POC demonstration.

Megger:

Megger's TWFL solution is an Off-line, portable fault location and diagnostic system and does not require integration with protection relays for its intended operation.

5.16 Effectiveness of On-line/ Off-line TWFL technologies for subsea cables

Subsea cable fault location represents a specialized and technically demanding application of TWFL technologies. The TC-TWFL Committee obtained OEM positions on this aspect which has been summarized below:

Technical Challenges Specific to Subsea Cables:

- Greater cable length compared to typical land-based installations.
- Higher cable capacitance, leading to greater signal attenuation and dispersion.
- Travelling wave propagation velocity in cables is significantly lower than overhead lines (typically 45-60% of overhead-line velocity), requiring correct velocity factor configuration.
- Cable joints; Sheath/ Bonding effects; and potentially very long cable sections affect the fault detection in Subsea Cable
- Fault pinpointing in subsea environment requires Remotely Operated Vehicles (ROVs) or specialized underwater equipment, which is fundamentally more complex than land-based fault location.
- High discharge requirements necessitate specialized high-power test equipment.

The Committee notes that subsea cable TWFL applications are significantly more complex than land-based transmission line applications, and all OEMs acknowledge that specialized equipment configurations and methodologies are required.

Megger: Megger reported experience on a 761 km subsea cable project connecting the UK and Denmark and indicated that specialized equipment/configuration is required for subsea applications. Challenges include longer cable length, higher cable capacitance, high discharge requirements, subsea pinpointing and the need for suitable pre-location techniques.

Qualitrol: Qualitrol stated that its TWFL system can be used on cable circuits and hybrid overhead/cable circuits. However, based on cable attenuation characteristics, it generally recommends approximately 50 km maximum cable-section length between measurement points for reliable automatic detection.

Taurus-MKS: Subsea cables require specialized approaches due to different electrical characteristics, propagation behaviour, attenuation, and reflection properties. Subsea cable systems are a specialized application area requiring further optimization. Taurus-MKS is willing to conduct studies and validation on suitable subsea cable installations.

6. Guidelines/ Recommendations for TWFL Technology

The Committee for preparation of Guidelines/ Procedure for implementation of Travelling Wave Fault Locator (TWFL) on critical transmission lines, examined the subject in a comprehensive manner through their meetings, technical presentations by OEMs, and responses to technical and operational queries raised to OEMs with respect to different TWFL technologies. The Committee considered both On-line and Off-line TWFL solutions, including their operating principles, system configuration, fault-location methodology, accuracy, applicability to different transmission line configurations, communication and synchronization requirements, integration with existing protection and substation systems, auxiliary power and space requirements, availability, manufacturing and deployment capability, Make in India aspect, cost, manpower requirements, operational suitability and scalability.

The Committee has observed that even though off-line TWFL is a more economical solution compared to on-line TWFL, the latter may still be preferred for highly important transmission corridors where rapid restoration of lines by automatic identification of fault locations is required for grid security. Off-line TWFL are more suitable where portability, multi-line utilization, diagnostic applications and lower infrastructure requirements are important considerations.

For finalizing the TWFL Guidelines w.r.t. HVDC and 400 kV & above systems, the Committee has considered the CEA Guidelines dated 11.05.2025 on Standard Operating Procedure for Restoration of Transmission System, which inter-alia, provides the criteria for identifying a substation as critical, and has concluded that those would be the ideal locations for providing Off-line TWFL Devices.

W.r.t. 220 (230) kV Network, the Committee observed that 220 kV lines exceeding 200 km are comparatively few in number in most parts of the country; hence, adopting 200 km line length as a general screening criterion would primarily identify unusually long 220 (230) kV lines where physical fault patrolling may be difficult and restoration time may be comparatively high. As such, a general criterion of 200 km line length could be considered for deployment of Off-line TWFL Devices. However, in locations where the lines pass through hilly, forested or otherwise difficult terrain, a lower threshold of approximately 100 km may be considered. This criterion of 200 km/ 100 km would be valid across all regions of India including North Eastern Region.

Considering the North-Eastern Region's distinct transmission network, difficult terrain and accessibility constraints, the Committee has agreed that there may be a need for providing Off-line TWFL Devices in its 132 kV transmission network also. After thorough deliberations, the Committee has decided to adopt 100 km as the minimum threshold for line length for stations in normal terrain and 50 km as the minimum threshold for line length for stations in difficult or hilly terrains for providing Off-line TWFL Devices in North Eastern Region.

After detailed deliberations, the following Guidelines/ Procedure have been formulated for implementation of TWFL across the country, covering both Inter-State Transmission System (ISTS) and Intra-State Transmission System, with due consideration to region-specific, system-specific and line-specific requirements.

6.1 Guidelines for Mandatorily Providing Off-line TWFL Devices

1. <u>400 kV & Above Stations [applicable across all Regions in India]:</u>

(a) All 765 kV stations
(b) All Stations at Voltage level 400 kV and above where Inter-Regional lines terminate or are important for import of power by any specific state
(c) All Stations which handle more than 3000 MW of power capacity
(d) All or selected Stations at 400 kV and above voltage level which are essential to ensure continuity of supply to following category of loads as per information furnished by State Load Despatch Centre and DISCOMs:
  (i) State Capitals
  (ii) Railways, metro rail, airports, refineries, underground mines, defence establishments. VIP areas, Space, ports and important industries.
  (iii) Important for islanding scheme of nuclear power plants or major metropolitan areas or defence establishments

2. <u>220 kV (230 kV) Stations [applicable across all Regions in India]:</u>

(a) All Stations in normal terrain having any lines with line length of more than 200 km
(b) All Stations in difficult or hilly terrain having any lines with line length of more than 100 km

3. <u>132 kV Stations (applicable only to North-Eastern Region):</u>

(a) All Stations in normal terrain having any lines with line length more than 100 km
(b) All Stations in difficult or hilly terrain having any lines with line length more than 50 km and susceptible to frequent tripping due to vegetation and/ or bamboo encroachment.

6.2 Guidelines for Mandatorily Providing On-line TWFL Devices:

On-line TWFL Devices shall be **mandatorily** provided on all HVDC Transmission lines. For remaining applicable cases, the concerned Utilities may decide upon providing the same (**hence optional**) in the following order of priority:

(a) All 765 kV and above transmission lines
(b) 400 kV and above transmission lines having average loading of more than 1500 MW or any higher threshold as deemed appropriate by the utility.

6.3 General Guidelines to be followed for TWFL

Along with the deployment of TWFL Technology in accordance with the guidelines/procedures specified in this Report, utilities shall ensure the following:

(a) TWFL should be deployed as an additional fault-location and diagnostic layer and should complement, and not replace, the primary protection system.

(b) In case of deployment of On-line TWFL Technology, only Double-Ended TWFL Technology shall be utilized. Single-Ended TWFL Technology shall not be considered for On-line TWFL applications.

(c) For On-line TWFL applications, accurate and reliable time synchronization should be ensured and periodically verified to maintain the required accuracy of fault-location estimation. Existing station GPS/ Time-synchronization infrastructure should be utilized wherever technically compatible and suitable for TWFL application.

(d) TWFL systems should be designed to operate independently of the make/ manufacturer of the existing protection relay.

(e) For Double-Ended On-line TWFL systems, secure and dedicated communication channels should be preferred to ensure reliable transmission of travelling-wave data and fault-location information. In no case public network shall be used for communication purpose.

(f) Cybersecurity provisions, availability of critical spares, calibration facilities, after-sales technical support and long-term maintainability should form an integral part of the procurement evaluation.

(g) Adequate provision should be made for critical spares, training of operating and maintenance personnel, Annual Maintenance Contracts (AMC), technical support and future software and firmware upgrades throughout the intended service life of the system.

(h) Applications involving mixed overhead line-cable sections and subsea cables should be subjected to project-specific technical evaluation, considering the effects of propagation velocity, attenuation, impedance discontinuities and associated reflections on TWFL performance.

(i) Periodic review of the deployed TWFL systems should be undertaken, with provision for incorporating future developments in high-speed data acquisition, protection-relay integration, line-health monitoring and AI-assisted travelling-wave analysis, as technically and operationally appropriate.

(j) Proper grounding/ earthing arrangements and necessary safety interlocks should be provided to ensure safe and reliable operation and maintenance of the TWFL system.

******

Annexure-I

सत्यमेव जयते

भारत सरकार/ Government of India
विद्युत मंत्रालय/ Ministry of Power
केन्द्रीय विद्युत प्राधिकरण/ Central Electricity Authority
विद्युत प्रणाली अभियांत्रिकी एवं प्रौद्योगिकी विकास प्रभाग
Power System Engineering & Technology Development Division

Date: 13.05.2026

विषय: Constitution of Committee to prepare Guidelines/Procedure for implementation of Travelling Wave Fault Locator (TWFL) on critical transmission lines for 220 kV and above (132 kV and above for NER) voltage levels - reg.

National Power Committee vide its meeting held on 27.02.2026 at Vizag, Andhra Pradesh requested PSE&TD Division of CEA to prepare Guidelines/Procedure for implementation of Travelling Wave Fault Locator (TWFL) on critical transmission lines for 220 kV and above (132 kV and above for NER) voltage levels.

2. In view of above the Committee is constituted with following members.

1.	Chief Engineer (PSE&TD), CEA	Chairperson
2.	Representative from NRPC	Member
3.	Representative from NERPC	Member
4.	Representative from GRID INDIA	Member
5.	Representative from POWERGRID	Member
6.	Representative from MSETCL	Member
7.	Deputy Director (PSE&TD), CEA	Member Convener

3. The Terms of reference (ToR) of the committee are as follows:
   a) To explore various Online and Offline fault locator technologies including TWFL.
   b) To assess the indigenous availability of the various Fault Locator Technologies
   c) Cost comparison of various Fault Locator Technologies of Fault Locator.
   d) To prepare Guidelines/Procedure for implementation of Fault Locator Technologies on critical Transmission Lines for 220 kV and above (132 kV and above for NER) voltage levels
   e) Any other relevant issues.

4. The Committee may invite or co-opt any other member as may be considered necessary.

5. The Committee shall submit the Guidelines/Report within 2 months (by July, 2026).

6. All the Organisations are requested to provide the nomination for the members.

This issues with the approval of competent authority.

भवदीय,

Digitally signed by Pankaj Kumar Verma
Date: 13.05.2026 18:07:51

(पंकज कुमार वर्मा /Pankaj Kumar Verma)
उप-निदेशक /Dy. Director

तीसरी मंजिल,सेवा भवन, आर. के. पुरम-I, नई दिल्ली-110066 टेलीफैक्स: 011-26732435 ईमेल: ce-psetd@gov.in वेबसाइट:www.cea.nic.in
3rd Floor, Sewa Bhawan, R.K Puram-I, New Delhi-110066 Telefax: 011-26732435 Email: ce-psetd@gov.in Website: www.cea.nic.in

Annexure-I

To,

1. Member Secretary, NRPC
2. Member Secretary, NERPC
3. CMD, GRID INDIA
4. CMD, POWERGRID
5. Managing Director, MSETCL

Copy To,

SA to Member (PS)

सत्यमेव जयते

भारत सरकार/ Government of India

विद्युत मंत्रालय/ Ministry of Power

केन्द्रीय विद्युत प्राधिकरण/ Central Electricity Authority

विद्युत प्रणाली अभियांत्रिकी एवं प्रौद्योगिकी विकास प्रभाग

Power System Engineering & Technology Development Division

Date: 09.06.2026

सेवा में,

<As per attached list>

विषय: Minutes of the First Meeting of the Committee to prepare Guidelines/ Procedure for Implementation of Travelling Wave Fault Locator on Critical Transmission Lines for 220 kV and above (132 kV and above for NER) Voltage levels [TC-TWFL] – reg.

महोदया/ महोदय,

First meeting of the Committee to prepare Guidelines/ Procedure for implementation of Travelling Wave Fault Locator on critical transmission lines for 220 kV and above (132 kV and above for NER) voltage levels [TC-TWFL] was held on 25.05.2026 at 15:00 Hrs in Hybrid Mode in the Manthan Conference Hall of CEA, Sewa Bhawan, R K Puram, Sector-I, New Delhi.

The minutes of the first meeting of the Committee is enclosed for your information and necessary action.

Encl: As above

भवदीय,

Digitally signed by
Pankaj Kumar Verma
Date: 09-06-2026

(पंकज कुमार वर्मा/Pankaj Kumar Verma)

उप-निदेशक /Dy. Director

To

1. Sh. Om Kishor, EE, NRPC Email ID: omkishor.sahu@gov.in
2. Sh. V. Muncha, Director, NERPC, Email ID: veerandranath.muncha@gov.in
3. Sh. P. P. Chand DGM, GRID INDIA, Email ID: purnprakash@grid-india.in, Sh. Deepak Kumar Dy. Manager, GRID INDIA, Email ID: deepak.kr@grid-india.in
4. Sh. Anurag, GM , Engg-SS, PGCIL, Email ID: anurag@powergrid.in
5. Sh. Manoj Joshi, Superintending Engineer (ACI&P), MSETCL, Email ID: seprotection@mahatransco.in

Copy to:

1. SA to Member (PS), CEA
2. PS to Chief Engineer, PSE&TD Division, CEA

Power System Engineering & Technology Development Division
Central Electricity Authority

Minutes of the First Meeting of the Committee to Prepare Guidelines/ Procedure for Implementation of Travelling Wave Fault Locator on Critical Transmission Lines for 220 kV and above (132 kV and above for NER) Voltage levels

A. Introduction

First meeting of the Committee to prepare Guidelines/ Procedure for implementation of Travelling Wave Fault Locator (TWFL) on critical transmission lines for 220 kV and above (132 kV and above for NER) voltage levels (TC-TWFL) was convened on 25.05.2026 at 15.00 hrs in Hybrid Mode at Manthan Conference Hall, 2nd Floor, Sewa Bhavan, R. K. Puram Sector-1, New Delhi under the chairmanship of Chief Engineer (PSE&TD Division), CEA. The list of participants is enclosed as **Annexure-I**.

At the outset, Sh. N.R.L.K. Prasad, Chief Engineer (PSE&TD), CEA and Chairperson of the Committee, extended warm welcome to all the Members & Special Invitees (OEMs). He then gave a brief background about the formation of the Committee, and informed that the Committee has been constituted as per the decision taken in the 17th NPC meeting held on 27.02.2026 at Vizag, Andhra Pradesh.

He stated that earlier based on the proposal by PGCIL presented to NRPC in their 80th meeting, NRPC had constituted a Sub-group comprising representatives from CEA, CTUIL, NRLDC and other stakeholders to evaluate the TWFL technology and to formulate criteria to identify critical transmission lines that warrant the installation of TWFL, based on operational importance and reliability considerations. In this regard, the NRPC Sub-group had conducted two meetings during August, 2025 and October, 2025. The Sub-group had also undertaken a field visit to the Meerut Substation, where the TWFL technology had already been implemented on a few transmission lines. It was observed that the accuracy levels (≈±500 m) achieved through TWFL technology were significantly better compared to conventional impedance or distance-based relay fault location methods. Based on these observations, the NRPC Committee had recommended implementation of Travelling wave-based Fault Locator on critical transmission lines.

He further stated that the study conducted by NRPC Committee was mainly intended for regional requirements and did not include lower voltage level lines such as 132 kV lines, which are important particularly in the North-Eastern region. The matter was discussed in the 17th NPC meeting held on 27.02.2026, wherein it was decided that to suggest a uniform National Policy Framework for TWFL implementation in ISTS and Intra-state Systems, PSE&TD of CEA may prepare guidelines/procedure for implementation of Travelling Wave Fault Locator (TWFL) on critical transmission lines for 220 kV and above (132 kV and above for NER) voltage levels.

Accordingly, the subject Committee has been constituted with members from NRPC, NERPC, Grid India, PFCIL and MSETCL. CE(PSE&TD), CEA informed that as the present meeting was the first meeting of the Committee, it was proposed to examine and assess the different Travelling Wave based Fault Locator technologies (on-line & off-line) including TDR (Time Domain Reflectometry) based off-line Fault Locator. He stated that the existing impedance-based fault location systems

are influenced by several factors, including line impedance mismatches, remote in-feeds, etc., due to which the fault location accuracy may vary significantly, sometimes even by several kilometers. Therefore, more accurate technologies such as travelling wave-based systems are being examined for possible implementation on critical lines.

CE (PSE&TD), CEA further stated that the committee intended to examine all available technologies in a holistic manner and not merely understand the technical principle behind them. Accordingly, the OEMs were requested to explain all aspects as mentioned in the agenda, covering the following:

- Details of the TWFL Technology
- Indigenous availability of the Technology
- Yearly Manufacturing Capacity (Domestic & abroad)
- Cost aspects of the Technology.
- Information about the Utilities where the Product has been supplied and its performance there
- Present Usage & its effectiveness (based no feedback from respective customers)
- Development aspects w.r.t. Integration with the existing Protection systems

He emphasized that before recommending any technology for large-scale implementation, it would be necessary to verify whether sufficient manufacturing and deployment capabilities exist in the country. He also highlighted the importance of indigenous availability of such technologies in view of cybersecurity concerns and the Government's focus on promoting indigenous systems.

CE (PSE&TD), CEA also emphasized the importance of evaluating the cost implications of implementing such Systems and stated that Substations already have existing protection systems in place, and any new technology would function as an additional or value-added system. Therefore, the cost of implementation should be economical and justified by the benefits achieved, particularly in terms of improved fault location accuracy and faster restoration times. He requested the OEMs to clearly explain whether the operational benefits of these technologies would justify the overall implementation cost.

CE (PSE&TD), CEA further requested the OEMs to provide complete details regarding the minimum setup required for implementation, such as data acquisition systems, central processing unit, interfacing arrangements with the existing systems, GPS synchronization requirements, auxiliary power supply requirements, battery backup systems, etc. for a typical line and substation configurations. He also requested them to elaborate on space requirements, installation feasibility in the existing substations for such systems.

Thereafter, he requested (i) NRPC representative to present the findings and observations brought out by the NRPC Sub-group in its report, and (ii) OEMs attended to present their technologies to the Committee.

B. NRPC Presentation

Representative from NRPC gave a brief presentation **(Annexure-II)** regarding the report of the Sub-group constituted for implementation of TWFL Systems on critical transmission lines in the Northern Region. He informed about the observations made by the Sub-group based on field

visits, discussions with utilities, and analysis of fault data from transmission lines where TWFL Systems have already been installed. Following are the salient points of the Presentation.

(a) It was explained that on-line TWFL Systems had been installed on transmission lines connected to the 765/400 kV Meerut Substation, including the Meerut–Bhiwani line and Meerut–Moga line.

(b) NRPC representative presented a comparison between fault locations detected by conventional Main-1 and Main-2 distance protection relays and those detected by online TWFL Systems. Referring to one of the fault cases on Koteshwar-2 line, it was stated that the Main-1 relay indicated the fault location at around 117 km, whereas the TWFL system indicated the location at around 128 km. The same location was subsequently confirmed through physical patrolling at approximately 128 km. It was highlighted that the differences between the TWFL indication and the actual fault location was negligible. Similar observations were discussed for other fault instances as well.

(c) It was noted by the Sub-group that the mismatch between the fault location detected by Online TWFL and the actual patrolling location remained very small, generally within one tower span or around 0.5 km. In contrast, the fault location indicated by Main-1 and Main-2 relays showed considerable variation in several cases. The mismatch between relay indication and actual fault location was stated to be in the range of 6 km to 20 km in some instances. Such inaccuracies were observed to increase the time required for manual patrolling and restoration of transmission lines.

(d) PGCIL had installed on-line TWFL systems on several other transmission lines as well and had observed similar performance benefits in almost all cases.

(e) The technology had proven particularly beneficial for long transmission lines (exceeding 300 km) in length and difficult terrain where manual fault identification is time-consuming.

(f) The major benefits highlighted included reduction in outage duration, improvement in system availability, enhancement of reliability indices, and reduction in manual patrolling efforts. It was also emphasized that faster restoration of transmission lines contributes significantly to grid security, particularly for renewable energy evacuation corridors and nuclear power transmission lines where prolonged outages may lead to generation backing down and grid instability.

(g) In India, Online TWFL systems manufactured by GE Vernova and Qualitrol are currently available. At the global level, Online TWFL System manufactured by SEL and Kehui are also available.

(h) The indicative cost is approximately ₹18 lakh for a single-circuit/single-line module and around ₹1 crore for an eight-line module. The cost includes supply, installation, testing and commissioning.

(i) Based on the discussions, field visits and analysis carried out by the Sub-group, phased implementation of TWFL systems were recommended. It was recommended that, in the first phase, TWFL systems may be installed on 220 kV and above transmission lines having length more than 200 km, renewable energy and nuclear power evacuation lines having length more than 150 km, transmission lines located in hilly terrain, and inter-regional transmission lines having length more than 150 km.

(j) The Sub-group further recommended that, considering the technical superiority and operational benefits of TWFL systems, a national-level policy and detailed implementation

guidelines may be formulated by CEA in coordination with CTUIL and other stakeholders for systematic implementation of TWFL technology across the transmission network.

C. M/s GE VERNOVA Presentation

Representative from M/s GE Vernova delivered a presentation **(Annexure-III)** on their TWFL technology, its working principle, system architecture, applications and operational advantages. Following are the salient points of the Presentation.

(a) The primary objective of TWFL technology is accurate fault location on transmission lines. The technology does not depend upon line length, type of fault, conductor type, or conductor impedance, and therefore provides fault location accuracy in meters.
(b) Whenever a fault occurs on a transmission line, high-frequency electromagnetic travelling waves in the range of approximately 100–500 kHz are generated at the fault point and travel towards both ends of the line at nearly the speed of light. By capturing these travelling waves at both substations and synchronizing the records using GPS time stamps, the exact fault location can be calculated accurately.
(c) He informed that GE Vernova is having both Single ended and Double ended TWFL technology. In case of Single ended TWFL, the setup is installed only at one end. However, the accuracy of Single ended TWFL is less in comparison of Double ended TWFL.
(d) In case of the Double ended TWFL, complete setup is installed at both ends of the transmission line and includes a central processing unit, acquisition unit, GPS receiver and DR Manager software. The acquisition units capture high-frequency signals, while the GPS provides accurate time synchronization. Communication between the two Substations through an Ethernet link is necessary for exchange of travelling wave records required for double-ended fault calculation. He explained that double-ended methods are preferred over single-ended methods because they rely only on direct travelling wave pulses and provide better accuracy, whereas single-ended methods depend on reflected pulses using it may sometimes become difficult to detect the fault location accurately.
(e) GE Vernova TWFL solution consists of the RT430 GPS receiver, RPV311 central processing unit, RA333 acquisition unit and DR Manager software. It was stated that the system provides a typical fault location accuracy of less than 150 meters with automatic fault location capability and SCADA integration support.

CE (PSE&TD), CEA sought clarification regarding the applicability and effectiveness of Online TWFL technology on long HVDC transmission lines, particularly 800 kV HVDC systems in India. In response, GE Vernova representative informed that the technology had already been implemented globally on HVDC lines and stated that detailed performance data could be shared separately after consultation with the global Project team.

CE (PSE&TD), CEA also enquired regarding the effectiveness of Online TWFL systems on mixed overhead and underground cable configurations commonly encountered near renewable energy evacuation systems and metropolitan areas. The discussion particularly focused on configurations involving overhead line–underground cable–overhead line combinations and whether the technology could effectively identify faults under such arrangements. Representative from M/s GE Vernova informed that detailed implementation data and field performance information regarding such applications in India would need to be obtained from the project team and could be shared subsequently.

Further CE (PSE&TD), CEA observed that most substations already have GPS systems installed and suggested that instead of supplying separate GPS equipment, the existing GPS may be used for time synchronization. In response, the representative from M/s GE Vernova clarified that the Online TWFL system generally uses GPS equipment with fibre optic output ports; however, if the existing station GPS system conforms to the required IRIG-B standards and spare ports are available, the existing GPS system could also be utilized. On this, it was stated that all available GPS systems generally conform to IRIG-B standards, and requested to examine the feasibility of using spare ports available from the master clock or the connected systems.

CE (PSE&TD), CEA emphasized that new technologies should conform to the existing Utility Standards and should not impose proprietary requirements on Substations. Representative from M/s GE Vernova clarified that the Online TWFL system conforms to Standard protocols. Further, compatibility with existing infrastructure could be explored during implementation.

Referring to the indicative cost figures already presented by NRPC, wherein the approximate cost ranged from ₹15–20 lakh for a single-line module and around ₹1 crore for an eight-line module, he sought to know the space, power supply and auxiliary requirements that would be required for deploying GE system. Representative from M/s GE Vernova informed that the Online TWFL equipment can operate on both AC and DC supply, though DC supply is preferred, and that the System normally utilizes existing station auxiliary DC supply without requiring a separate UPS arrangement.

CE (PSE&TD), CEA further elaborated on the importance of TWFL systems for renewable energy evacuation corridors and long transmission lines. It was observed that renewable energy grid pooling stations are generally connected through long 765 kV, 400 kV or HVDC transmission corridors. Therefore, the effectiveness of Online TWFL technology on such long transmission lines also must be clearly demonstrated before large-scale adoption. GE acknowledged the observations and agreed to provide further details and supporting data separately.

D. M/s Megger (India) Pvt. Ltd. Presentation

Representative from M/s Megger (India) Pvt. Ltd. [Megger] delivered a presentation **(Annexure-IV)** on the overhead line fault locator and analyzer solution for transmission and distribution networks. Following are salient points of the Presentation.

(a) The proposed System of Megger is an off-line fault location and analysis solution which is capable of identifying permanent open circuits, short circuit faults and high impedance faults on overhead transmission lines. The system combines both fault location and line signature analysis functions within a single unit, thereby enabling not only fault identification during breakdown conditions but also predictive analysis of developing defects and insulation weaknesses.

(b) The equipment includes on-board display, on-board analysis capability and graphical representation of test results. It was informed that the System works on the principle of signature analysis, wherein reference signatures of transmission lines can be recorded during healthy conditions and subsequently compared with later measurements taken during periodic maintenance activities. By comparing the signatures over time, utilities can identify developing insulation weaknesses, loose connections and line irregularities before they

evolve into major faults. The trend comparison allows utilities to understand the progression of faults and deterioration in the transmission line system.

(c) The proposed solution can inject test pulses of up to 1500 volts with operating frequencies ranging from approximately 100 kHz to 50 MHz. The System supports testing and fault location for transmission line lengths up to 2000 km. The claimed fault location accuracy of the system is within ±16 meters, while in practical applications the accuracy achieved has been close to 20 meters.

(d) The off-line method provides highly accurate results and can effectively complement existing online fault location techniques.

(e) M/s Megger has manufacturing and support facilities in India as well as globally in the UK, Germany, USA and Sweden.

(f) The approximate cost of one complete system is around ₹45 lakh, including the main instrument, training, calibration and associated accessories.

(g) Single unit can cater to multiple transmission lines connected to an entire 220 kV or 400 kV Substation, thereby reducing the need for separate Systems for individual lines.

(h) The solution has already been deployed in several Indian utilities including Tata Power, Adani utilities, UPPTCL, TSCL, JUSNL and utilities in Arunachal Pradesh.

CE (PSE&TD), CEA enquired regarding consistency of measurements under repeated testing conditions. Representative from Megger clarified that the System provides consistent readings even when tests are repeated multiple times. CE (PSE&TD), CEA further sought clarification on the effect of improper grounding or incorrect equipment connection during testing. In response, representative from Megger informed that the system includes safety and cut-off features, including ground loop detection and LED indications, which prevent signal injection unless proper connections are established. He further stated that the system will not allow operation if the grounding conditions are not satisfactory, thereby reducing the possibility of inaccurate measurements caused by improper setup. In this regard, the Committee opined that the technologies intended for field implementation should be easy to operate and should not require highly complex setup procedures.

Representative from Megger further informed that the Instrument can operate on both AC mains supply and an external battery-based DC power pack. It was clarified that the instrument itself does not contain an inbuilt battery but can be operated using a UPS or external DC battery arrangement wherever AC supply is not available in the Switchyard. He further stated that external battery arrangement can support operation for approximately eight hours and is charged through normal AC supply. CE (PSE&TD), CEA stated that field deployment in switchyards may require battery-based operation because AC supply may not always be conveniently available near the testing location. In response, representative from Megger clarified that the system can derive AC supply from nearby marshalling boxes or alternatively use the provided battery power pack during field operations.

CE (PSE&TD), CEA also enquired about the extent of deployment of the technology within PGCIL and other utilities. In response, representative from Megger informed that only limited installations had been undertaken in PGCIL so far, mainly due to commercial competition and availability of deployment opportunities, but the company had been actively promoting the technology across utilities.

E. M/s Taurus MK Srinivasan Systems Pvt. Ltd.

Representative from M/s Taurus MK Srinivasan Systems Pvt. Ltd. (Taurus-MKS) delivered a presentation **(Annexure-V)** on the transmission line fault detection, preventive maintenance, and their off-line fault locating technology for Power transmission Systems. Following are the salient points of the Presentation.

(a) Representative from Taurus-MKS Highlighted the growing challenges in detecting faults in modern transmission networks, especially due to increasing use of polymer insulators. Unlike porcelain or glass insulators, polymer insulators do not show visible physical damage after flashover, making it difficult to identify the fault through conventional inspection methods. He also Emphasized the importance of preventive and predictive maintenance instead of only locating faults after a transmission line trips.

(b) The proposed approach of Taurus-MKS aims to reduce transmission line trippings by identifying weak points in advance. Similar to Transformer's Sweep Frequency Response Analysis (SFRA), where baseline signatures are compared over time to identify abnormalities, initial signature of line taken can be compared with the signature carried out during monitoring of transmission lines, to proactively identify the faults before they become severe.

(c) The presentation identified eight major categories of transmission line faults that account for nearly 99% of field failures observed over several decades. These include conductor breakage, loose jumper connections, conductor corrosion due to humidity or pollution, insulator degradation, phase-to-earth faults, phase-to-phase faults, conductor sagging causing reduced clearance, and vegetation-related faults such as tree or bamboo interference. Special mention was made to North Eastern Region (NER), where rapidly growing bamboo creates high resistance faults that are difficult to detect using conventional methods.

(d) Taurus-MKS claimed that "Offline Fault Locator" is a single solution for detecting these faults. The technology, developed under Made in India initiative since 1988, has been supplied to several Indian power utilities over the past 35 years.

(e) The System works on the principle of Time Domain Reflectometry (TDR), where a voltage pulse is injected into the transmission line and the reflected signal is analyzed to detect abnormalities. Unlike conventional methods that focus mainly on waveform interpretation, the System analyses changes in capacitance and impedance along the line to identify anomalies such as tree encroachment, insulator degradation, or conductor faults.

(f) The software output categorizes faults into three major groups: insulator or high resistance faults, phase-to-earth clearance issues, and phase-to-phase clearance issues. The reports also indicate the severity or "intensity" of the fault. Fault intensity levels ranging from 6 to 8 were categorized as permanent faults likely to trip the line, while lower intensity values represent developing or less critical faults. This feature enables utilities to prioritize maintenance activities and dispatch patrolling teams directly to critical locations, thereby reducing inspection time and improving maintenance efficiency.

(g) The cost of equipment is around Rs. 55 Lakhs for all voltages in HVAC.

CE (PSE&TD), CEA then inquired about the necessity of injecting so much higher voltages for accurate fault detection over long distances and in noisy transmission environments. In response, Taurus-MKS replied that earlier systems with 5 kV or 10 kV pulses were found insufficient for detecting high resistance faults such as bamboo interference in NER regions. Based on field Studies and trials, the System was upgraded to inject up to 20 kV impulses, improving signal-to-noise ratio and enabling accurate fault identification in transmission lines up to 400 km in length.

CE (PSE&TD), CEA inquired whether equipment can be used for HVDC, to which representative from Taurus-MKS replied that for HVDC systems, the technology can work for lines up to 1500 km.

CE (PSE&TD), CEA inquired about the safety features of the equipment with such high magnitude of pulses. Taurus-MKS replied that the instrument uses insulated cables rated for 40 kV and injects only very short-duration impulse signals lasting a few milliseconds, making the operation non-lethal and safe for operators. The equipment also includes protective arrangements through Lightning Arresters (LA) to safeguard both the User and the Instrument during lightning events.

Representative from PGCIL stated that equipment can only be utilized if line is fully isolated. It takes around half an hour to isolate a line. After isolating the line fully only, connection of this equipment to line can be carried out for obtaining the fault location.

In this regard, it was noted that the TDR-based technology works by isolating the faulty transmission line, injecting a high-frequency signal, and observing the reflected signal to identify the fault location. And it cannot be operated under charged line conditions.

F. Conclusion

Based on the presentations given by various OEMs of on-line and off-line travelling wave based fault locator technologies, the Committee noted the following technical aspects w.r.t. both the systems:

SN	On-line TWFL	Off-line TWFL
1	The on-line system relies on the inherent energy of the electro-magnetic transient that is generated during the fault occurrence, and uses time-snychronized end systems (consisting of data acquisition, data processing, data managing, and reliable data sharing arrangements) to detect the fault location	The off-line system relies on injecting a pulse of specific magnitude & frequency, and uses its reflection to detect the fault location
2	Because the magnitude of the transient is fixed and is available for only one-time, proper detection of the same by the end-systems is important. Because its intensity is bound to reduce based on condition & length of the line, and type of fault, double-ended system is more accurate than single-ended system	By using pulse of suitable intensity (as stipulated by OEM), the fault location can be accurately determined.
3	The fault location detection is automatic. But this requires putting place quite an elaborated set-up as mentioned above at both ends of the lines. This set up requires dedicated GPS systems for time synchronization, dedicated internet connection for data exchange, dedicated software for data processing, configuring DR's of Protection Relays at both	Fault location detection not automatic. After occurrence of the fault (line tripping), the off-line system has to be physically brought near to the faulty line's surge arrestor in the switchyard. And after ensuring the line is physically isolated, then the equipment is

	ends for same set of signals, and additional interfacing requirements imposed at both ends by the Fault locator system.	connected to the faulty line to detect fault location. Over all, one hour to two-hour time required to detect the fault location.
4	The on-line system once installed serves only those line(s) for which it has been has been configured	This system can be used for any line connected to any substation; hence highly flexible
5	Intended for immediate fault location detection	Apart from fault location detection, the off-line systems also serve as an effective solution for diagnostics, and preventive maintenance.

The committee noted the promising nature of the TWFL technology while emphasizing the need for comprehensive evaluation before formulation of any national-level implementation policy or guidelines. CE (PSE&TD), CEA concluded the meeting with the remarks that a detailed set of technical and operational queries would be circulated to all OEMs, and the next meeting would be convened after obtaining all relevant details.

The meeting ended with thanks to all the participants.

*****

Annexure I

List of Participants

CEA

1. Sh. N.R.L.K. Prasad, Chief Engineer (PSE&TD)
2. Sh. Pankaj Kumar Verma, Deputy Director (PSE&TD)
3. Smt. Rashmi, Assistant Director (PSE&TD)
4. Sh. Manthan Sharma, Assistant Director (PSE&TD)

NRPC

1. Sh. Om Kishor, EE

NERPC

1. Sh. V. Muncha, Director

GRID INDIA

1. Sh. P. P. Chand, DGM
2. Sh. Deepak Kumar, Dy. Manager

POWERGRID

1. Sh. Anurag, GM , Engg-SS

MSETCL

1. Sh. Manoj Joshi, Superintending Engineer (ACI&P)

M/s GE Vernova

1. A. Gokulakrishnan

M/s Megger (India) Pvt. Ltd.

1. Sh. Shivaraj TS, Design Product Manager
2. Sh. Paila Ganesh, BDE& Application Engineer

M/s Taurus MK Srinivasan Systems Pvt. Ltd.

1. Devaki Srinivasan, Director
2. Sridevi, VP-Technology
3. Narasimha, VP-Technology

Annexure-II

PRESENTATION ON THE REPORT OF THE SUB-GROUP FOR IMPLEMENTATION OF TRAVELLING WAVE FAULT LOCATOR (TWFL) ON CRITICAL TRANSMISSION LINES IN THE NORTHERN REGION

Annexure-II

Background

- In the 55th TCC and 80th NRPC meeting, a proposal of PGCIL for Implementation of Travelling Wave Fault Locator (TWFL) in Critical Renewable & NCR lines in Northern Region was discussed and forum decided to formulate a sub-group comprising members from CEA, CTU, NRPC, NRLDC, Powergrid, Indigrid, ATIL, Sterlite, Sekura, RVPNL, PTCUL, HPPTCL and JKPCTL with the following Terms of Reference.

  - Formulate criteria to identify critical transmission lines that warrant the installation of TWFL, based on operational importance and reliability considerations.
  - Evaluate the restoration benefits of TWFL—specifically in terms of fault location and faster restoration—by comparing scenarios with and without TWFL, using data provided by Powergrid for lines where TWFL is already implemented.

- Accordingly, based on nominations received from concerned utilities, the sub-group was formed under chairmanship of SE(O&P) NRPC.

Annexure-II

Background

- Sub-group held two meetings on 28.08.2025 and 17.10.2025 respectively. Further, a physical visit at POWERGRID Meerut S/s was conducted by a team comprising of members from CEA, NRLDC, CTU and NRPC Secretariat on 19.09.2025 to understand the functioning of the TWFL system.

Annexure-II

Principle of Operation of TWFL

- When a fault occurs on a transmission line, sudden collapse of voltage and surge in current generates high-frequency electromagnetic transients, known as travelling waves. These waves propagate along the transmission line in both directions at a velocity close to the speed of light.

- TWFL systems detect the precise arrival time of the first wavefront at each line terminal using high-speed acquisition units synchronized through GPS. By correlating the arrival times at both ends and using known line length and wave propagation velocity, the fault location is calculated using time-difference algorithms. This principle is inherently independent of line impedance parameters, fault resistance, and power flow conditions.

Annexure-II

System Architecture and Implementation

- TWFL systems implemented in the Indian grid, particularly at POWERGRID substations, adopt decentralized architecture. Each transmission line is equipped with a dedicated travelling wave acquisition unit that captures high-frequency voltage and/or current signals. These acquisition units communicate with a central processing unit, which interfaces with the substation network and human–machine interface for analysis and visualization.

- Both single-ended and double-ended TWFL methodologies exist; however, the double-ended, GPS-synchronized approach provides the highest accuracy and robustness and is the preferred configuration for EHV and UHV transmission systems.

- The architecture integrates seamlessly with existing protection schemes and does not replace distance or differential relays. TWFL functions purely as fault location tool and operates independently of protection tripping logic.

Annexure-II

Field Experience and Observations

- A team comprising of members from CEA, NRLDC, CTU and NRPC Secretariat visited the 765/400 kV Meerut Substation on 19.09.2025 to understand the functioning of the TWFL system and to evaluate the benefits of its installation on transmission lines.
- At Meerut Substation, TWFLs have been installed on four 765 kV transmission lines, namely Meerut–Koteshwar Line-1 and Line-2, Meerut–Bhiwani Line, and Meerut–Moga Line. All the installed TWFLs are of GE (Reason) make and are based on a decentralized architecture.
- During the visit the PGCIL apprised about the details of the fault location recorded by TWFL at Meerut Substation for some of the faults in last two months as tabulated below:

Sr. No.	Line Name	Date	Time	M-1	M-2	TWFL		Patrolling Distance
				(km)	(km)	Local End (km)	Remote End (km)	(km)
1	Koteshwar-2	12.09.25	10:50:22	117.1	116.9	128.31	47.32	128.4
2	Koteshwar-2	18.09.25	04:57:07	92.8	89.69	74.37	104.32	74.9
3	Koteshwar-1	07.09.25	03:58:56	117.2	118.8	125.38	53.31	125
4	Moga	31.07.25	01:13:21	222.2	222.7	245.64	91.5	245.6
5	Moga	16.07.25	09:29:07	0.3	0.3	0	337.14	0.3

Comparison and Analysis

Annexure-II

- The details of some tripping incidents of 400 kV transmission lines where Travelling Wave Fault Locator (TWFL) is not installed are mentioned below:

Sr. No.	Name of Line	Line Length	Date & Time of Outage	Fault Location Mismatch	Outage Duration
1	400kV Agra-Bhiwadi-I	209.77	25.05.2020	15.74 kM	05:08 Hrs.
2	400kV Gurugram-Ballabgarh	37.80	05.05.2021	06.44 kM	18:38 Hrs.
3	220kV Anta-Lalsot	175.9	29.09.2021	15.1 kM	29:10 Hrs.
4	400kV Dehradun-Baghpat	164	28.04.2022	09.6 kM	08:48 Hrs.
5	400kV Kaithal-Hissar-II	113.15	30.06.2022	25.95 kM	15:16 Hrs.
6	400kV Mahendragarh-Bhiwani	65.71	14.08.2023	09.09 kM	07:48 Hrs.
7	400kV Roorkee-Kashipur-I	150.8	07.09.2023	12.08 kM	06:36 Hrs.
8	400kV Kanpur-Ballabgarh-I	385.7	01.12.2023	20.08 kM	21:12 Hrs.
9	400kV Hissar-Mahendragarh-III	111.72	13.12.2023	09.21 kM	19:23 Hrs
10	400kV Meerut-Bareilly-I	249.52	11.01.2025	03.29 kM	05:04 Hrs
11	400kV Dehradun-Baghpat	164	11.04.2025	11.49 kM	11:53 Hrs.
12	400kV Meerut-Mandola-II	59.75	13.07.2025	11.79 kM	12:14 Hrs.
13	400kV Kanpur-Ballabgarh-II	370.77	14.07.2025	06.51 kM	15:17 Hrs.
14	400kV Kanpur-Ballabgarh-I	385.7	18.07.2025	09.12 kM	12:57 Hrs.
15	400kV Bhiwadi-Hissar-III	144.08	29.07.2025	04.15 kM	06:44 Hrs.
16	400kV Roorkee-Kashipur-II	150.86	29.12.2025	06.27 kM	60:28 Hrs.
17	400kV Maharanibagh-Narela-III	57.20	02.01.2026	08:87 kM	05:56 Hrs

- In all the above cases, significant mismatch is observed between the actual fault location (as confirmed by patrolling) and the fault location indicated by Main-I and Main-II distance protection relays. The deviation ranges from 6 km to 20 km.

Comparison and Analysis

Annexure-II

- During the sub-group meetings POWERGRID presented following comparison of the distance shown by distance relays during faults, distance observed on TWFL and the actual fault location detected by the patrolling team on the lines on which TWFL has already been installed:

REGION	NAME OF ELEMENT	TRIPPING DATE (sample 01-12-2022)	TIME HRS (sample 00:00)	REASON (Type of fault)	Total Line length	Relay Details	Relay Details	Location as per TWFL (H)		Location as per Patrolling (J)		Error(in km) B	% error (B)
					in km	M-1 Distance	MAIN-2	From Station A	From Station B	From Station A	From Station B	(H-J)	
NER	400 KV New Mariani-Misa-2(404L)	24.07.2024	11:57		221.7	126.7	128.7	138.57	82.24	139	82	-0.24	-0.3
NERTS	400kV Misa-Silchar #1	29-05-2024	2:34		178.36	127	108.1	130.92	47.44	131.384	46.97	-0.47	-1.0
NERTS	400kV Misa-Silchar #2	01-05-2024	20:00		178.36	--	102.9	133.16	45.2	133.954	44.4	-0.8	-1.8
NERTS	400kV Misa-Silchar #1	26-06-2024	15:11		178.36	151.1	102.2	113.04	65.32	111.32	67.034	1.714	2.6
NERTS	400kV Silchar-Misa #2	23-07-2024	13:08		178.36	28.91	29.9	--	26.1	151.834	26.52	0.42	1.6
ER-1	765KV GAYA-VARANASI-2	21-05-2024	5:07	TRIPPED DUE TO R-N FAULT.	273.18	109.4	108.2	116.09	157.09	115.71	157.47	0.38	0.2
ER-1	765KV NEW RANCHI-DHARAMJAIGARH-1	11-05-2024	18:12	TRIPPED DUE TO R-N FAULT.	302	2.9	NA	1.24	299.76	1.3	300.7	0.94	0.3
ER-1	400KV RANCHI - SIPAT 2	07-05-2024	18:23	TO Y-N FAULT	404.5	23.16	NA	23.9	380.6	24.5	380	-0.6	-0.2
SR-I	765kV NIZAMABAD-WARDHA-1	21.10.2024	13:45	R-N fault	291.1	118	120	125.7	165.4	126	165	-0.4	-0.2
SR-I	765KV KURNOOL- NPS-2	18.08.2024	15:30	B-N fault	302.2	200	201	199.11	103.09	198.9	103.3	0.21	0.2
SR-I	JEYPORE- GAJUWAKA-2	27.08.2024	13:37	Y-N fault	225	13	10	2.43	222.07	2.5	222.5	0.43	0.2
SR-I	RAICHUR- KURNOOL-2	18.09.2024	3:37	Y-N fault	118.4	21.51	21.5	97.26	21.14	97.484	20.916	-0.224	-1.1
SR-I	RAICHUR-KURNOOL-2	29.09.2024	19:11	R-N fault	118.4	45.16	45.2	70.3	48.1	71.48	46.92	-1.18	-2.5
ODISHA	765KV SUNADARGARH-DHARMAJAYGARH-1	20-08-2024	4:48	R-N fault	151.5	22.1	22.9	23.4	128.1	24	127.5	-0.6	-0.5
ODISHA	765KV ANGUL-SUNDARGARH-II	05-09-2024	12:04	B-N fault	272	220.2	212.8	208.6	63.4	210	65	1.6	2.5
ODISHA	400KV JEYPORE-GAZUWAKA-I	06-09-2024	17:45	B-N fault	225	43.43	41.1	55.24	170.1	53.67	171.33	1.23	0.7
NR3	765KV VARANASI-BALIA	27-08-2024	16:44:00	B-N fault	167.676	125.10	125.3	141.9	24.72	142.57	25.106	0.386	1.5
NR3	765KV AGRA-FATEHPUR-II	14-11-2024	4:38:00	B-N fault	334.308	89.00	88.7	84.72	249.92	84.95	249.358	-0.562	-0.2
NR3	765KV AGRA-FATEHPUR-II	14-11-2024	4:42:00	B-N fault	334.308	89.50	89	85.15	249.53	84.95	249.358	-0.172	-0.1
NR3	765KV AGRA-FATEHPUR-II	14-11-2024	4:53:00	B-N fault	334.308	77.70	77.4	82.46	252.21	84.95	249.358	-2.852	-1.1
NR3	765KV AGRA-FATEHPUR-I	20-11-2024	5:49:00	Y-N fault	333.582	293.30	294.5	302.96	31.2	302.282	31.3	0.1	0.3
ER-1	400KV BIHARSHARIF-BALIA-1	09/28/2024	16:08	Y-N fault	241.79	119.30	120.9	122.98	118.81	123.49	118.3	-0.51	-0.4
NR-1	765kV PHAGI(RRVPNL)-GWALIOR-1	07/02/2025 2:22:00 AM	03-07-2025 02:07	R-N fault. Gwalior_gis_ais	306.21	181.2	119.3	185.65	120.49	189.24	120.92	0.43	0.4
NR-1	765kV BHIWANI-MOGA	05/02/2025 3:40:00 AM	02-05-2025 09:18	B-N fault. Moga765_ais_g	273	33.31	239.69	Distance not fetched	238.86	33.7	239.3	0.44	0.2
NR-1	765kV KOTESHWAR-MEERUT-2	03/15/2025 3:05:00 AM	15-03-2025 03:05	Y-N fault. Koteshwar765:	175.63	37.84	134.1	38.49	137.14	38.498	137.14	0	0.0
NR-1	765kV KOTESHWAR-MEERUT-1	02/21/2025 4:38:00 AM	21-02-2025 04:38	B-N fault. Koteshwar765:	179.27	74.44	100.47	73.86	104.83	77.42	101.85	-2.98	-2.9
NR-1	765kV CHITTORGARH-AJMER-1	01/13/2025 5:23:00 AM	15-01-2025 07:20	R-N fault. Chittorgarh:6.1	211.79	36.86	161.1	37.35	174.04	37.758	172.934	-1.106	-0.6
NR-1	765kV KOTESHWAR-MEERUT-1	01/01/2025 8:54:00 PM	02-01-2025 16:07	Y-N fault. Koteshwar765:	179.27	44.5	132.712	48.61	130.53	49.165	130.008	-0.522	-0.4

Comparison and Analysis

Annexure-II

- From the above data it is observed that there is significant difference in the fault location provided by TWFL than that indicated by Main-1 and Main-2 distance relays. Fault location provided by TWFL matches the actual fault location detected during patrolling with an accuracy within one tower span or approximately 0.5 km.

Annexure-II

Operational and System-Level Benefits

- TWFL systems consistently achieve fault location accuracy within ±100–500 meters, even on long transmission lines exceeding 300 km, mixed overhead–underground lines, and lines with series compensation or shunt reactors.

- The deployment of TWFL provides tangible operational benefits, including significant reduction in outage duration, improved system availability, enhanced reliability indices, and reduced manual patrolling effort. Faster restoration directly contributes to grid security, particularly for lines evacuating renewable and nuclear power, where prolonged outages can lead to generation backing down and grid instability.

Annexure-II

Availability and Cost Considerations

- TWFL devices manufactured by GE and Qualitrol are currently available in the Indian market. Additionally, TWFL devices manufactured by SEL and Kehui are also available globally.

- Based on recent procurement experience of PGCIL, the latest indicative cost of TWFL systems, including supply, installation, testing, and commissioning, ranges approximately for Rs.18 lakh for a single-line module to Rs.100 lakh for an eight-line module.

Annexure-II

Recommendations

- Recommendations of the Sub-group members are as under:

a. TWFL implementation may be taken up in phased manner. Following criteria may be used to identify critical transmission lines for installation of TWFL in the first phase:

   i. 220kV, 400kV and 765 kV lines having length more than 200Km.
   ii. 220kV, 400kV and 765 kV lines used for evacuating nuclear and RE Power having length more than150 Km.
   iii. 220kV and above lines in hilly terrain.
   iv. Inter-regional 220kV and above lines having length more than150 Km.

b. In view of the technical superiority, field-validated performance, and substantial operational benefits, it is recommended that a national-level policy be formulated for systematic adoption of TWFL technology. CEA, in coordination with CTU, and other stakeholders, may frame detailed guidelines for implementation of TWFL on both inter-state and intra-state transmission systems, aligned with the phased criteria finalized by the sub-group.

Annexure-II



Thank You

How many kilometers to patrol over dense forests?

How much error can you accept for underground or underwater Fault Location?

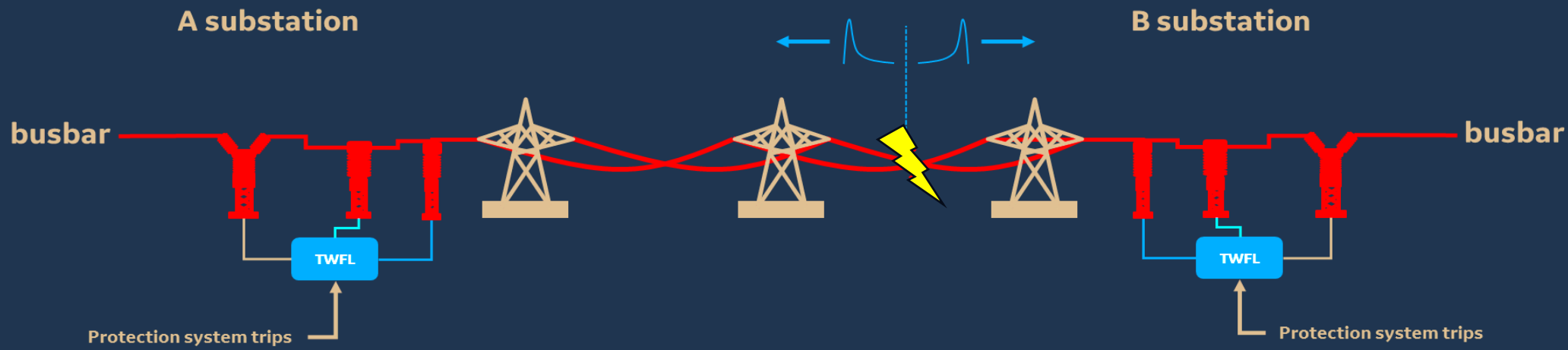
How much costs one hour with a line down?

Agenda

- Traveling Waves Fault Location – Introduction
- GE Reason TWFL Solution
- Double Ended TWFL advantages
- Summary

Traveling Waves Fault Location – The theory behind it

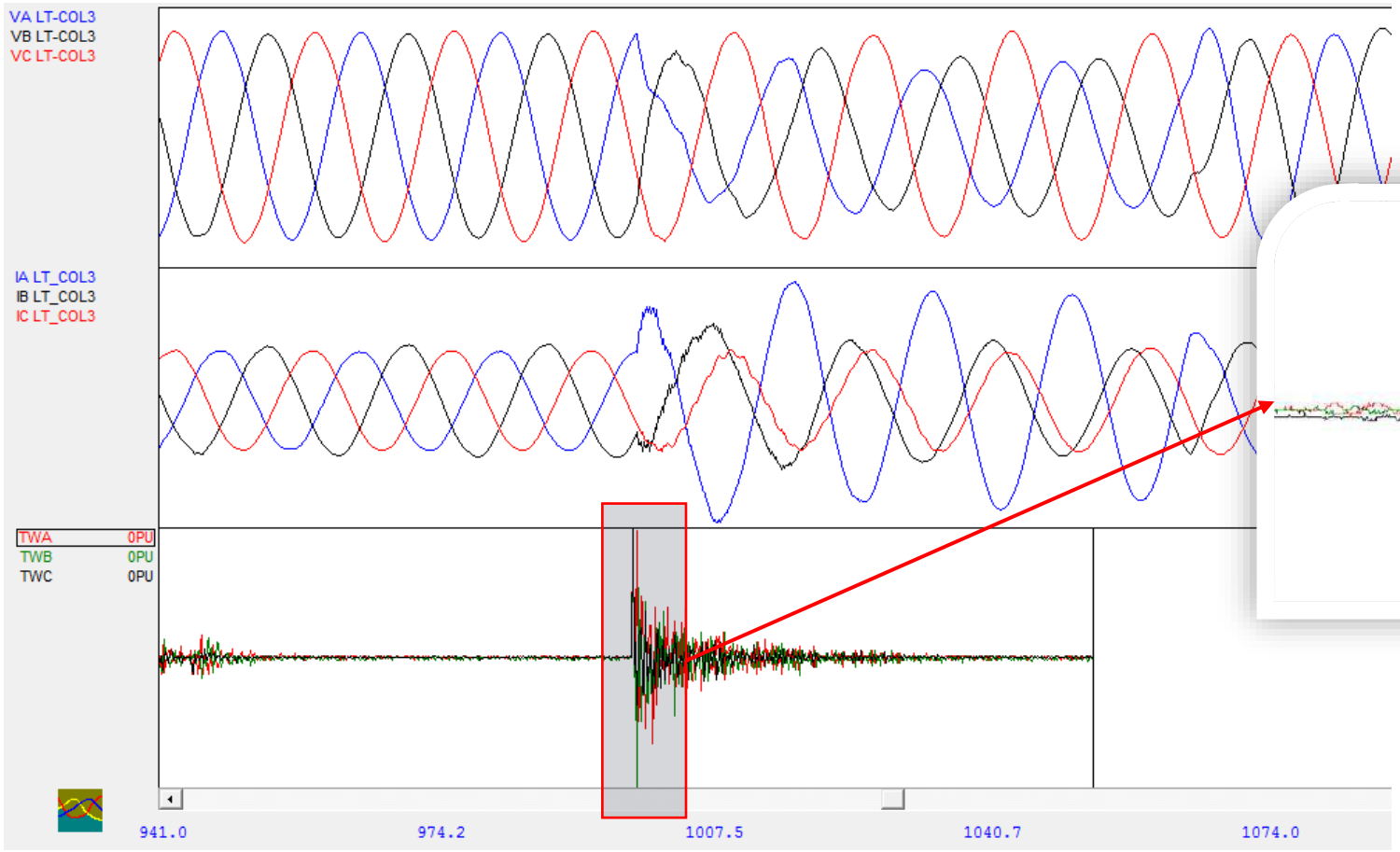
- Traveling Waves (TW) are High Frequency waves (100 ~ 500kHz) generated by Electromagnetic transients – Usually faults;
- TWs “travels” through voltages and currents in the electrical system from the faulty point to the near substations and lines;
- Since the 30’s researchers study ways to use these signals for grid applications but still not many products available;



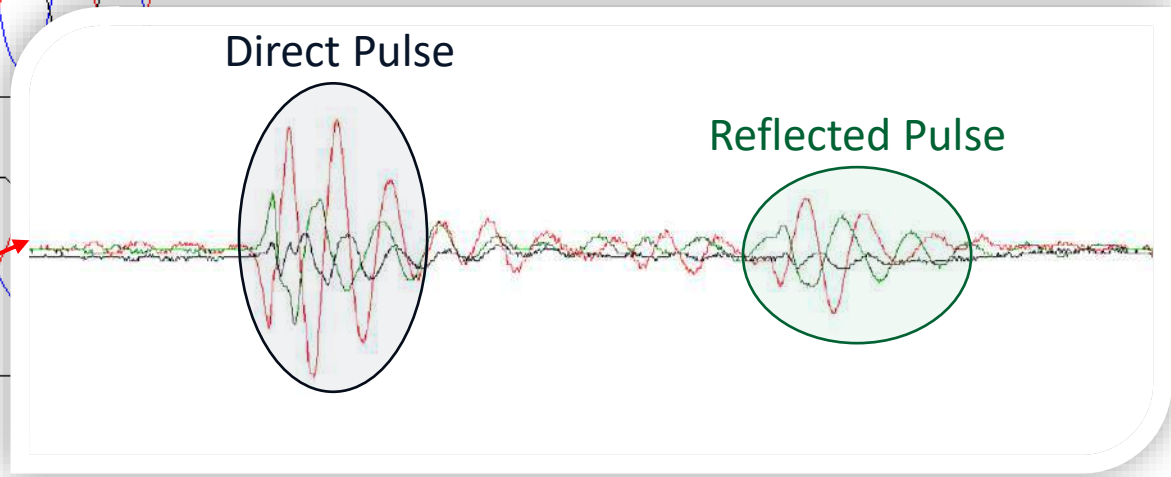
GE Renewable Energy

© 2020 General Electric Company. Proprietary. All Rights Reserved.

Traveling Waves – The shape of it



Real fault record from one terminal



TW waveform (zoom)

GE Renewable Energy

© 2020 General Electric Company. Proprietary. All Rights Reserved.

Annexure-II

GE TW Fault Location Solution

Accurate, Mature and Patented

GE Renewable Energy

GE TWFL Solution – Reason Product Line

GE Complete offering: RT430, RPV311 + RA333, DRmanager

Double ended TWFL

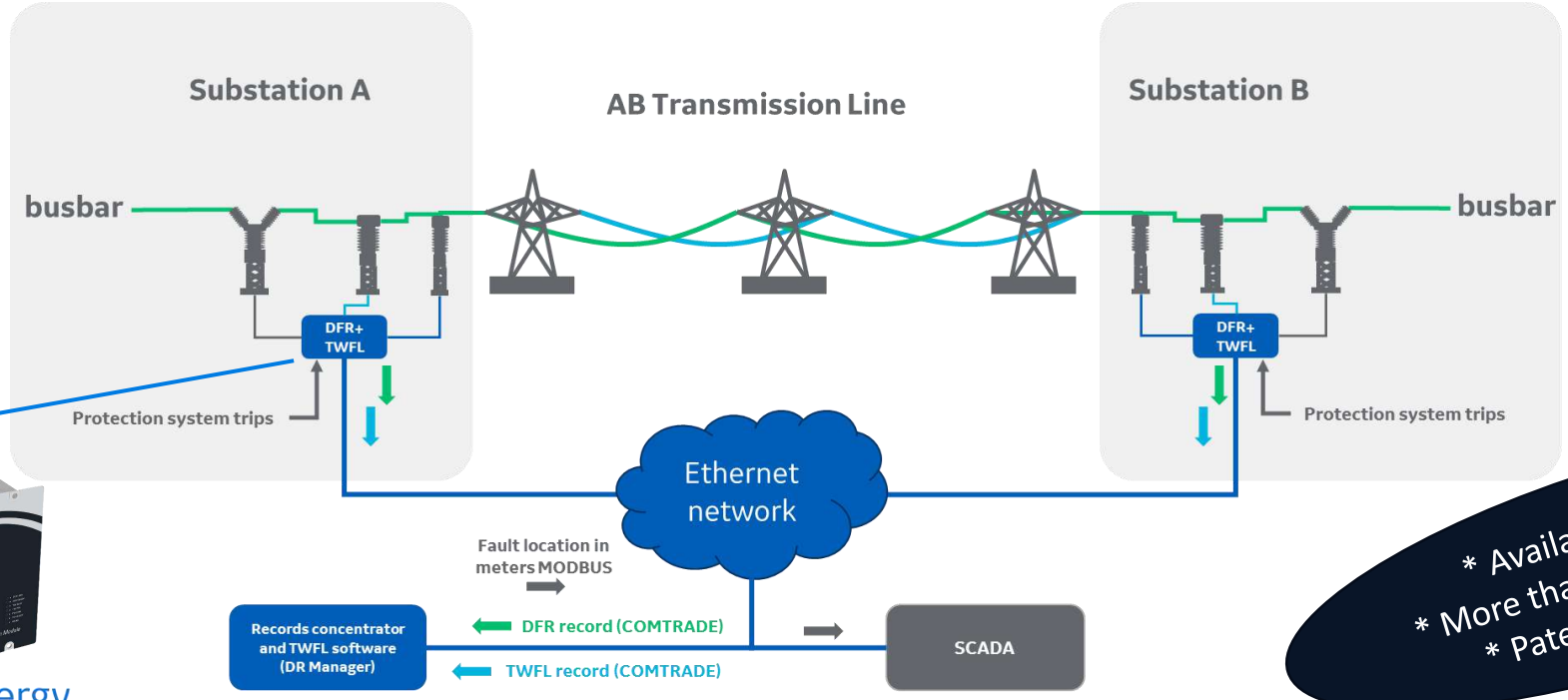
Typ. Accuracy < 150m

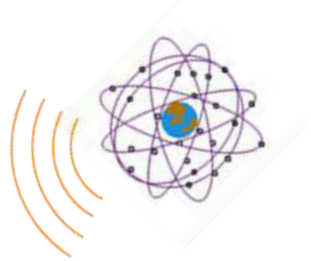
5Mhz Voltage Acquisition

Automatic Fault Location

Modbus to SCADA





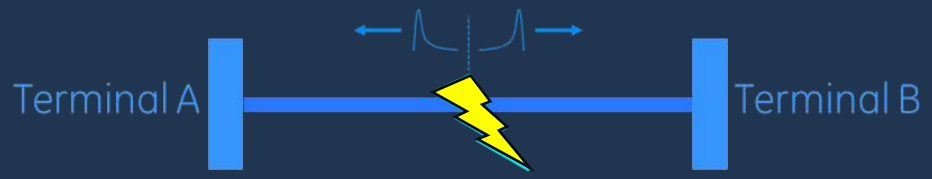


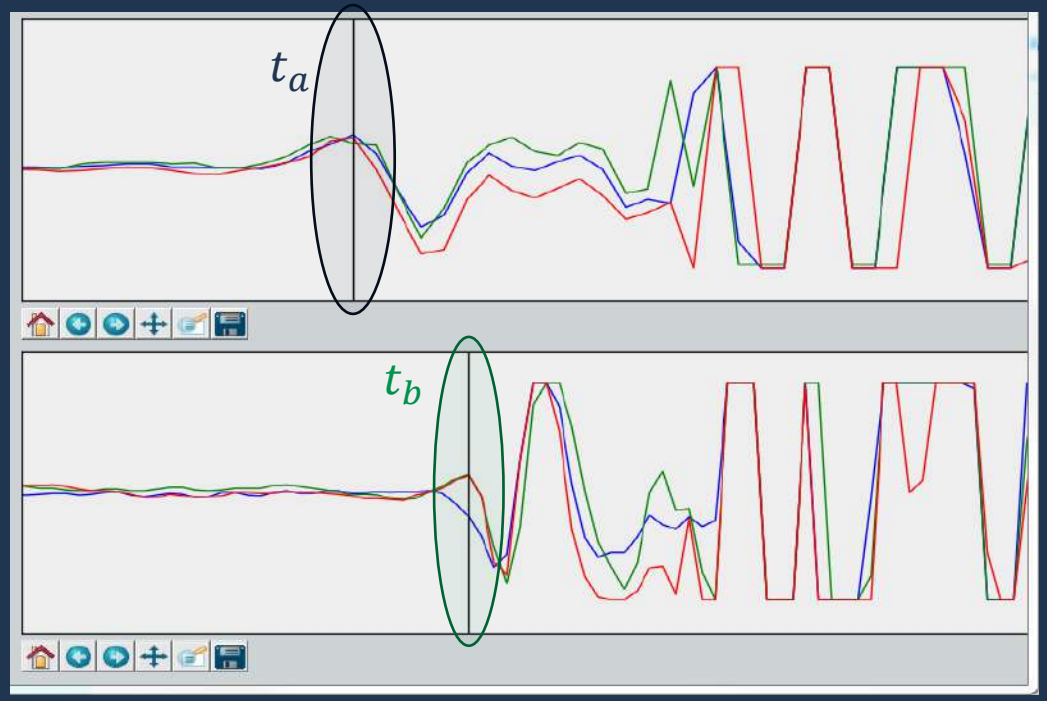
* Available Since 2008
* More than 300 lines Globally
* Patented Technology

GE Renewable Energy

© 2020 General Electric Company. Proprietary. All Rights Reserved.

GE TWFL Solution - How do we calculate fault location?





$$X_{Distance\ to\ fault} = \frac{l + k \cdot c \cdot (t_a - t_b)}{2}$$

l – line length
c – light speed
k – velocity factor
t_a – wavehead timestamp T_a
t_b – wavehead timestamp T_b

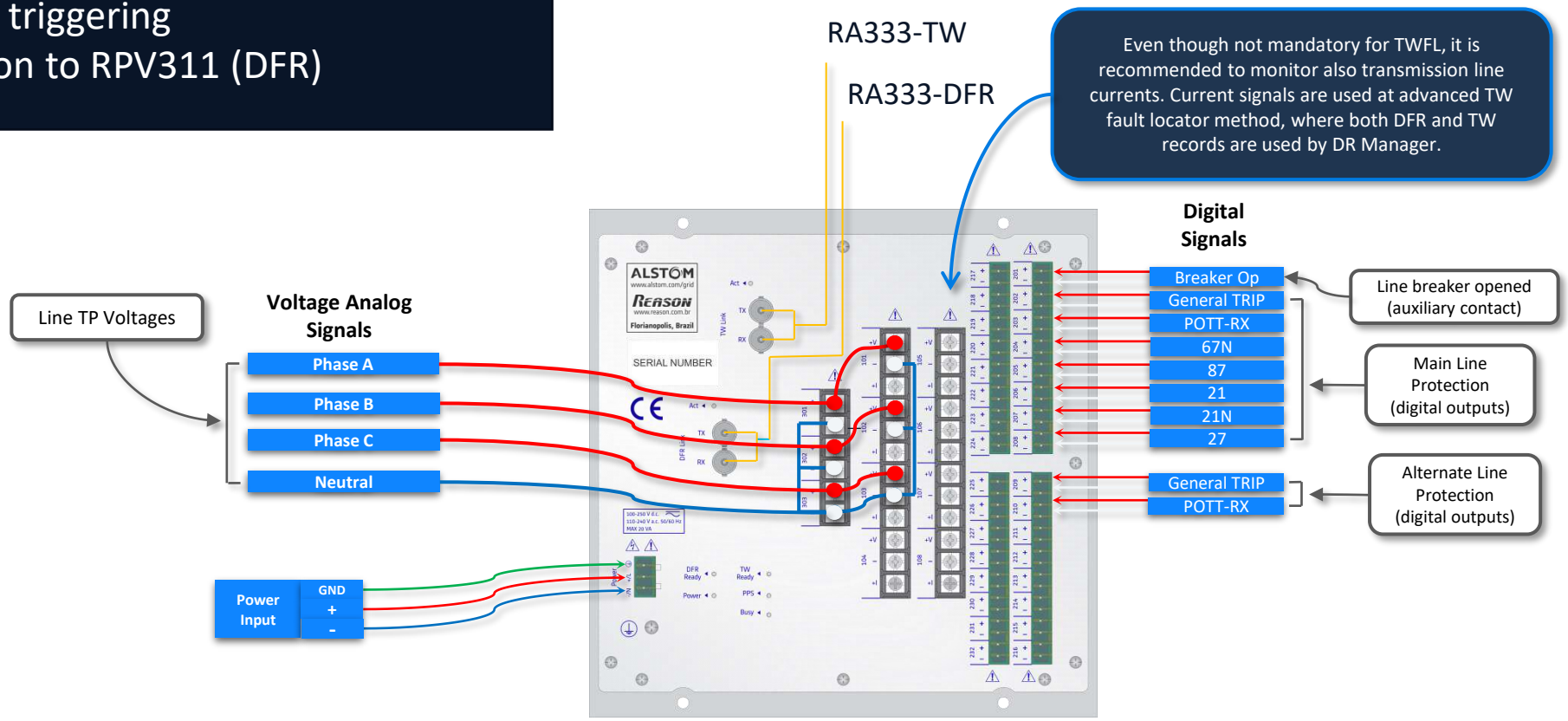
GE Renewable Energy

© 2020 General Electric Company. Proprietary. All Rights Reserved.

GE TWFL Solution – RA333 Remote Acquisition Unit

- RA333 - 5MHz Voltage Acquisition
- Possible to measure conventional voltages and Currents up to 15kHz;
- Recommended to measure digital signals from protection to configure triggering
- Point to Point connection to RPV311 (DFR)





GE Renewable Energy

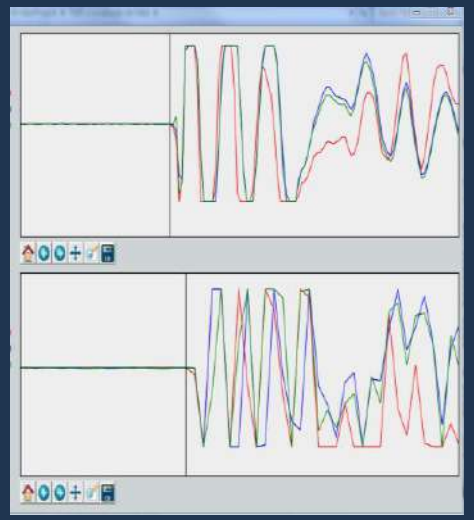
© 2020 General Electric Company. Proprietary. All Rights Reserved.

GE TWFL Solution – Real Cases and Applications

Accurate in any case

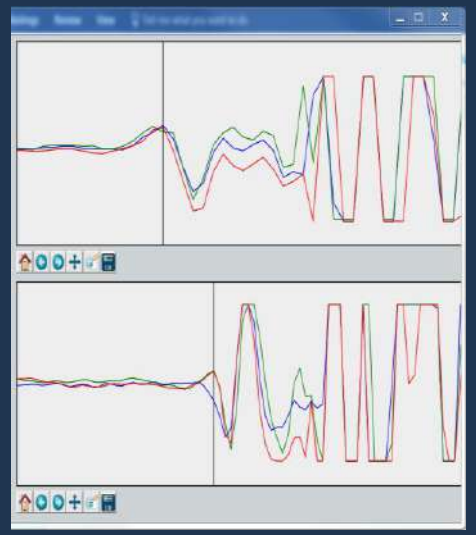
AC Overhead 500kV

Brazil:
- Samambaia – Serra da Mesa
- 248 km, 500kV, 60Hz
- Series Capacitance, Busbar reactors



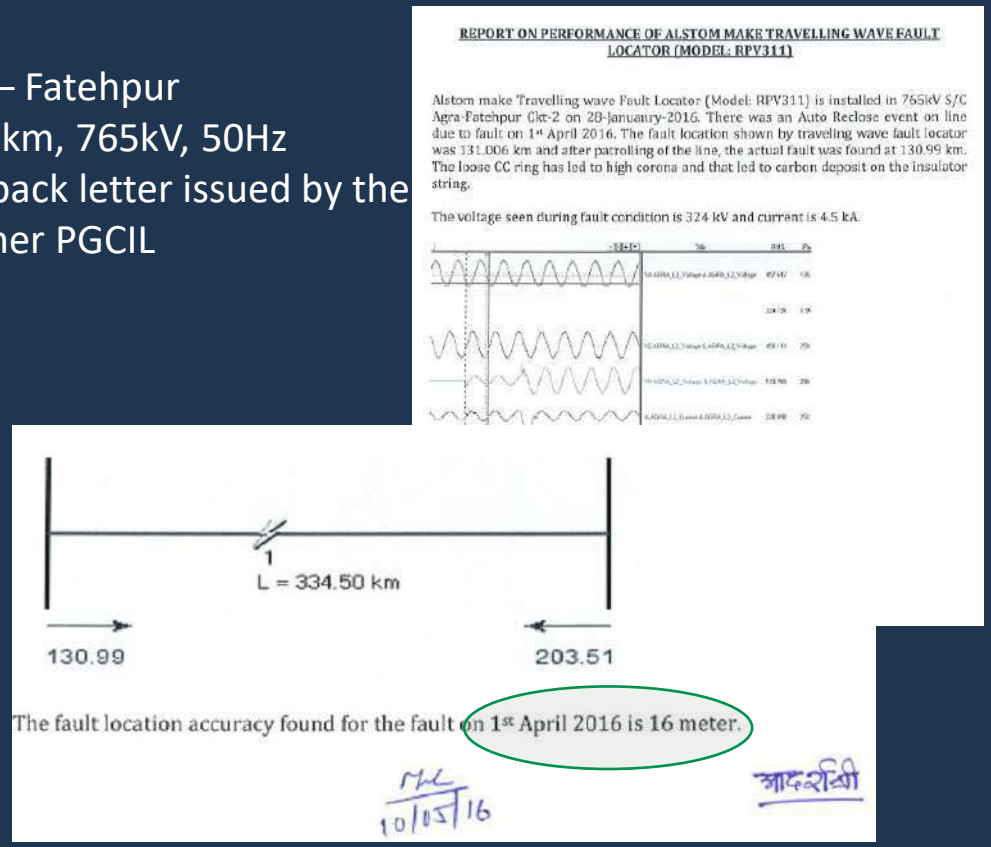
AC Overhead 230kV

Peru:
- Cajamarca – Kiman Ayllu
- 223km, 230kV, 60Hz



AC Overhead 765kV - Accuracy of 16m

India:
- Agra – Fatehpur
- 334.5km, 765kV, 50Hz
- Feedback letter issued by the customer PGCIL



REPORT ON PERFORMANCE OF ALSTOM MAKE TRAVELLING WAVE FAULT LOCATOR (MODEL: RPV311)

Alstom make Travelling wave Fault Locator (Model: RPV311) is installed in 765kV S/C Agra-Fatehpur Ckt-2 on 28-Januanry-2016. There was an Auto Reclose event on line due to fault on 1st April 2016. The fault location shown by traveling wave fault locator was 131.006 km and after patrolling of the line, the actual fault was found at 130.99 km. The loose CC ring has led to high corona and that led to carbon deposit on the insulator string.

The voltage seen during fault condition is 324 kV and current is 4.5 kA.

The fault location accuracy found for the fault on 1st April 2016 is 16 meter.

10/05/16

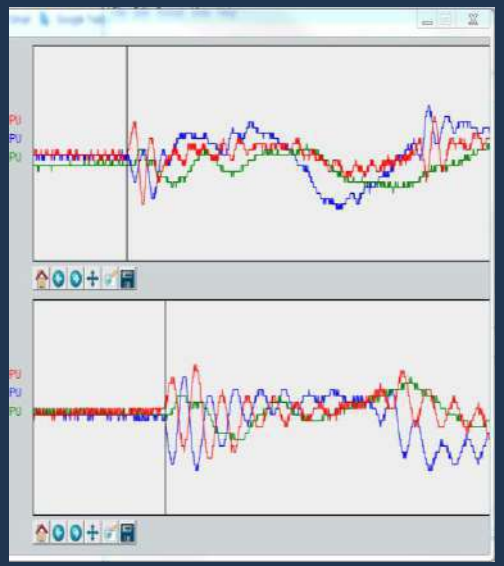
© 2020 General Electric Company. Proprietary. All Rights Reserved.

GE TWFL Solution – Real Cases and Applications

Perfect in many applications

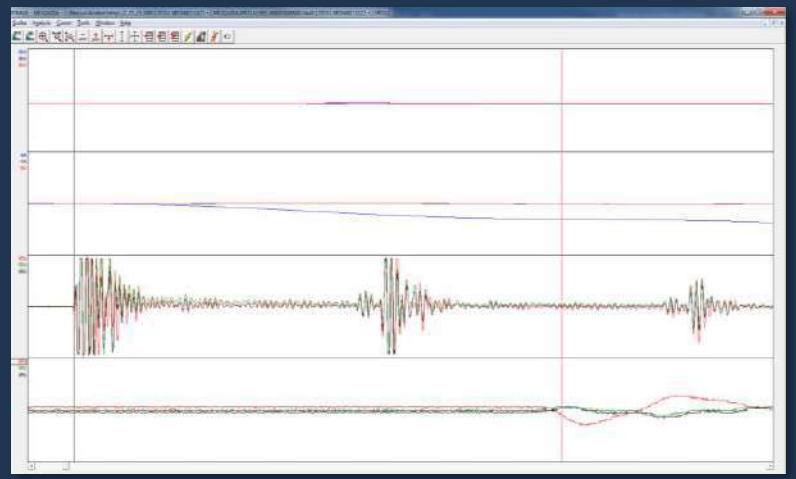
AC High Impedance Faults

Brazil:
- Miracema – Colinas
- 174km, 500kV, 60Hz
- Series capacitance Busbar reactors



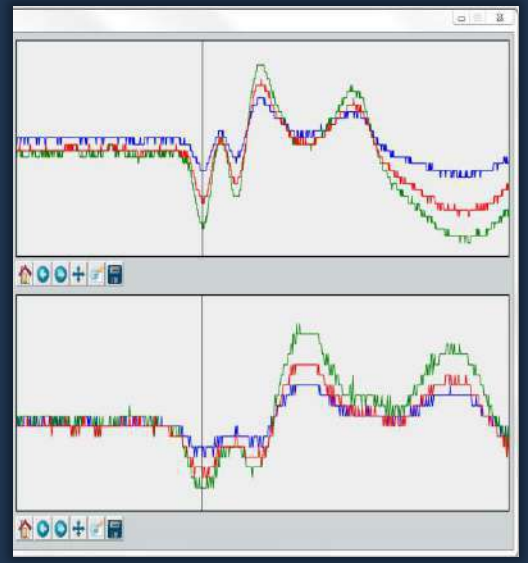
AC Mixed Lines

Spain:
- Ciudadela – Mesquida
- 51km, 132kV, 50Hz



HVDC Transmission Lines

Brazil:
- Porto Velho – Araraquara
- 2411km, 600kVdc
- 3150MW



GE Renewable Energy

© 2020 General Electric Company. Proprietary. All Rights Reserved.

GE TWFL Solution – Real Installed Base































Power Grid Corporation of India









TRUSTED IN AC AND HVDC APPLICATIONS – THE WORLD'S POWER HIGHWAYS

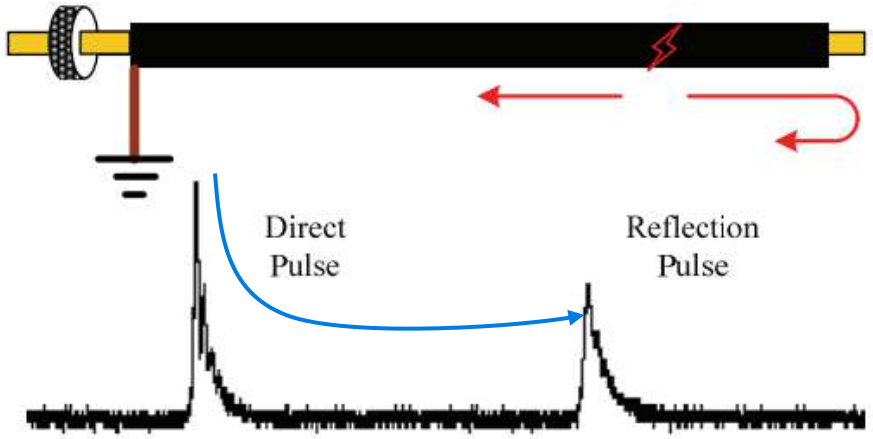
GE Renewable Energy

© 2020 General Electric Company. Proprietary. All Rights Reserved.

Double Ended TWFL advantages

And Single Ended disadvantages

Technical Strengths for double ended TWFL

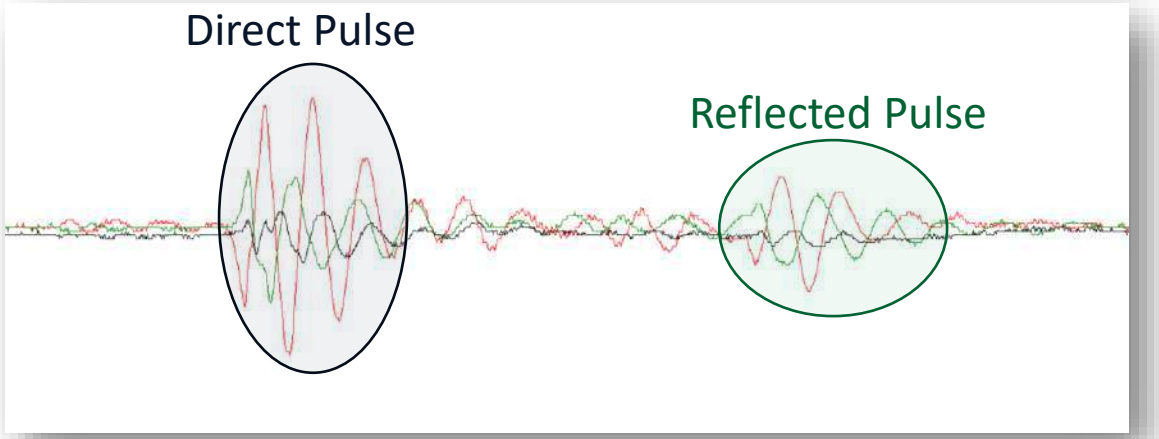


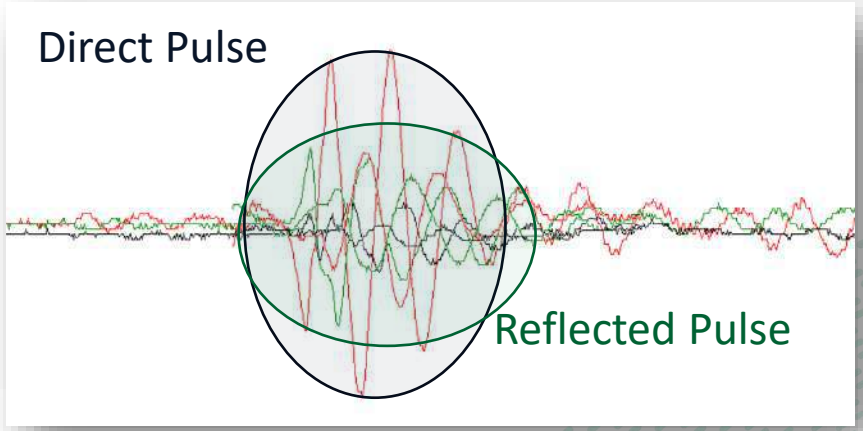
Double ended x Single Ended

- Double ended TWFL rely only on the arrival of the direct pulse generated by the event in each terminal
- Single Ended Fault Location rely on the detection of the direct pulse and the reflected pulse
- The reflected pulse is attenuated and depending on the type of fault and the distance from the measurement point it is difficult to be identified
- Simpler and more accurate algorithms can be applied using Double ended TWFL since the direct pulse is easier to identify than the reflected pulse

© 2020 General Electric Company. Proprietary. All Rights Reserved.

Single Ended TWFL Weakness





- Because single ended TWFL relies on the reflected pulses depending on where the fault happened, we might have a superposition of the direct pulse and the reflected pulse, becoming almost impossible to locate the fault
- In short lines it is not recommended to use Single Ended TWFL since in short lines the reflected pulse will always be very close to the direct pulse, becoming hard to have accurate fault location
- Non-linear lines (Hybrid lines or Railways) will have multiple reflections not related to the fault invalidating its method for such conditions

GE Renewable Energy

© 2020 General Electric Company. Proprietary. All Rights Reserved.

Double Ended TWFL is suitable for all type of applications

Applications not covered by Singled ended TWFL, but covered by Double ended

Switch-on to Fault	Short Lines	Mixed Lines	T lines	Railways
SOTF can only be located for all occasions by Double Ended Method	Short lines may have location with single ended since the reflected and direct pulse are too close	Each mixed section generates a non-linearity in the line and reflections. In this case only TW-D can be used	Reflections can travel through all segments making it hard to automatically locate the fault with Single Ended	Auto-Transformers impact generating reflections. In this case only TW-D can be used

© 2020 General Electric Company. Proprietary. All Rights Reserved.

Annexure-II

Summary

The main messages behind our TWFL Solution

GE Renewable Energy

Quick Summary

Main messages for TWFL

Accurate Fault Location Matters

Accurate Fault location is an important to reduce operational costs, outage times and improve system reliability

GE has a mature and proven tech

With Reason Product Line experience GE has more than 12 years of accurate TW fault location based on a patented and mature solution

Double Ended suits all cases

Double ended Fault location offers reliable fault location for all applications Railways, Mixed Lines, HVDC, High Impedance faults, etc…

An eye on the future

GE believes in TWFL as an important solution to improve the system and is constantly catching up with the new technologies

© 2020 General Electric Company. Proprietary. All Rights Reserved.

Annexure-II

GE TWFL Solution

Thank you!

GE Renewable Energy

Annexure-II

Annexure-IV

Megger

Overhead Line Testing System- Offline Fault Analyser

Presented by: Shivaraj TS



Content

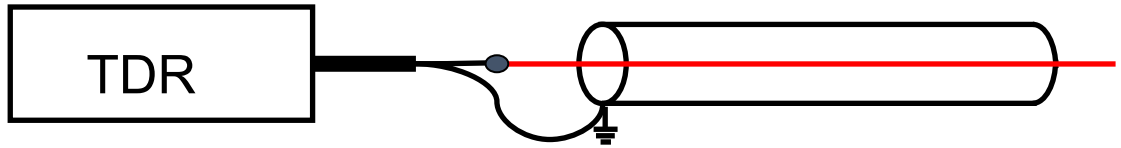
- Overhead Line Testing system-Introduction
- Working Principal
- Product Overview
- Technology Availability & capacity
- Cost Estimation
- Credentails



Megger

Overhead Line Testing system-working Principal

Technology for Fault finding and the principle of operation

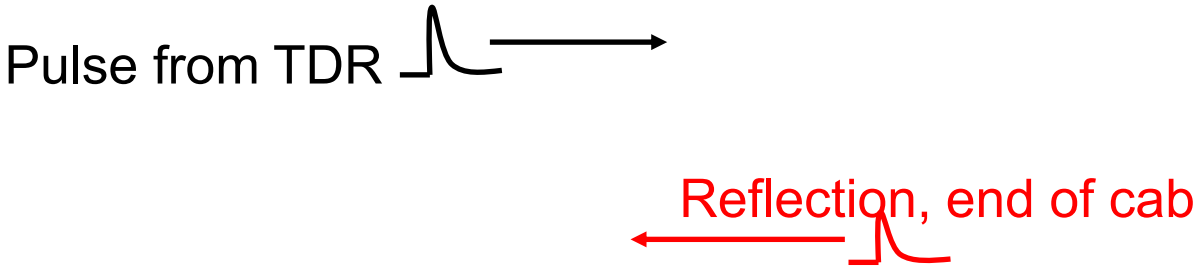


TDR stands for **Time Domain Reflectometry**.

It is like radar: A pulse is sent into the conductor .

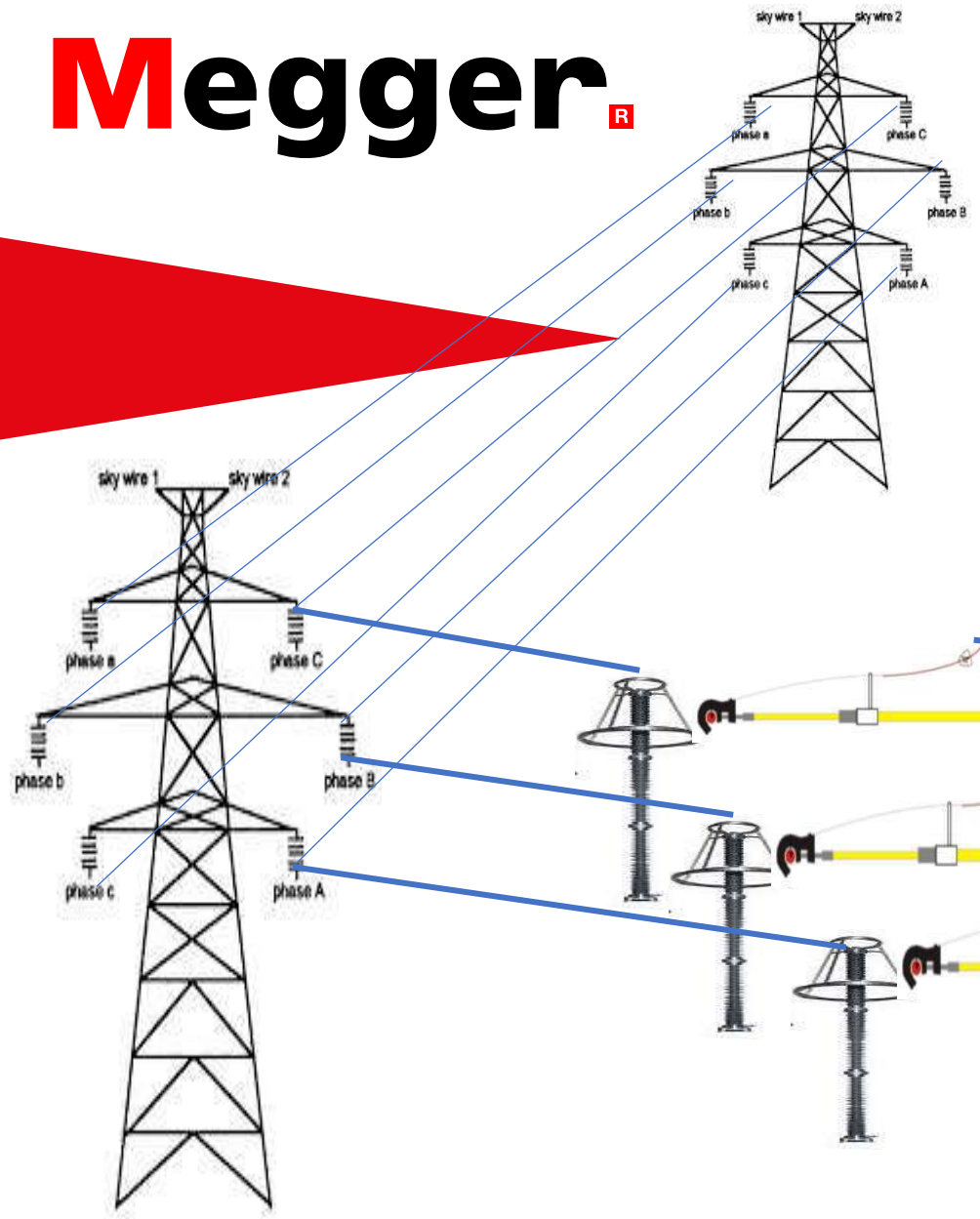
A change in Powerline impedance will reflect this pulse.

The time is measured between the transmitted and reflected pulse.



Megger

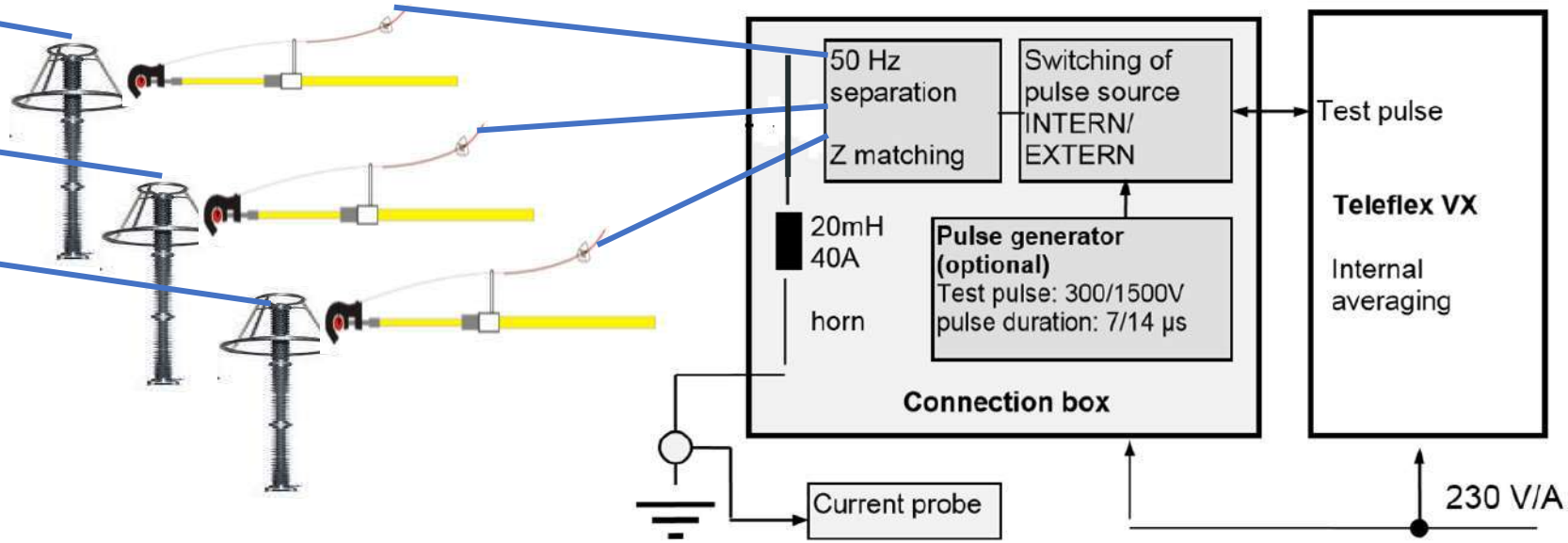
LINE CONNECTING DIAGRAM







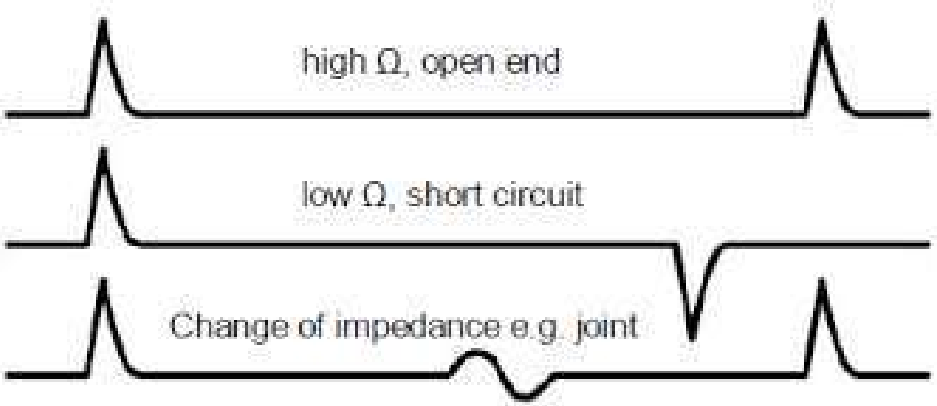
Test lead (with freely suspended 40 A wire fuse)



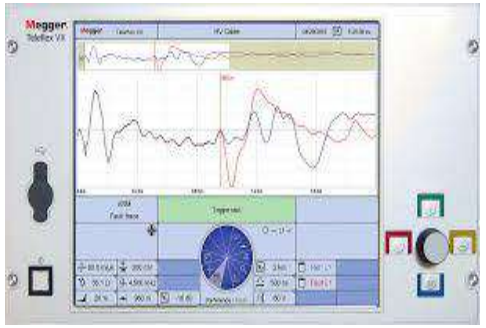
Over head Line Testing System

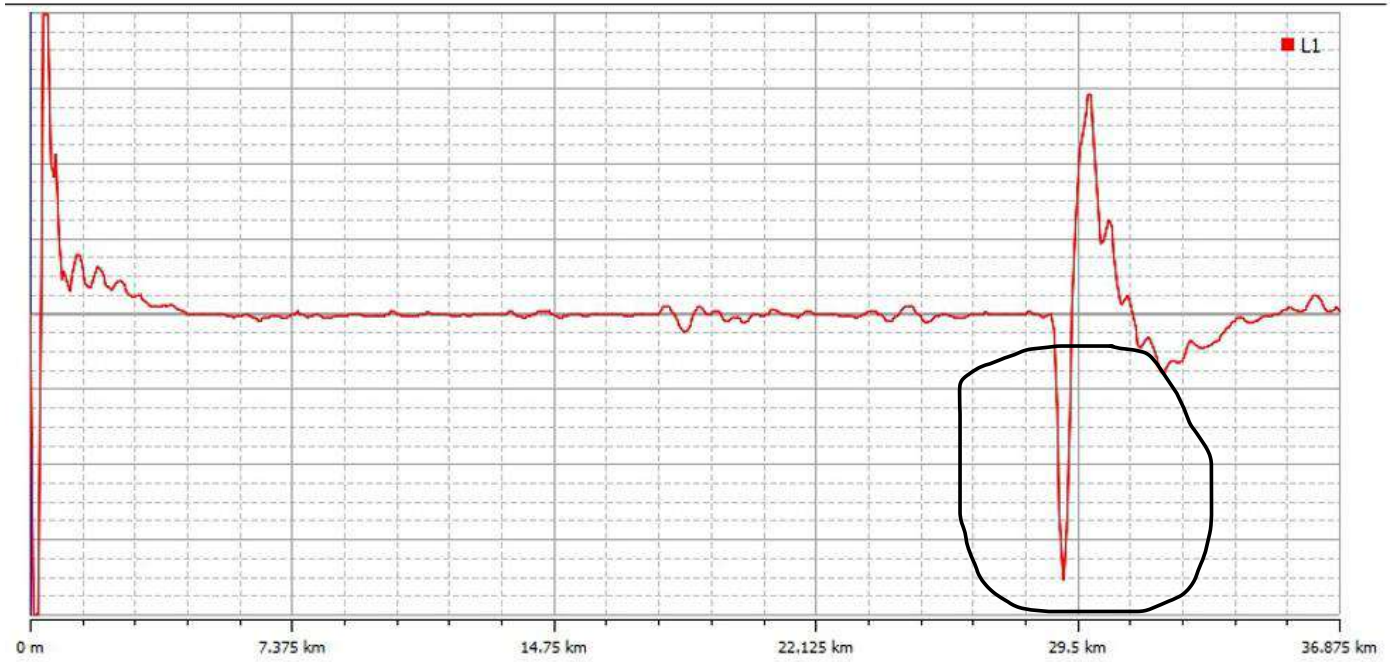
Megger

How the TDR represent the Fault Condition in a transmission line symbolically









Overhead Line Testing system-Overview

Megger Overhead Line Testing System- Two in one System

- Fault Locator cum Analyser

- Adapter for safe operation of Teleflex reflectometers on overhead line systems

- Used for testing on offline mode for overhead lines before re-energization/during fault condition

- Detects Short circuits/Open conductors/Intermediate impedance faults





Test pulse up to 1500 V

- Supports long-distance testing (>2000 km)

- Safe discharge of induced voltages

- High-resolution fault detection - +/- 20Mtr

- Easy operation and portable setup

Indigenous availability of the Technology & Capacity

Indigenous Availability in India.

Indigenous Substitutes: Highly competitive options developed by Megger under MII

- Core TWFL technologies are mainly developed internationally Major suppliers due to **Strategic Shift**: Indian power utilities are transitioning from manual patrolling to automated, locally designed offline fault Analyzers.
- Complex Grid Network
- Major Overhead Faults

Manufacturing Capacity (Domestic & Abroad)

Megger operates globally with manufacturing and support centers in:

- UK
- Germany
- **India (Mumbai)**
- USA
- Sweden

Global production supports utility-scale deployment worldwide.

-200+ units/year and can be expanded.

Cost Estimation

Cost Estimation & Capital Outlay (CapEx)

Investment Component	Cost (INR)	Description
Base Equipment Cost	₹45,00,000	1 Unit of Advanced Megger/Line Testing System.
Training & Calibration	₹1,50,000	Operator training and initial field calibration.
Total Initial CapEx	**₹46,50,000**	**Total upfront investment required.**

ROI Analysis & Payback

Assuming a conservative average of **4 major transmission line faults per year** across the targeted 132kV+ circles:

- **Gross Annual Savings**: ₹7,50,000 × 4 faults = **₹30,000,000**
- **Net Annual Benefit**: Gross Savings (₹30.0L) – OpEx (₹2.25L) = **₹27,75,000**

$$\text{ROI} = \left(\frac{\text{Net Annual Benefit}}{\text{Initial CapEx}} \right) \times 100 = \left(\frac{27,75,000}{46,50,000} \right) \times 100 = \mathbf{59.68\%}$$

- **Payback Period**: **1.68 Years** (~20 months to fully recover the capital investment).

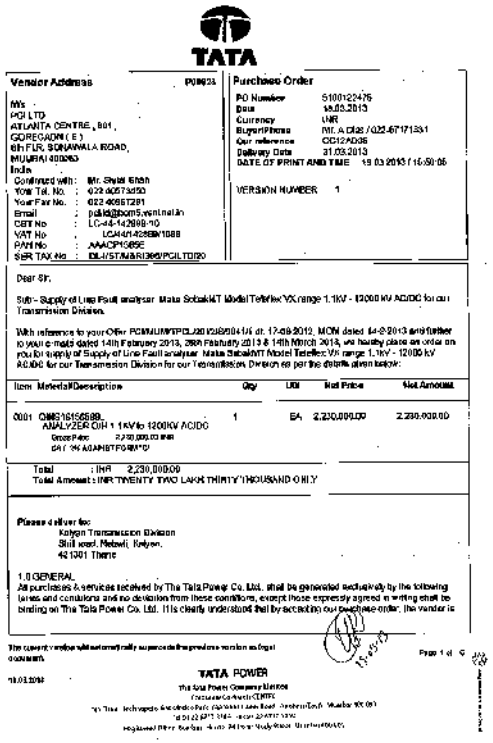
Financial Savings Framework

- **Average 132kV Outage Cost**: ₹1,50,000 per hour (Lost transmission tariff + grid deviation penalties).
- **Time Saved Per Fault**: 5 Hours (Restoration time cut from 6 hours down to 1 hour).
- **Total Savings per Major Fault**: 5 hours × ₹1,50,000 = **₹7,50,000 saved per breakdown**.



Megger

Credentials



TATA

Vendor Address

M/s
PGI LTD
ATLANTA CENTRE , 801 ,
GOREGAON (E)
6th FLR, SONAWALA ROAD,
MUMBAI 400063
India
Contact with : Mr. Shital Shah
Your Tel. No. : 022-40573450
Your Fax No. : 022-40567291
Email : pgild@bom5.vsnl.net.in
CST No : LC-44-142989-10
VAT No : LC44014289V1988
PAN No : AAACP1589E
SER TAX No : DLH/ST/M&R1369/PGILTD/20

Purchase Order

PO Number 5100122476
Date 18.03.2013
Currency INR
Buyer/Phone Mr. A Das / 022-67171351
Our reference CC12A035
Delivery Date 31.03.2013
DATE OF PRINT AND TIME 19.03.2013 (16:59:05

VERSION NUMBER 1

Dear Sir,

Sub:- Supply of Line Fault analyser Make Sebakmt Model Teleflex VX range 1.1kV - 12000 kV AC/DC for our Transmission Division.

With reference to your Offer PGIMUMTPCL2013030004 dt. 12-03-2013, MON dated 14-2-2013 and further to your e-mail dated 14th February 2013, 28th February 2013 & 14th March 2013, we hereby place an order on you for supply of Supply of Line Fault analyser Make Sebakmt Model Teleflex VX range 1.1kV - 12000 kV AC/DC for our Transmission Division for our Transmission Division as per the details given below:

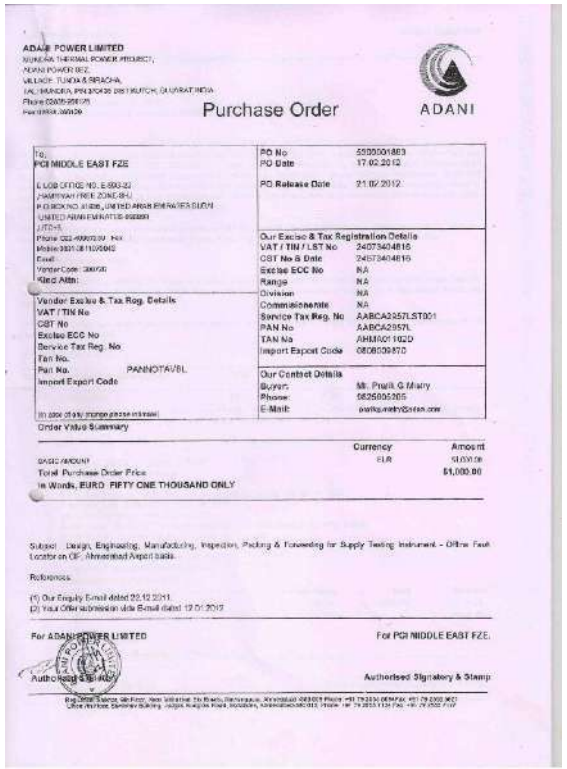
Item	Material/Description	Qty	UOI	Net Price	Net Amount
0001	CMG16155689 ANALYZER CUM 1.1kVto 12000kV AC/DC Gross Price : 2,230,000.00 INR DAT : 0% ADAMSTFORMED	1	EA	2,230,000.00	2,230,000.00

Total : INR 2,230,000.00
Total Amount : INR TWENTY TWO LAKH THIRTY THOUSAND ONLY

Please deliver to:
Kalyan Transmission Division
Shill road, Metewli, Kalyan,
421301 Thane

1.0 GENERAL
All purchases & services received by The Tata Power Co. Ltd. shall be generated exclusively by the following terms and conditions and no deviation from these conditions, except those expressly agreed in writing shall be binding on The Tata Power Co. Ltd. It is clearly understood that by acceptance of our Purchase order, the vendor is

TATA POWER



ADANI POWER LIMITED

Purchase Order

ADANI

To,
PGI MIDDLE EAST FZE

PO No 5500001803
PO Date 17.02.2012

PO Release Date 21.02.2012

Our Excise & Tax Registration Details
VAT / TIN / LST No 24073404816
CST No & Date 24073404816
Excise ECC No NA
Range NA
Division NA
Commissionerate NA
Service Tax Reg. No AABCA2957LST001
PAN No AABCA2957L
TAN No AHMM01102D
Import Export Code 0808009870

Our Contact Details
Buyer: Mr. Pratik G Mistry
Phone: 9825005305
E-Mail: pratik.mistry@adani.com

Vendor Excise & Tax Reg. Details
VAT / TIN No
CST No
Excise ECC No
Service Tax Reg. No
Tan No.
Part No. PANNOTAVBL
Import Export Code

Order Value Summary

	Currency	Amount
BASE AMOUNT	EUR	51,000.00
Total Purchase Order Price		51,000.00

In Words, EURO FIFTY ONE THOUSAND ONLY

Subject : Design, Engineering, Manufacturing, Inspection, Packing & Forwarding for Supply Testing Instrument - Offline Fault Locator on CF, Ahmedabad Airport India.

References

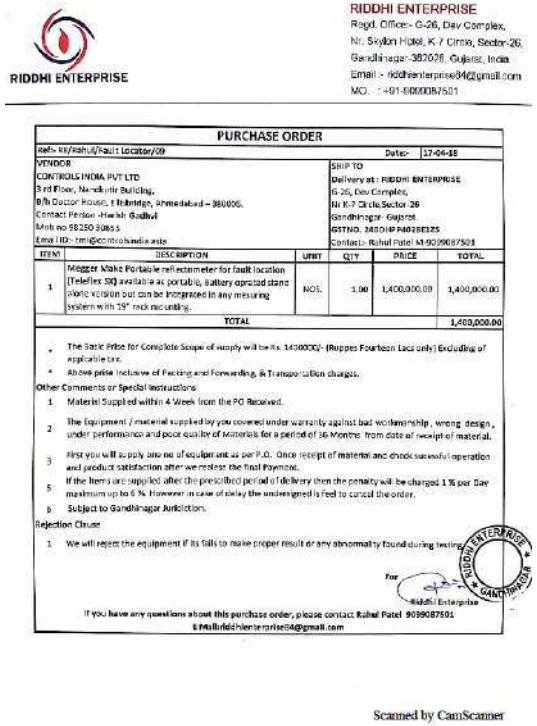
(1) Our Enquiry E-mail dated 22.12.2011
(2) Your Offer submission vide E-mail dated 12.01.2012

For ADANI POWER LIMITED

Authorised Signatory & Stamp

For PGI MIDDLE EAST FZE.

Authorised Signatory & Stamp



RIDDHI ENTERPRISE

RIDDHI ENTERPRISE
Regd. Office:- G-26, Dev Complex,
Nr. Skylon Hotel, K 7 Circle, Sector-26,
Gandhinagar-382026, Gujarat, India
Email :- riddhienterprise94@gmail.com
MO. :-+91-9099087501

PURCHASE ORDER

Ref:- Rd/Rahul/Fault Locator/09 Date:- 17-04-13

VENDOR
CONTROLS INDIA PVT LTD
3rd Floor, Nandkrite Building,
B/h Doctor House, Ellisbridge, Ahmedabad – 380006.
Contact Person -Hetish Godhvi
Mob no 98250 80855
Email ID:- cmi@controlsindia.asia

SHIP TO
Delivery at : RIDDHI ENTERPRISE
G-26, Dev Complex,
Nr K 7 Circle,Sector-26
Gandhinagar - Gujarat
GSTNO. 24BDIPP4028E1ZS
Contact:- Rahul Patel M-9099087501

ITEM	DESCRIPTION	UNIT	QTY	PRICE	TOTAL
1	Megger Make Portable reflectometer for fault location (Teleflex SX) available as portable, Battery oprated stand alone version but can be integrated in any measuring system with 19" rack mounting.	NOS.	1.00	1,400,000.00	1,400,000.00
	TOTAL				1,400,000.00

* The Basic Price for Complete Scope of supply will be Rs. 1400000/- (Rupees Fourteen Lacs only) Excluding of applicable tax.
* Above price Inclusive of Packing and Forwarding, & Transportation charges.

Other Comments or Special Instructions

1. Material Supplied within 4 Week from the PO Received.
2. The Equipment / material supplied by you covered under warranty against bad workmanship, wrong design, under performance and poor quality of materials for a period of 36 Months from date of receipt of material.
3. First you will supply only one of equipment as per P.O. Once receipt of material and check successful operation and product satisfaction after we release the final Payment.
5. If the items are supplied after the prescribed period of delivery then the penalty will be charged 1 % per Day maximum up to 6 %. However in case of delay the undersigned is Feel to cancel the order.
6. Subject to Gandhinagar Jurisdiction.

Rejection Clause

1. We will reject the equipment if its fails to make proper result or any abnormality found during testing.

For Riddhi Enterprise

If you have any questions about this purchase order, please contact Rahul Patel 9099087501
E Mail:riddhienterprise94@gmail.com

Scanned by CamScanner



TATA

TPCL/RCTL/10419-20 10.04.2013

To,
Rachel Energy Solution Pvt Ltd
office No 3, Sunshine CHS,
Plot 58, Sector 21,
Kharghar, Navi Mumbai – 410210
Mob: +919819107644
www.rachelenergy.com

SUB: PERFORMANCE REPORT FOR OVER HEAD FAULT LOCATOR SUPPLIED TO TATA POWER
REF: PO NO. 5100122476 DT. 18.03.2013

Dear Sir,

This is to certify that Tata Power Ltd has procured overhead line fault analyzer of Seba KMT model Teleflex VX range 1.1kV to 12000kV AC/DC for our transmission line in the year 2013.

The system performance is found to be satisfactory till date and been utilize for identifying overhead cable fault location.

Thanking you

Yours Sincerely

Pradeep Sawant
Head-Kalyan Circle & Trans. Lines

TATA POWER

Summary

- Only 2 Units using for Testing of any overhead Lines
- Fault locator cum Signature analyser
- One Instrument we can use for Overhead lines Transmission, Distribution and Underground cables.
- Control by TDR Unit,15“ color TFT SXGA, CCFL backlight 14 (Touch Screen).
- Inbuilt Software Operation.
- On Screen Data analysis

Megger

Thank You

TAURUS MKS

M K SRINIVASAN SYSTEMS Pvt. Ltd.

Bangalore, India

PROBLEM STATEMENT



No Dedicated Health Monitoring Instrument

Transmission lines are among the most critical and expensive assets in the power transmission network, yet there is no dedicated instrument available for continuous assessment of their health and maintenance condition.



No Method to Validate Fault Clearance

Existing protection relays mainly focus on fault detection and isolation, but utilities lack an independent method to verify whether a fault has been completely cleared after rectification and restoration.



Hard to Detect Insulator-Related Faults

Insulator-related defects, especially in polymer insulators (surface tracking, puncture, contamination, internal degradation), are difficult to detect through conventional inspection methods and often require extensive patrolling and manual fault localization.



No Instrument to Detect Weak Points in Advance

There is no instrument available to detect weak points or failing points of the transmission line in advance, making it difficult to identify developing issues and prevent sudden failures.



No Instrument for Predictive and Preventive Maintenance

Lack of real-time condition monitoring and early fault indication prevents effective predictive maintenance and proactive actions, leading to unexpected outages, higher downtime and increased maintenance costs.

TYPES OF FAULTS
IN A TRANSMISSION LINE

FAULTS

BROKEN CONDUCTOR



Mechanical breakage of conductor due to overloading, fatigue or external impact.

LOOSE JUMPER



Loose or improper connections in jumpers leading to arcing and heating.

CONDUCTOR CORROSION



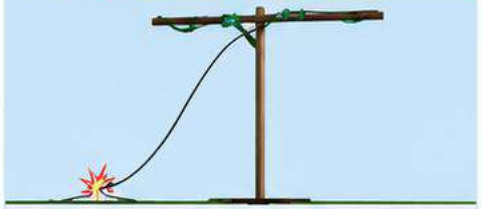
Corrosion and degradation of conductor surface reducing mechanical strength and conductivity.

INSULATOR DEGRADATION



Aging, tracking, cracking or contamination of insulators leading to flashover or puncture.

LINE SHORTING WITH GROUND



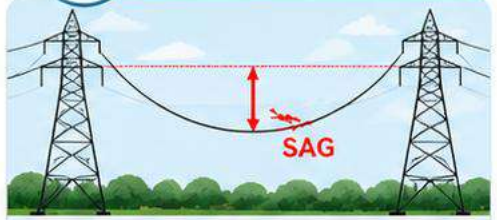
Conductor coming in contact with

LINE TO LINE FAULT



Arcing or contact between two

SAG



Excessive sag of conductor causing

TREE GROWTH



Tree branches growing close to

MAKE IN INDIA
MADE FOR THE WORLD

OFFLINE FAULT LOCATOR

MODEL: EHT-1250-MAX-3 / Max-4

A unique product of TAURUS, that scans the entire power Transmission line , identifying existing and impending fault points, however, large or small the line may be.

ACCURATE
100m Accuracy for precise fault location

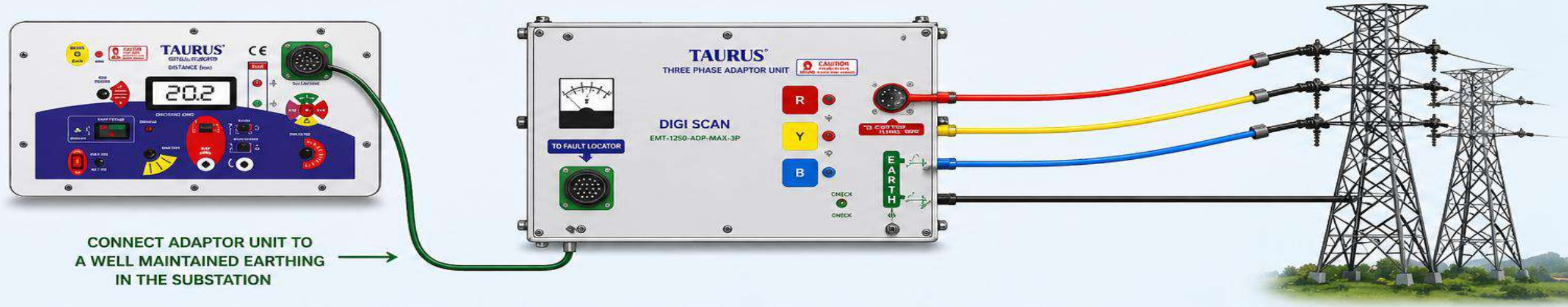
RELIABLE
Detects both existing and impending faults

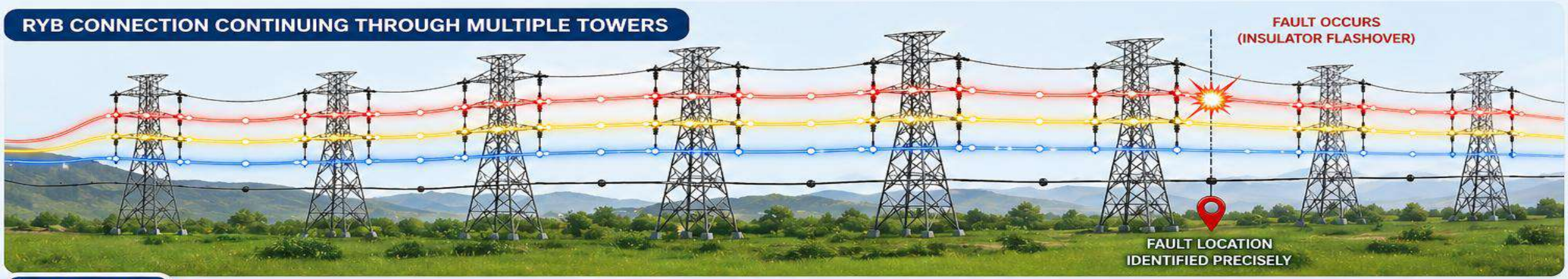
FAST & EFFICIENT
Quick scanning of entire transmission line

RUGGED & PORTABLE
Built for field use in all conditions

OFFLINE FAULT LOCATOR CONNECTION & OPERATION

Accurate Fault Location | Verify Line Health | Safe & Fast Restoration





KEY BENEFITS

ACCURATE FAULT LOCATION
Pinpoint the exact distance of the fault

VERIFY LINE HEALTH
Ensure the line is safe to re-energize

FASTER RESTORATION
Minimize downtime & improve reliability

REDUCE MANUAL PATROLLING
Save time, manpower & operational cost

DETECT INSULATOR FAULTS
Identify hidden insulation failures before re-energization

PRECISE LOCATION. CONFIDENT RESTORATION. RELIABLE POWER.

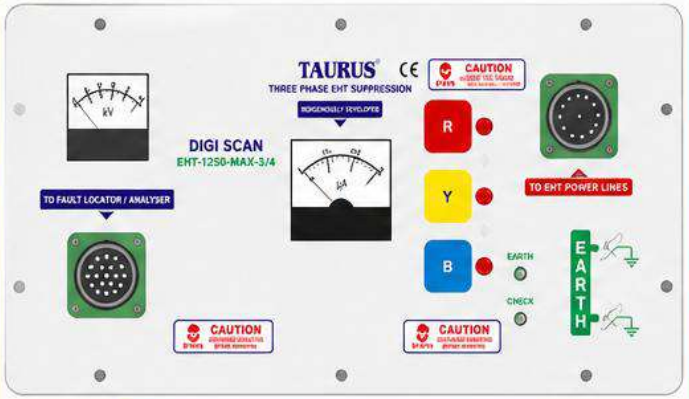
PARTS OF TAURUS EHT-1250-MAX-3/MAX-4

This instrument directly displays the distance of major fault like **broken conductor or earthed conductor.**

If the line is fault free it shows the **distance of termination.**



POWER LINE FAULT LOCATOR



THREE PHASE ADAPTOR

This instrument suppresses all the **induction**, noise and any transient surges present in the line protecting the **user.**

This instrument graphically plots the entire line from the point of testing to the point of termination indicating all the **faulty distances.**



SIGNATURE ANALYSER

Together, these instruments ensure accurate fault location, line analysis, and protection for EHV transmission lines.

- Locate faults with distance accuracy
- Suppress noise and transients for reliable results
- Visualize entire line and identify all fault points

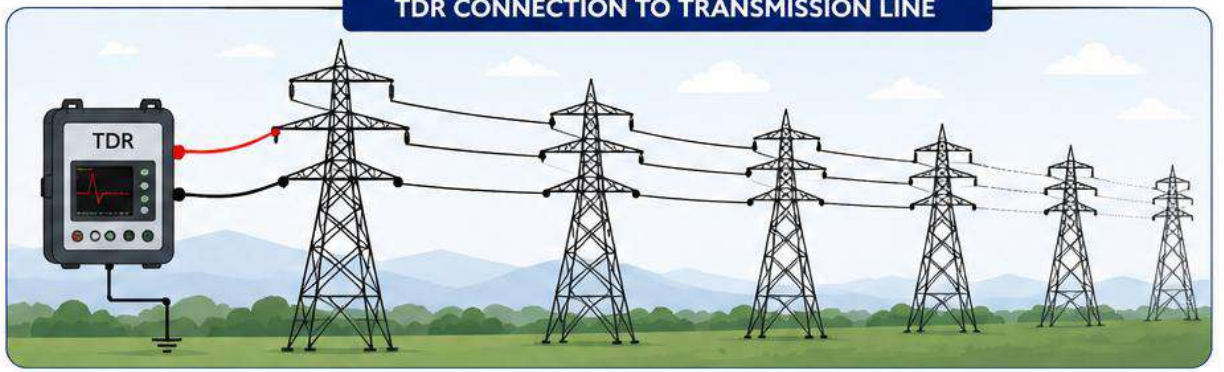
PRINCIPLE

MAX operates on the principle of Time Domain Reflectometry (TDR).

Time Domain Reflectometry (TDR) is a technique that injects an impulse into a transmission line and measures the reflected signals.

These reflections occur due to changes in impedance along the line and provide information about faults or discontinuities.

TDR CONNECTION TO TRANSMISSION LINE



TDR REFLECTIONS – WHAT DO THEY MEAN?



High Ω, Open End
Positive reflection

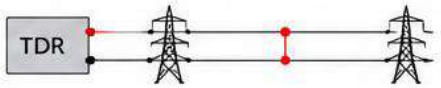


Low Ω, Short Circuit Fault
Negative reflection



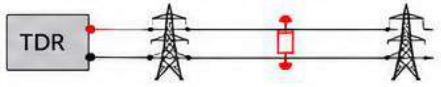
Change of Impedance
Partial reflection (e.g., joint)

TYPICAL FAULTS AND THEIR TDR SIGNATURES

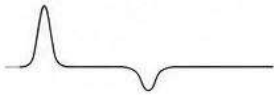


Short Core to Core



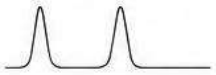


Parallel Resistance Core to Core





Interrupt





Serial Resistance



Key Takeaway: TDR helps locate faults and impedance changes by analyzing the time and shape of reflected signals.

PRINCIPLE

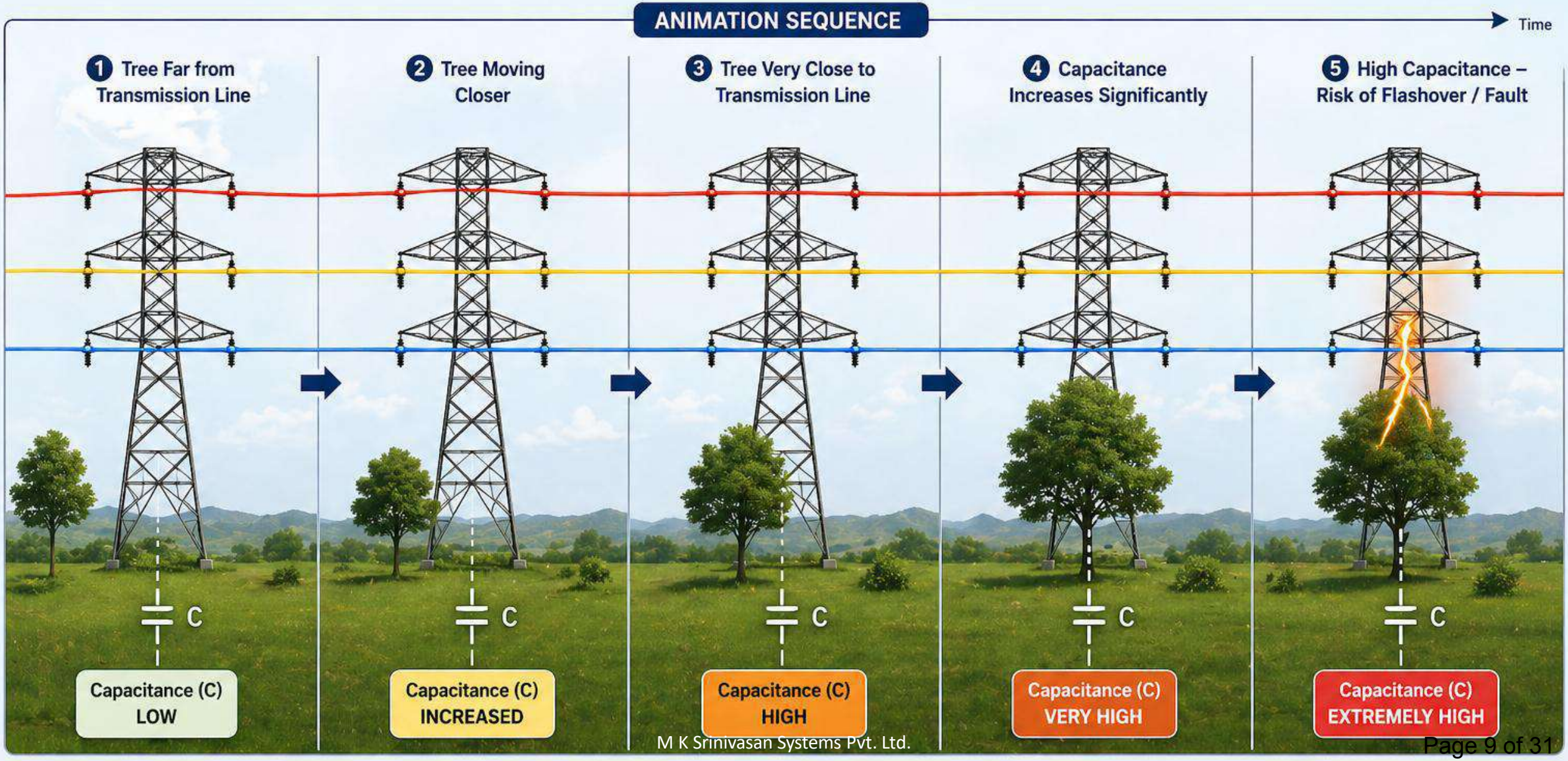
- The working principle of our test kit is also based on the capacitive health of the line .
- When the capacitance increases or decreases due to change in dielectric, it is detected by the high voltage pulse injected by the test kit .

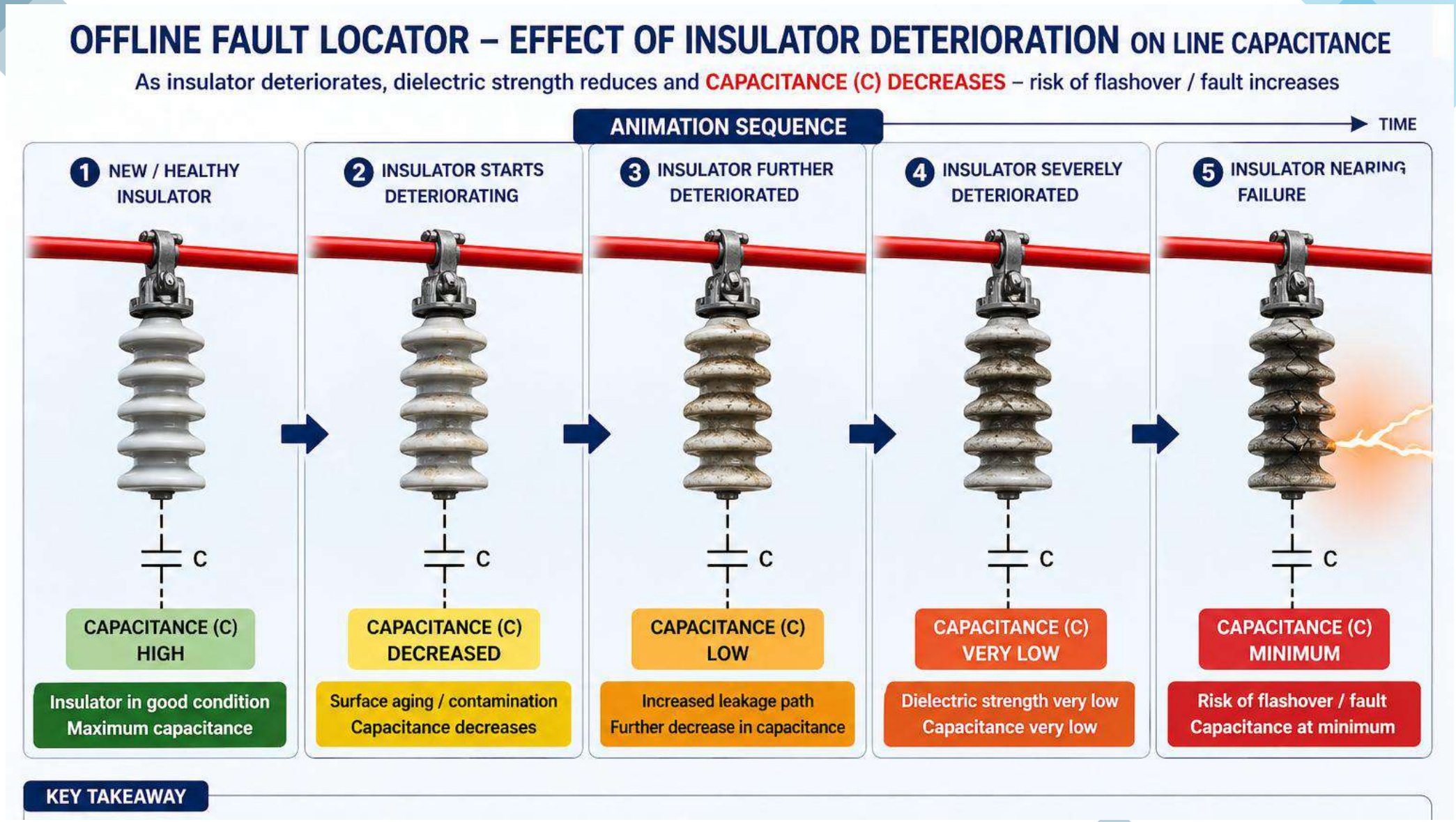




Offline Fault Locator – Effect of Tree Proximity on Line Capacitance

As tree approaches the conductor, shunt capacitance (C) increases – risk of flashover/fault increases




OFFLINE FAULT LOCATOR – EFFECT OF INSULATOR DETERIORATION ON LINE CAPACITANCE
As insulator deteriorates, dielectric strength reduces and CAPACITANCE (C) DECREASES – risk of flashover / fault increases
ANIMATION SEQUENCE
TIME
1 NEW / HEALTHY INSULATOR
2 INSULATOR STARTS DETERIORATING
3 INSULATOR FURTHER DETERIORATED
4 INSULATOR SEVERELY DETERIORATED
5 INSULATOR NEARING FAILURE
C
CAPACITANCE (C) HIGH
CAPACITANCE (C) DECREASED
CAPACITANCE (C) LOW
CAPACITANCE (C) VERY LOW
CAPACITANCE (C) MINIMUM
Insulator in good condition
Maximum capacitance
Surface aging / contamination
Capacitance decreases
Increased leakage path
Further decrease in capacitance
Dielectric strength very low
Capacitance very low
Risk of flashover / fault
Capacitance at minimum
KEY TAKEAWAY

MIN INJECTION VOLTAGE REQ FOR EHV LINE DIAGNOSTICS

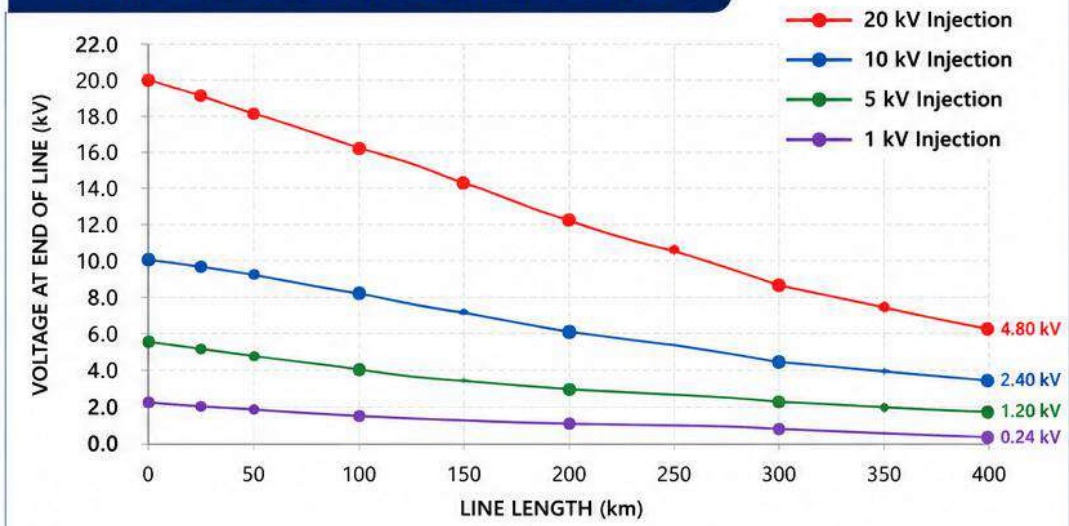
INDUSTRY PRACTICE

LT systems	500 V – 1 kV
11 – 22 kV networks	2.5 kV
33 – 66 kV systems	5 kV
110 – 132 kV lines	5 – 10 kV
220 – 765 kV (EHV/UHV)	10 kV or higher

KEY OBSERVATION

"To reliably detect high-resistance faults, insulation degradation, and weak points over long transmission distances, **sufficient voltage stress must reach the remote end of the line.**"

VOLTAGE ATTENUATION OVER LINE LENGTH



** Values calculated with line attenuation = 0.0159 dB/km*

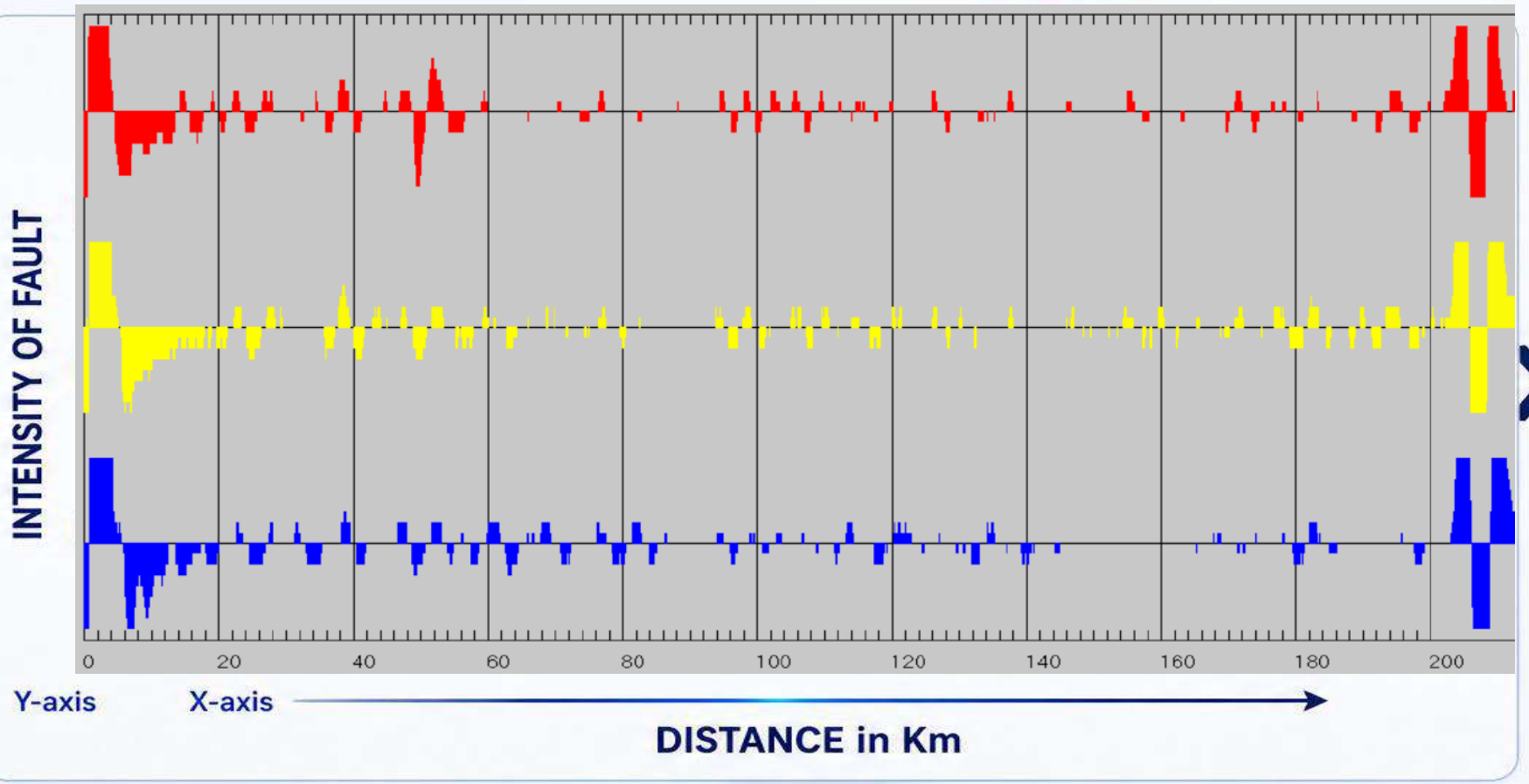
VOLTAGE REACHING END (AT 400 km LINE LENGTH)

INJECTION VOLTAGE	VOLTAGE AT END (400 km)
1 kV	0.24 kV
5 kV	1.20 kV
10 kV	2.40 kV
20 kV	4.80 kV

Only 20 kV injection maintains sufficient detectable voltage at the remote end of long EHV transmission lines.

Due to transmission line attenuation, lower injection voltages become ineffective over long distances, making higher-voltage impulse injection essential for reliable fault localization and weak-point detection.

GRAPH INTERPRETATION



1. X-axis indicates the **distance** of the transmission line in km

2. Y-axis indicates the intensity of fault in 8 levels.

- If the fault is not severe the intensity will be between 0-3 levels.
- If the fault is **developing** then the intensity will be between 3-5 levels.
- If the fault is **fully occurred** then the intensity will be between 6-8 levels.

Distance Measurement
X-axis shows location in kilometers.

Intensity Levels
Y-axis shows fault intensity in 8 levels.

Analyze Fault Severity
Identify whether the fault is not severe, developing or fully occurred.

Pinpoint Fault Location
High intensity at a specific distance indicates the fault location.

ACCURATE ANALYSIS. PRECISE LOCATION. RELIABLE POWER SYSTEM.

FAULT ANALYSIS SUMMARY

INSULATOR FAULTS (HIGH RESISTANCE FAULTS)

R PHASE		Y PHASE		B PHASE	
Distance (km)	Intensity	Distance (km)	Intensity	Distance (km)	Intensity
12.4	3	14.8	4	16.5	5
45.7	6	53.2	2	60.1	3
82.3	2	91.6	5	96.4	7
126.8	7	137.3	3	144.7	2
169.5	4	182.9	6	190.2	4

P-E CLEARANCE ISSUES

R PHASE		Y PHASE		B PHASE	
Distance (km)	Intensity	Distance (km)	Intensity	Distance (km)	Intensity
18.3	2	16.2	3	20.4	4
47.9	5	41.5	4	50.9	3
88.6	3	79.8	2	93.2	6
132.4	6	120.6	5	135.8	2
175.1	4	163.7	3	178.6	5

P-P CLEARANCE ISSUES

R PHASE		Y PHASE		B PHASE	
Distance (km)	Intensity	Distance (km)	Intensity	Distance (km)	Intensity
11.6	4	13.9	3	15.7	2
38.2	6	44.7	5	47.6	4
71.4	2	84.1	4	89.3	3
112.5	5	128.9	6	131.6	5
158.3	3	171.2	2	176.8	4

INDUCTION CURRENT DUE TO PARALLEL CIRCUITS

Estimated Induced Current in an Adjacent OFF Circuit due to a Parallel Energized Transmission Line



Induced Loop Reactance Assumed:

X ≈ 6.28 Ω

(At 50 Hz, Practical Typical Value)

Transmission Voltage (kV)	Typical Induction Current (At 50 Hz) $I = \frac{V_{induced}}{X}$ (A)	Long Parallel Corridor / High Coupling (Typical Range) (A)
132 kV	10 – 12 A	15 – 20 A
220 kV	35 – 60 A	65 – 75 A
400 kV	60 – 83 A	85 – 90 A
765 kV	72 – 90 A	~90 A

CALCULATION BASIS

At 50 Hz,

$$I = \frac{V_{induced}}{X}$$

Where,

$V_{induced}$ = Induced Voltage on OFF Circuit (RMS)

X = Induced Loop Reactance ≈ 6.28 Ω (Typical Practical Value at 50 Hz)

EXAMPLE CALCULATIONS

- **For 132 kV**

$$I = \frac{75}{6.28} = 11.9\ A \quad (\approx 12A)$$

- **For 765 kV**

$$I = \frac{565}{6.28} = 90.0\ A \quad (\approx 90A)$$

KEY FACTORS AFFECTING INDUCTION CURRENT

- Long parallel transmission corridor
- Tower geometry and spacing
- Mutual coupling between circuits
- System loading on energized circuit
- Switching operations and transients
- Fault conditions (SLG, LL, 3P faults)
- Grounding arrangement of OFF circuit
- Untransposed or partially transposed lines

Induction currents > 50 A are common in 220 kV and above systems | Design, Protection and Safety Planning is Essential!

SPECIFICATION OF TAURUS -1250-MAX-3/MAX-4

TRANSMISSION LINE RATING	66kV to 800kV
DISTANCE RANGE	0 – 800 km
INJECTION SIGNAL TYPE / VOLTAGE	Impulse – 20kV
PHASES	Can test all three phases simultaneously
INDUCTION RATING	Can withstand upto 100 amps of induction
IMPULSE TIME PERIOD	Time period in milli / micro seconds
ACCURACY	± 100 m
POWER SUPPLY	90V – 230V, 50–60Hz AC, Battery Operated
BATTERY BACK UP	6 – 8 hrs

This instrument is capable of testing all multi circuits and double circuit lines when the adjacent circuit is in charged condition upto 765kV.

SALIENT FEATURES OF POWER LINE FAULT LOCATOR



01 NO INPUT DATA

This system is a standalone system where no input is to be fed.
The system automatically detects the kV of the line, length of the line, configuration of the conductor and automatically adjusts the internal settings of the instrument.



02 EASY TO HANDLE

This system is very easy to handle as it had only one knob to be operated to obtain the results.



03 DIRECT RESULT

This system will directly give the distance of the fault in Km indicating any open jumpers/conductor or earthed conductors or insulator or any abnormalities in the line.

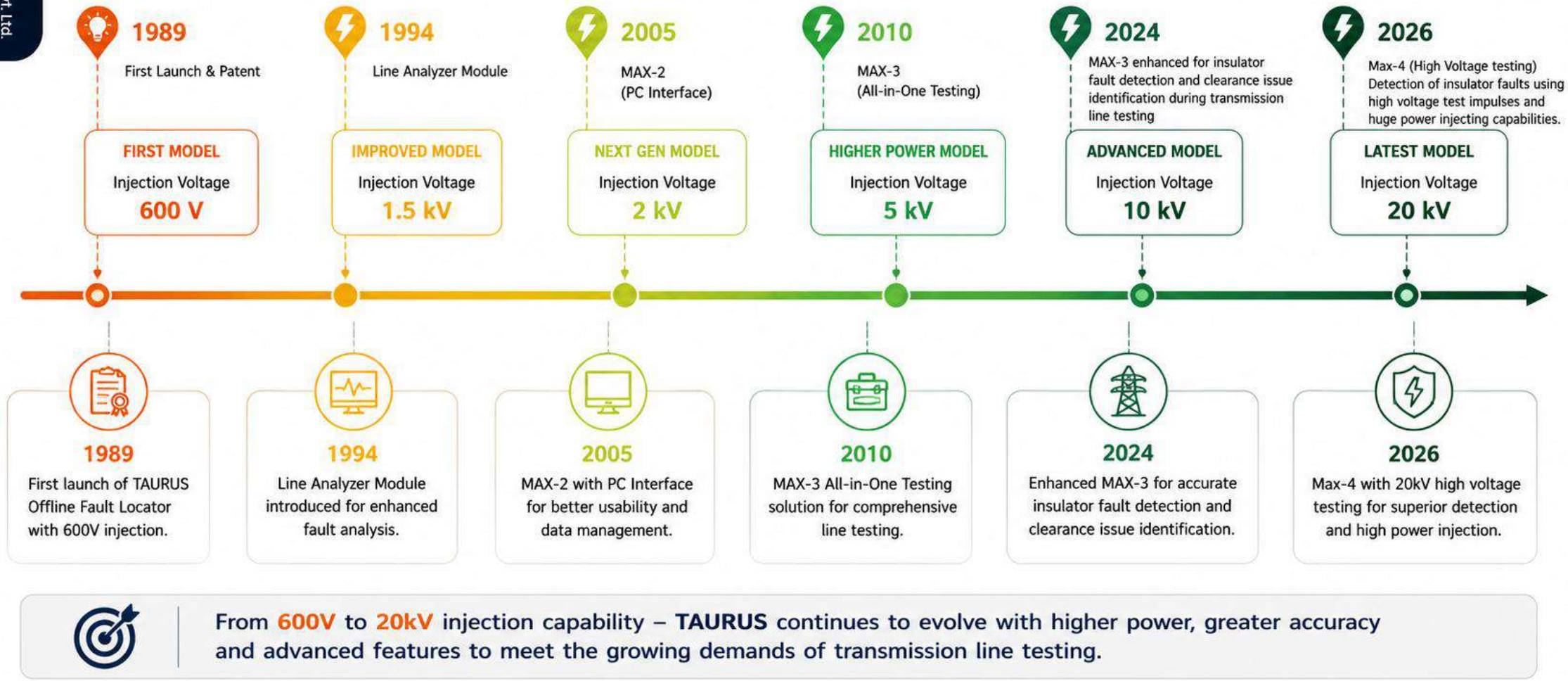


04 ACCURACY

This system gives the result with an accuracy of 100m.

M K Srinivasan Systems Pvt. Ltd.

Milestone – Evolution of TAURUS Offline Fault Locator



From 600V to 20kV injection capability – **TAURUS** continues to evolve with higher power, greater accuracy and advanced features to meet the growing demands of transmission line testing.

Annexure-II



Annexure-V





YEARLY PRODUCTION CAPACITY

राष्ट्रीय लघु उद्योग निगम लिमिटेड
THE NATIONAL SMALL INDUSTRIES CORPORATION LIMITED
(A Government of India Enterprise)

एम एस आई सी
N S I C

S.No. BAN-0004055
Sr. No. 229745

Branch Office : NSIC Limited No. 25, 1st Main Road, KSSIDC Industrial Estate, 6th Block Rajajinagar, Bangalore Zip Code -560010
Ph : 080-23109059, 23307791,23147858 Fax : 080-23386578
Email : boban@nsic.co.in Website : www.nsic.co.in

STORE DETAILS CERTIFICATE

Renewal Certificate **(Valid From 26/02/2026 to 25/02/2028)**
ANNEXURE TO GOVERNMENT PURCHASES ENLISTMENT CERTIFICATE
NO. **NSIC/GP/BAN/2021/0048400** D.T. 29/01/2026
ISSUED TO **M/s. M K SRINIVASAN SYSTEMS PRIVATE LIMITED**, KARNATAKA

UNIT-1) MANUFACTURING: No 80,East Park Road, Malleshwaram, , BANGALORE, KARNATAKA-560003

Sno	Store(s)/ Service(s) Name	Specification(s)	Qualitative Capacity	Quantitative Capacity PA	Remarks
1	Over Head Power Line Fault Locator for Transmission Lines & HVDC Lines **NIC code:** 2610	Fault Detection Range 1KM to 1000 KM Fault Detection Range 1KM to 2500 KM	33KV to 66KV,110KV to 765KV & 500KV	400 Nos On Mixed Basis	OEM
2	Integrated HT Distribution Line Earth Fault Locator, Online DC Earth Fault Locator with Multi Channel **NIC code:** 2610	1. Fault Detection Range 10M to 10 KM 2. Upto 400 K Ohm & Upgradable to 1.5 M Ohm 3. Multiples of 16 Channels Fault Detection Range 400 K Ohm	11KV to 66KV Any Floating System from 20VDC to 1000VDC	500 Nos on Mixed Basis.	OEM
3	Tower Foot Resistance Measurement Meter **NIC code:** 2610	0.01 Ohm to 2 K Ohm Measurement Accuracy +/- 5%	Fall of Potential 3 point frequency	600 Nos	CEM

OUR YEARLY PRODUCTION CAPACITY

400+

UNITS PER ANNUM (APPROX.)

ROI Offline Fault Locator

Smart Investment. Maximum Returns.

Instrument Price
₹55 Lakh + GST
Use Life: 10 – 15 Years

Annual Revenue Loss: Without Locator (3–4 Hrs) vs With Locator (1 Hr)



Key Benefit

- ✓ Fault location time reduced from 3–4 hrs to ~1 hr
- ✓ Significant reduction in revenue loss
- ✓ Faster line restoration & improved reliability
- ✓ Lower manpower & patrolling costs
- ✓ Higher grid availability

Transmission Voltage	Typical Revenue Loss per Fault (3–4 Hrs)	Faults per Year (5–6 Times)	Annual Loss Without Locator (3–4 Hrs)	Annual Loss With Locator (1 Hr)	Approx. Annual Savings	Approx. 10-Year Savings	Savings vs ₹55L Instrument Cost (ROI) (X Times)
132 kV Line	₹8 – 12 Lakh	5 – 6	₹0.40 – 0.72 Cr	₹0.10 – 0.18 Cr	₹0.30 – 0.54 Cr	₹3 – 5.4 Cr	~5x – 10x
220 kV Line	₹20 – 30 Lakh	5 – 6	₹1.00 – 1.80 Cr	₹0.25 – 0.45 Cr	₹0.75 – 1.35 Cr	₹7.5 – 13.5 Cr	~14x – 25x
400 kV Line	₹40 – 60 Lakh	5 – 6	₹2.00 – 3.60 Cr	₹0.50 – 0.90 Cr	₹1.50 – 2.70 Cr	₹15 – 27 Cr	~27x – 49x
765 kV Line	₹80 – 120 Lakh	5 – 6	₹4.00 – 7.20 Cr	₹1.00 – 1.80 Cr	₹3.00 – 5.40 Cr	₹30 – 54 Cr	~55x – 98x

10-Year Savings
(Without Locator vs With Locator)

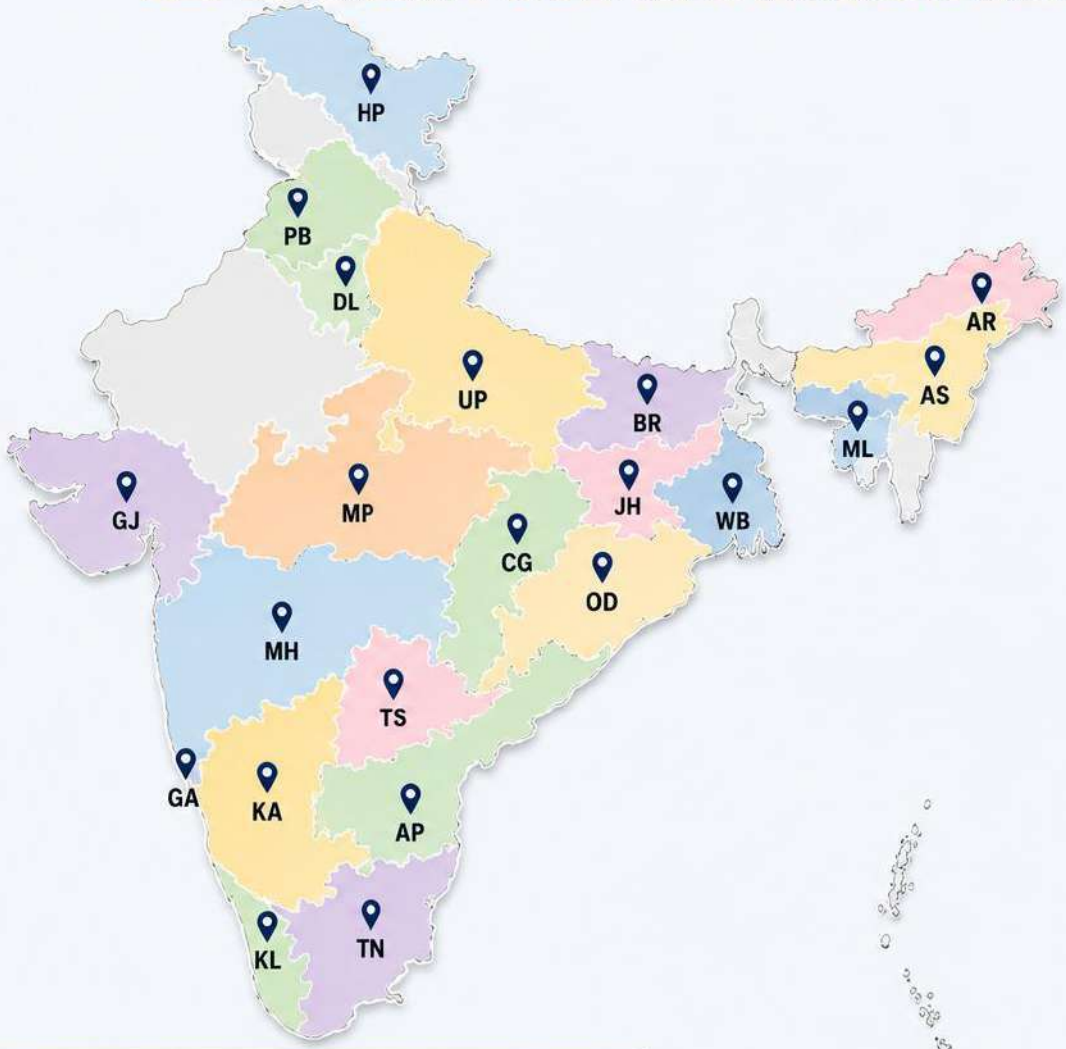


Invest once. Save every time. Higher ROI. Stronger Grid. Smarter Future.

Assumptions:
- Offline Fault Locator cost: ₹55 Lakhs + GST
- Equipment operational life: 10 – 15 years
- Fault restoration time reduced from 3 – 4 hours to ~1 hour
- Faults per year considered: 5 – 6 times
- Values are indicative and vary based on system, load & region

ROI Insight:
Even a few major avoided prolonged outages can recover the full instrument cost, while long-term savings can exceed **10 – 90x** the initial investment depending on voltage class.

DEPLOYMENT FOOTPRINT ACROSS INDIAN TRANSMISSION UTILITIES



SUPPLIED IN STATES / UTs

AP	–	Andhra Pradesh (Transmission Corporation of Andhra Pradesh Limited)
TS	–	Telangana (Transmission Corporation of Telangana Limited)
KA	–	Karnataka (Karnataka Power Transmission Corporation Limited)
TN	–	Tamil Nadu (Tamil Nadu Transmission Corporation Limited)
KL	–	Kerala (Kerala State Electricity Board)
MH	–	Maharashtra (Maharashtra State Electricity Transmission Company Limited)
GJ	–	Gujarat (Gujarat Energy Transmission Corporation Limited)
PB	–	Punjab (Punjab State Transmission Corporation Limited)
UP	–	Uttar Pradesh (Uttar Pradesh Power Transmission Corporation Limited)
MP	–	Madhya Pradesh (Madhya Pradesh Power Transmission Company Limited)
CG	–	Chhattisgarh (Chhattisgarh State Power Transmission Company Limited)
OD	–	Odisha (Odisha Power Transmission Corporation Limited)
BR	–	Bihar (Bihar State Power Transmission Company Limited)
JH	–	Jharkhand (Jharkhand Urja Sancharan Nigam Limited)
WB	–	West Bengal (West Bengal State Electricity Transmission Company Limited)
AS	–	Assam (Assam Electricity Grid Corporation Limited)
DL	–	Delhi (Delhi Transco Limited)
HP	–	Himachal Pradesh (Himachal Pradesh Power Transmission Corporation Limited)
GA	–	Goa (Electricity Department, Government of Goa)
AR	–	Arunachal Pradesh (Department of Power, Arunachal Pradesh)
ML	–	Meghalaya (Meghalaya Energy Corporation Limited)

SUPPLIED TO MAJOR ORGANIZATIONS

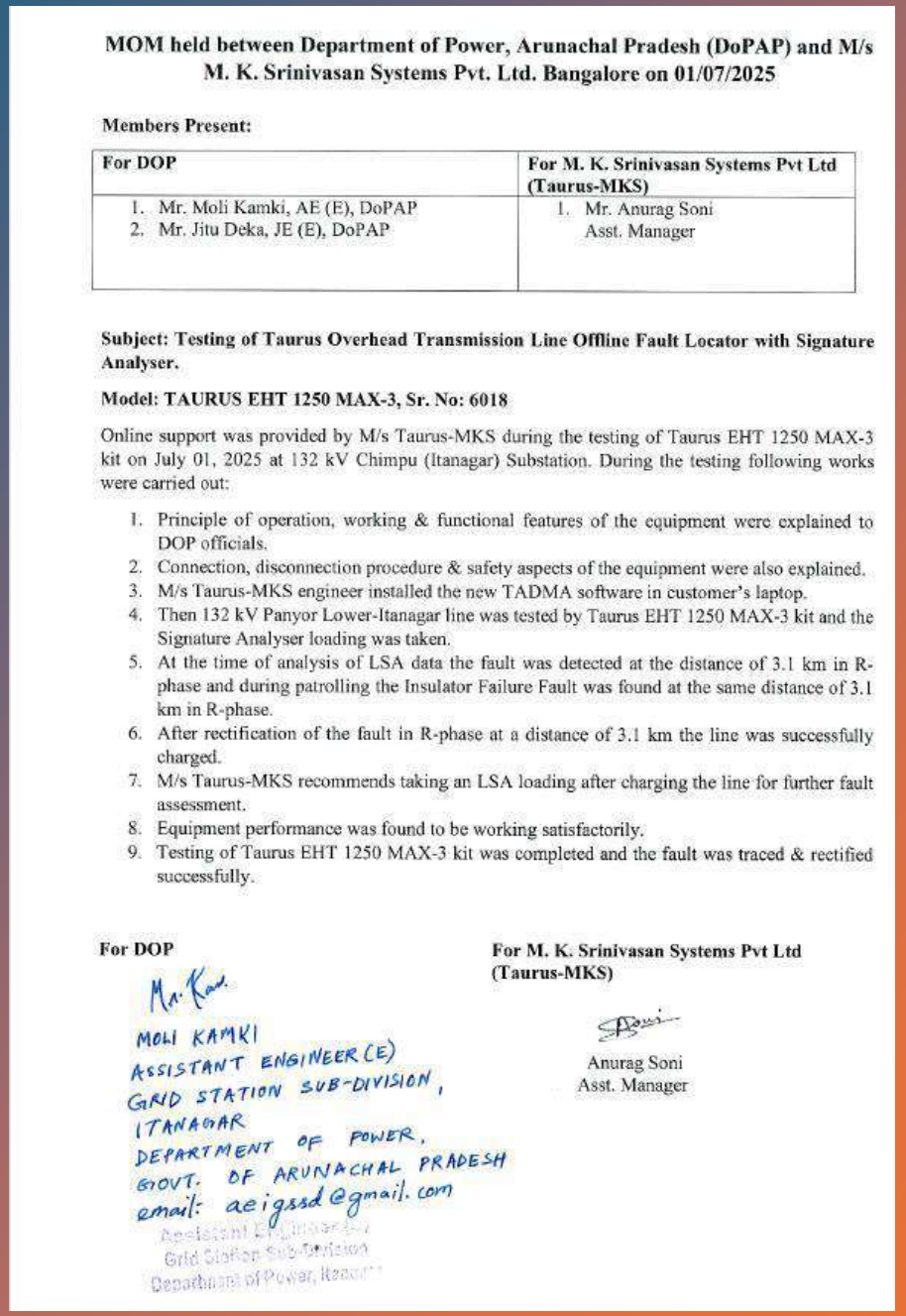
- Adani Energy Solutions Limited (ADANI)
- Power Grid Corporation of India Limited (PGCIL)
- Damodar Valley Corporation (DVC)

adani

पावरग्रिड PGCIL

दामोदर DVC

Indicates locations where systems have been supplied



MOM held between Department of Power, Arunachal Pradesh (DoPAP) and M/s M. K. Srinivasan Systems Pvt. Ltd. Bangalore on 01/07/2025

Members Present:

For DOP	For M. K. Srinivasan Systems Pvt Ltd (Taurus-MKS)
1. Mr. Moli Kamki, AE (E), DoPAP 2. Mr. Jitu Deka, JE (E), DoPAP	1. Mr. Anurag Soni Asst. Manager

Subject: Testing of Taurus Overhead Transmission Line Offline Fault Locator with Signature Analyser.

Model: TAURUS EHT 1250 MAX-3, Sr. No: 6018

Online support was provided by M/s Taurus-MKS during the testing of Taurus EHT 1250 MAX-3 kit on July 01, 2025 at 132 kV Chimpu (Itanagar) Substation. During the testing following works were carried out:

1. Principle of operation, working & functional features of the equipment were explained to DOP officials.
2. Connection, disconnection procedure & safety aspects of the equipment were also explained.
3. M/s Taurus-MKS engineer installed the new TADMA software in customer's laptop.
4. Then 132 kV Panyor Lower-Itanagar line was tested by Taurus EHT 1250 MAX-3 kit and the Signature Analyser loading was taken.
5. At the time of analysis of LSA data the fault was detected at the distance of 3.1 km in R-phase and during patrolling the Insulator Failure Fault was found at the same distance of 3.1 km in R-phase.
6. After rectification of the fault in R-phase at a distance of 3.1 km the line was successfully charged.
7. M/s Taurus-MKS recommends taking an LSA loading after charging the line for further fault assessment.
8. Equipment performance was found to be working satisfactorily.
9. Testing of Taurus EHT 1250 MAX-3 kit was completed and the fault was traced & rectified successfully.

For DOP

MOLI KAMKI
ASSISTANT ENGINEER (E)
GRID STATION SUB-DIVISION,
ITANAGAR
DEPARTMENT OF POWER,
GOVT. OF ARUNACHAL PRADESH
email: aeigssd@gmail.com

Assistant Engineer (E)
Grid Station Sub-Division
Department of Power, Itanagar

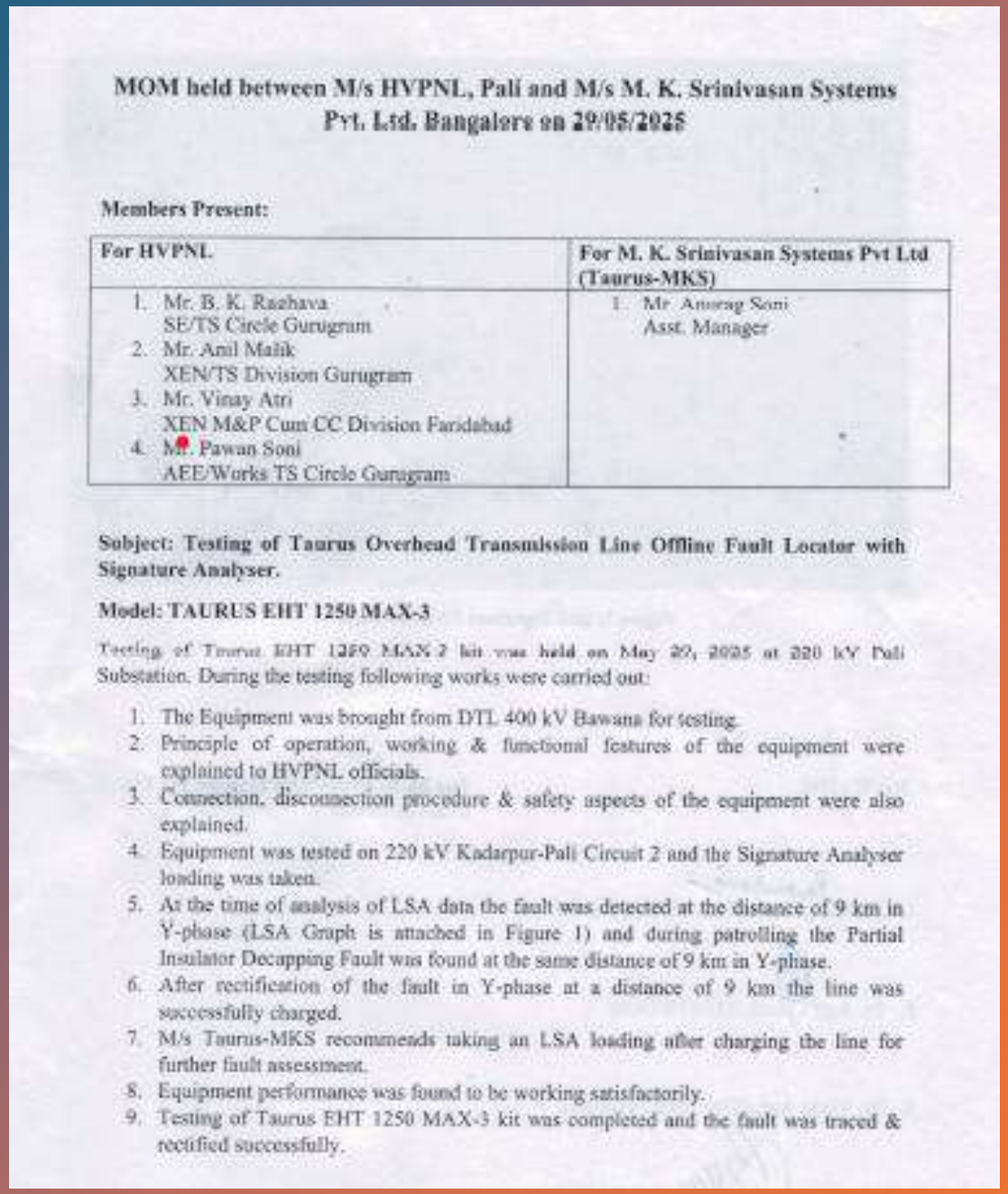
For M. K. Srinivasan Systems Pvt Ltd (Taurus-MKS)

Anurag Soni
Asst. Manager

Success Stories:

- **Company name:**
- Department Of Power Arunachal Pradesh
- **Line under fault :**
- 132kV Panyor lower – Itanagar
- The fault was identified at 3.1km within a span of 20min and as per the located distance of the offline fault locator **the line was successfully recharged .**

Annexure-II



MOM held between M/s HVPNL, Pali and M/s M. K. Srinivasan Systems Pvt. Ltd. Bangalore on 29/05/2025

Members Present:

For HVPNL.	For M. K. Srinivasan Systems Pvt Ltd (Taurus-MKS)
1. Mr. B. K. Rathava SE/TS Circle Gurugram 2. Mr. Anil Malik XEN/TS Division Gurugram 3. Mr. Vinay Atri XEN M&P Cum CC Division Faridabad 4. Mr. Pawan Soni AEE/Works TS Circle Gurugram	1. Mr. Anurag Soni Asst. Manager

Subject: Testing of Taurus Overhead Transmission Line Offline Fault Locator with Signature Analyser.

Model: TAURUS EHT 1250 MAX-3

Testing of Taurus EHT 1250 MAX-3 kit was held on May 29, 2025 at 220 kV Pali Substation. During the testing following works were carried out:

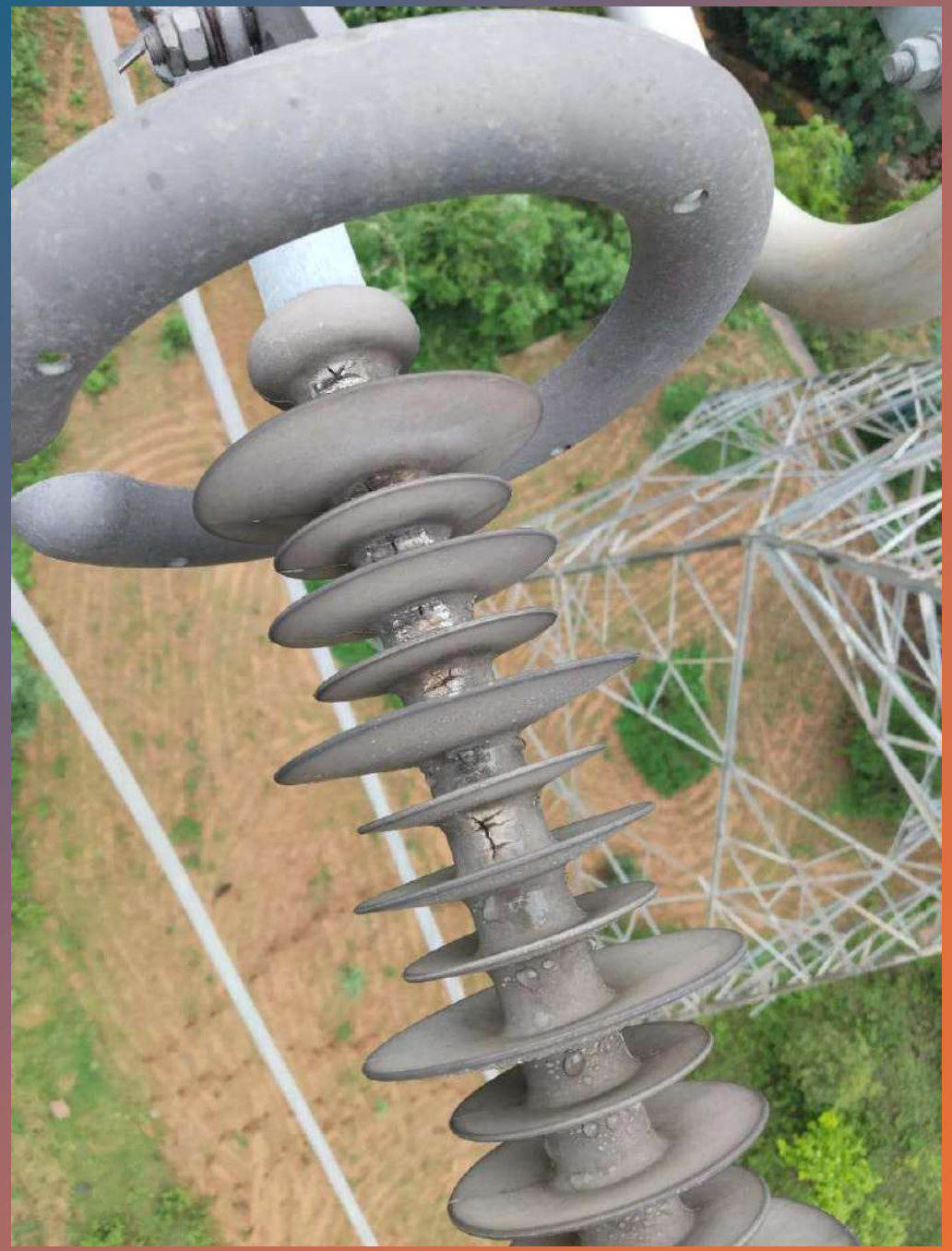
1. The Equipment was brought from DTL 400 kV Bawana for testing.
2. Principle of operation, working & functional features of the equipment were explained to HVPNL officials.
3. Connection, disconnection procedure & safety aspects of the equipment were also explained.
4. Equipment was tested on 220 kV Kadarpur-Pali Circuit 2 and the Signature Analyser loading was taken.
5. At the time of analysis of LSA data the fault was detected at the distance of 9 km in Y-phase (LSA Graph is attached in Figure 1) and during patrolling the Partial Insulator Decapping Fault was found at the same distance of 9 km in Y-phase.
6. After rectification of the fault in Y-phase at a distance of 9 km the line was successfully charged.
7. M/s Taurus-MKS recommends taking an LSA loading after charging the line for further fault assessment.
8. Equipment performance was found to be working satisfactorily.
9. Testing of Taurus EHT 1250 MAX-3 kit was completed and the fault was traced & rectified successfully.

Annexure-V

Success Stories:

- **Company name:**
- Haryana Vidyut Prasaran Nigam Limited
- **Line under fault :**
- 220kV Kadarpur –Pali Ckt2

- The fault was identified at 9km within a span of 45min as per the located distance of the offline fault locator **the line was successfully recharged .**



Success Stories:

- **Company name:**
- PowerGrid
- **Line under fault :**
- 400kv Allahabad-Singrouli line 3

- The fault was identified at 113km within a span of 90min as per the located distance of the offline fault locator **the line was successfully recharged .**

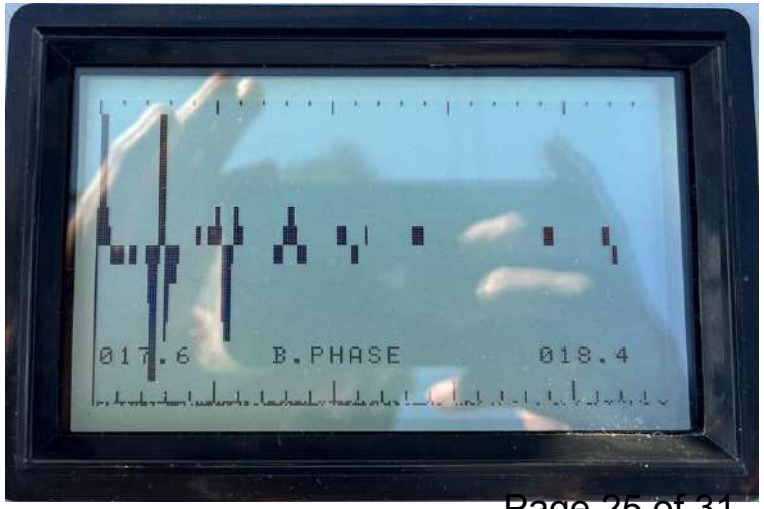
Rapid Fault Detection And Restoration Of A 400 kV Transmission Line Under Extreme Snowfall Conditions In Jammu & Kashmir, India-February 2024

During heavy snowfall in Jammu & Kashmir, a 400 kV line unexpectedly tripped, prompting an urgent grid response. The extreme conditions suggested potential mechanical stress or phase contact due to snow buildup and thermal contraction.

The TAURUS high-precision analyzer unit identified a sharp impedance anomaly, indicating a phase-to-phase fault. On-site inspection confirmed a tower collapse due to snow load and fatigue, causing a conductor to sag and contact another phase, leading to a short circuit and system trip.

The incident highlighted the vulnerability of high-voltage infrastructure to extreme weather conditions. It underscored the need for real-time diagnostic tools such as the TAURUS MAX to localize and resolve faults in harsh environments.

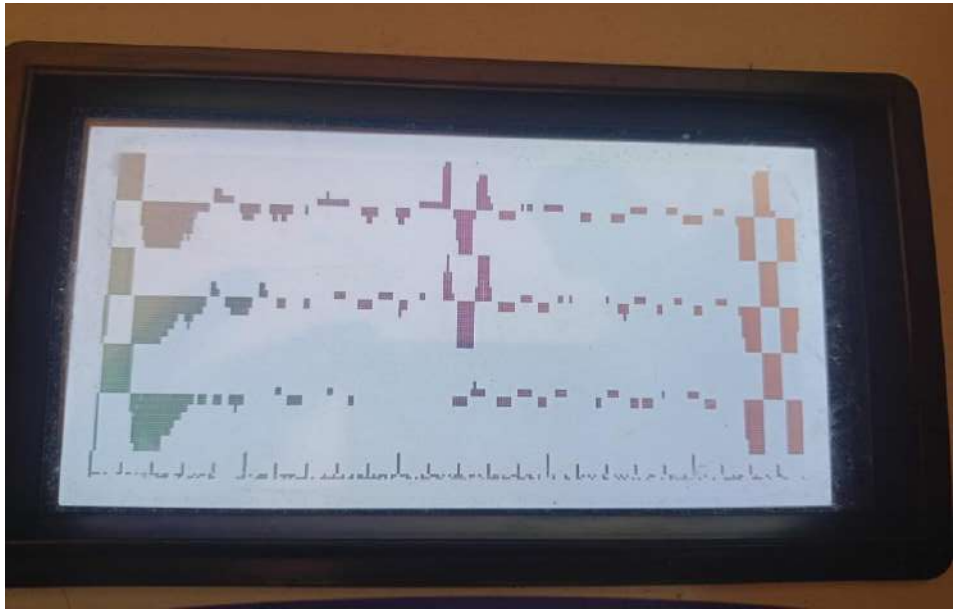




Annexure I

Diagnostic Analysis And Restoration Of A 220 kV Transmission Line In PGCIL-NER Using TAURUS Fault Locator And Signature Analyzer- December 2022

A fault occurred on a 220 kV transmission line operated by PGCIL in the North Eastern Region (NER) grid. To identify the cause, a test was carried out using the TAURUS Signature Analyzer. The TAURUS analyzer clearly captured the fault signatures, helping locate the exact point of the issue. The results showed a phase-to-phase fault, with unusual waveforms pointing to a sudden external disturbance. It was found that a tree branch had fallen onto the line at the point indicated by the analyzer, causing two conductors to come into contact. This contact resulted in a short-circuit condition that disrupted power transmission along the affected section. Field personnel were immediately deployed to the location to confirm the fault and carry out necessary clearance activities. The tree branch was removed, and the line was safely recharged and restored to service.





Perfomance Certificates :

BMTE

ATESTADO DE EXECUÇÃO DE SERVIÇOS
CERTIFICATE OF EXECUTION OF SERVICES

SUPPLIER: TAURUS

COUNTRY: Bengalore - ÍNDIA

CONTRACT: BMTE-TMA-0180/2018

SIGNED: DECEMBER, 04 2018

TO WHOMSOEVER IT MAY CONCERN

This is to inform you that M/s. TAURUS had supplied Portable Overhead HVDC Power Line Fault Analyser bearing serial no: 3505 and 3506 to BMTE – Converter Station ESTREITO 800kVCC, site vide PO.

TAURUS had carried out commissioning, demonstration & training of Over Head HVDC Power Line Fault analyser system at BMTE site on 14th Nov 2019.

We are using the kit since November 2019 and performance of the same has been found satisfactory.

We certify, for the due purposes, that the aforementioned Supplier provided **BMTE – Belo Monte Transmissora de Energia SPE S.A.** the divice **"LFA – Line Fault Analizer"**, satisfying the commercial and technical requirements required for the supply, with nothing that discredits it in our records until the present date.

Rio de Janeiro/BR, april, 14 2022.

JOSE FLAVIO SERAFIM PENNA:73902659815 Assinado de forma digital por JOSE FLAVIO SERAFIM PENNA:73902659815 Dados: 2022.04.14 10:45:28 -03'00'

José Flávio Serafim Penna
Diretor Técnico / Meio Ambiente

Av. Presidente Vargas, 955 / 9º andar – SGCC Rio Tower – Centro – Rio de Janeiro-RJ - Brasil CEP: 20071-004 Tel: (21)3609-8200 FL. 1/1

Perfomance Certificates :

GOVERNMENT OF ARUNACHAL PRADESH
DEPARTMENT OF POWER
OFFICE OF **THE EXECUTIVE ENGINEER (E)**
TRANSMISSION DIVISION NO. I, BOMDILA
APEC-IV OFFICE COMPLEX, DIRANG-790101

E-mail: td1pmz@gmail.com

No. TD-I/W-05/2025-26/297 Dated: 14th July 2025

TO WHOM IT MAY CONCERN

Sub: Performance Certification of Taurus Offline Fault Locator (Model: MAX-3 EHF, S/N: 16269)

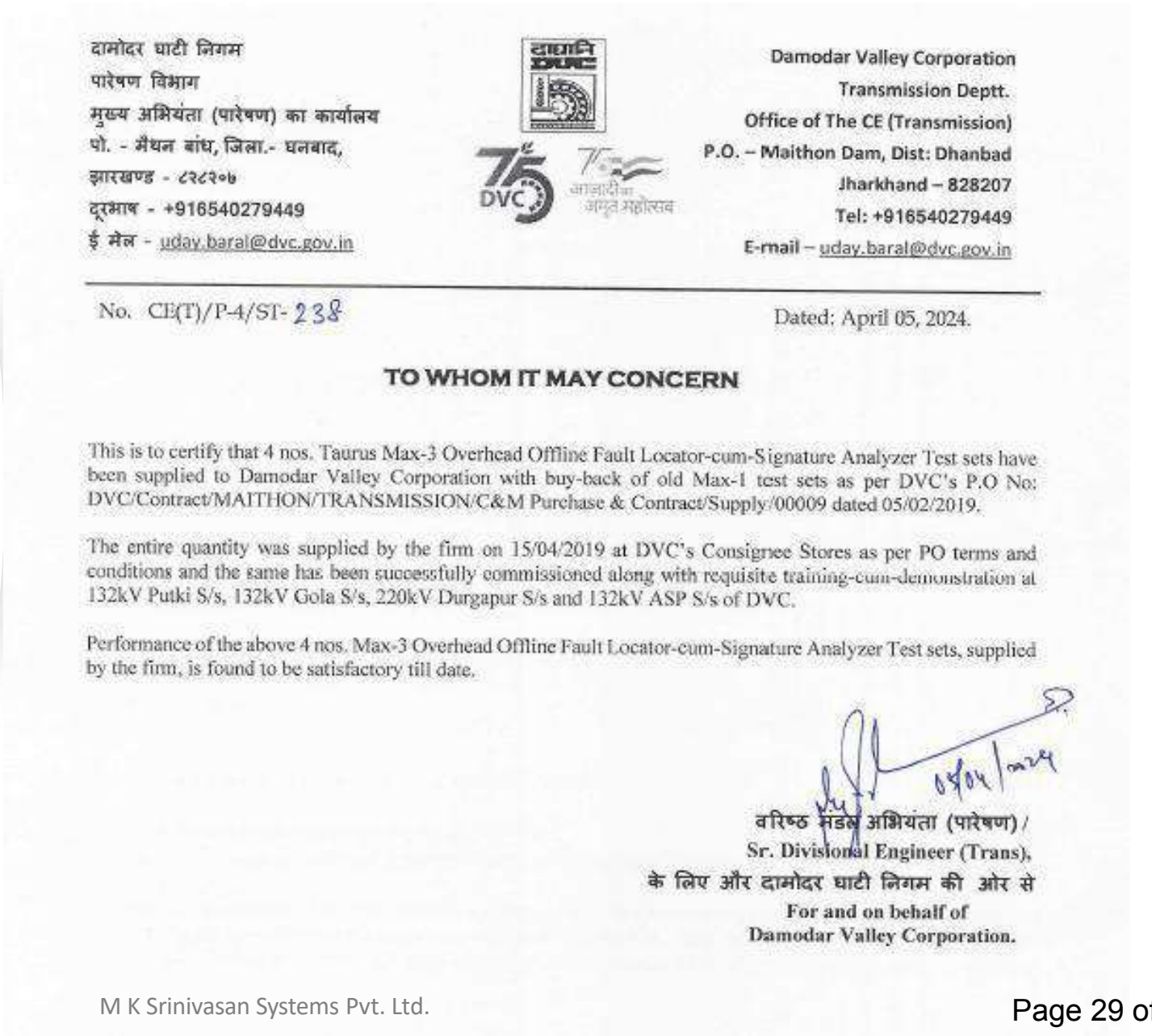
This is to certify that the Taurus Offline Fault Locator (Model: MAX-3 EHF, Serial No. 16269) was supplied to us against Purchase Order No. TD-I/KGSSD/S0/2023-24/17-20 dated 18.12.2023.

The equipment has been in use since its receipt, and its performance has been found satisfactory to date.

(Moli Kamki)
Executive Engineer (E)
Transmission Division No. I

Executive Engineer (E)
Transmission Division No. I, Dirang
Department of Power
Govt. of Arunachal Pradesh

Perfomance Certificates :



दामोदर घाटी निगम
पारेषण विभाग
मुख्य अभियंता (पारेषण) का कार्यालय
पो. - मैथन बांध, जिला.- धनबाद,
झारखण्ड - ८२८२०७
दूरभाष - +916540279449
ई मेल - uday.baral@dvc.gov.in

Damodar Valley Corporation
Transmission Deptt.
Office of The CE (Transmission)
P.O. – Maithon Dam, Dist: Dhanbad
Jharkhand – 828207
Tel: +916540279449
E-mail – uday.baral@dvc.gov.in

No. CE(T)/P-4/ST- 238

Dated: April 05, 2024.

TO WHOM IT MAY CONCERN

This is to certify that 4 nos. Taurus Max-3 Overhead Offline Fault Locator-cum-Signature Analyzer Test sets have been supplied to Damodar Valley Corporation with buy-back of old Max-1 test sets as per DVC's P.O No: DVC/Contract/MAITHON/TRANSMISSION/C&M Purchase & Contract/Supply/00009 dated 05/02/2019.

The entire quantity was supplied by the firm on 15/04/2019 at DVC's Consignee Stores as per PO terms and conditions and the same has been successfully commissioned along with requisite training-cum-demonstration at 132kV Putki S/s, 132kV Gola S/s, 220kV Durgapur S/s and 132kV ASP S/s of DVC.

Performance of the above 4 nos. Max-3 Overhead Offline Fault Locator-cum-Signature Analyzer Test sets, supplied by the firm, is found to be satisfactory till date.

05/04/2024

वरिष्ठ मंडल अभियंता (पारेषण) /
Sr. Divisional Engineer (Trans),
के लिए और दामोदर घाटी निगम की ओर से
For and on behalf of
Damodar Valley Corporation.

National & International Technical Training Programs



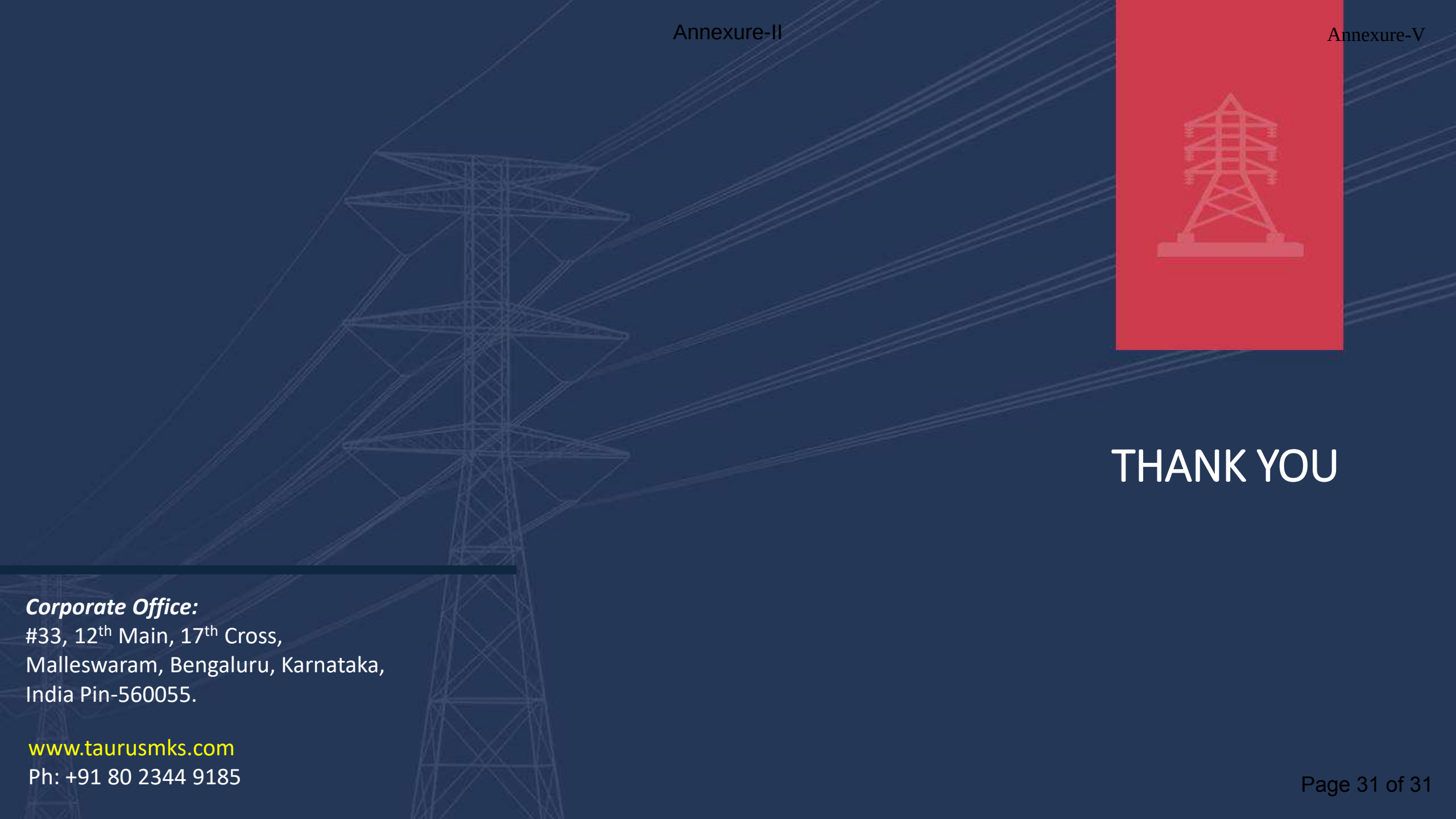












THANK YOU

Corporate Office:
#33, 12th Main, 17th Cross,
Malleswaram, Bengaluru, Karnataka,
India Pin-560055.

www.taurusmks.com
Ph: +91 80 2344 9185

Annexure-III

भारत सरकार/ Government of India

विद्युत मंत्रालय/ Ministry of Power

केन्द्रीय विद्युत प्राधिकरण/ Central Electricity Authority

विद्युत प्रणाली अभियांत्रिकी एवं प्रौद्योगिकी विकास प्रभाग

Power System Engineering & Technology Development Division

Date: 02.09.2026

सेवा में,

<As per attached list>

विषय: Minutes of the Second meeting of the Committee to prepare Guidelines/ Procedure for implementation of Travelling Wave Fault Locator (TWFL) on critical transmission lines for 220 kV and above (132 kV and above for NER) voltage levels [TC-TWFL] – reg.

महोदया/ महोदय,

Second meeting of the Committee to prepare Guidelines/ Procedure for implementation of Travelling Wave Fault Locator (TWFL) on critical transmission lines for 220 kV and above (132 kV and above for NER) voltage levels [TC-TWFL] was held under the chairmanship of Chief Engineer (PSE&TD Division), CEA on 27.08.2026 at 15:00 hrs at Manthan Conference Hall, CEA, Sewa Bhawan, New Delhi.

The Minutes of the meeting is enclosed for your information and necessary action.

Encl.: As above

भवदीय,

Digitally signed by
Pankaj Kumar Verma
Date: 02-09-2026
13:32:58

(पंकज कुमार वर्मा /Pankaj Kumar Verma)

उप-निदेशक /Dy. Director

To,

1. Sh. Om Kishor, EE, NRPC, Email ID: omkishor.sahu@gov.in
2. Sh. V. Muncha, Director, NERPC, Email ID: veerandranath.muncha@gov.in
3. Sh. P. P. Chand DGM, GRID INDIA, Email ID: purnprakash@grid-india.in, Sh. Deepak Kumar Dy. Manager, GRID INDIA, Email ID: deepak.kr@grid-india.in
4. Sh. Anurag, GM, Engg-SS, PGCIL, Email ID: anurag@powergrid.in
5. Sh. Manoj Joshi, Superintending Engineer (ACI&P), MSETCL, Email ID: seprotection@mahatransco.in

Copy to,

1. SA to Member (PS)
2. PS to Chief Engineer, PSE&TD Division, CEA

Annexure-III

Power System Engineering & Technology Development Division
Central Electricity Authority

Minutes of the Second Meeting of the Committee to Prepare Guidelines/ Procedure for Implementation of Travelling Wave Fault Locator on Critical Transmission Lines for 220 kV and above (132 kV and above for NER) Voltage levels

1. Second meeting of the Committee to prepare Guidelines/ Procedure for implementation of Travelling Wave Fault Locator (TWFL) on critical transmission lines for 220 kV and above (132 kV and above for NER) voltage levels (TC-TWFL) was convened on 27.08.2026 at 15.00 hrs in Hybrid Mode at Manthan Conference Hall, 2nd Floor, Sewa Bhavan, R. K. Puram Sector-1, New Delhi under the chairmanship of Chief Engineer (PSE&TD Division), CEA. The list of participants is enclosed as **Annexure-I**.

2. At the outset, Sh. N.R.L.K. Prasad, Chief Engineer (PSE&TD), CEA and Chairperson of the Committee, extended warm welcome to all the Members. Chief Engineer (PSE&TD), then gave a brief background regarding agenda of the second meeting of the Committee. He stated that in the first meeting convened on 25.05.2026, a detailed discussion was held and presentations were also made by the participating OEMs covering both online and offline TWFL technologies. The presentations covered the principle of travelling-wave-based fault location, system configuration, technical features and applicability of both online and offline solutions. Subsequent to the first meeting, a detailed set of technical and operational queries were circulated to all OEMs. The responses received from all the OEMs of online as well as offline TWFL technology was compiled (**Annexure-II)** and circulated among the committee members as part of the agenda of the meeting. These responses covered approximately 17 identified points. Now, as all the relevant information of the both the online as well as offline TWFL technology is available, therefore, in this meeting, criteria to identify the critical transmission lines where these technologies can be deployed, would be decided.

3. He further stated that since the matter is being considered for possible implementation at the national level, a comprehensive assessment is required before taking a decision, particularly considering the likely implications on cost, manpower requirement, technical feasibility, operational suitability and scalability.

4. CE (PSE&TD), CEA explained the basic operating principles of online and off-line TWFL Systems. In the online TWFL method, the travelling wave generated by a fault on a high-voltage transmission line, using the inherent energy associated with the fault, propagates in both directions along the line. The travelling waves reaching the two ends of the line are detected and time-correlated to determine the location of the fault. The principal advantage is that fault location can be determined automatically without line-shutdown, and no external pulse needs to be injected into the line for determining fault location. However, in the off-line TWFL technology, the line has to be taken out of service or kept under shutdown/ de-energized conditions for determining fault-location. Once the line is de-energised, a pulse of suitable magnitude and frequency is then injected into the line. Under normal conditions, the injected pulse travels along the line with same speed due to absence of any impedance discontinuities (as the line's characteristic impedance remains constant throughout its length). In the event of a fault, impedance discontinuities occur causing a portion of the travelling wave to reflect back. By measuring the reflected wave and its travel time, the location of the fault can be determined.

Annexure-III

5. It was noted that both online and off-line systems are based on the travelling-wave principle, but their operational requirements and limitations are different. Therefore, the relative merits of both technologies need to be examined before deciding their suitability for large-scale deployment.

6. It was also emphasized that such an assessment should also take into account the Government's emphasis on Make in India/indigenous technology and the requirements of cyber security. Accordingly, the availability of indigenous technology, manufacturing capability, data communication architecture, cyber-security provisions, after-sales support and long-term maintainability are identified as important considerations while evaluating the responses received from the OEMs.

7. CE (PSE&TD), CEA stated that for effective operation of an online TWFL system, a complete system comprising high-speed data acquisition, data processing, data management, time synchronization, communication between both ends and suitable application/ processing software is required. He further mentioned that measuring equipment at both ends need to be properly configured and mapped, particularly where equipment (protection relays) of different makes are involved. He also emphasized that the data acquisition system should have sufficiently high sampling capability to capture high-frequency travelling-wave transients generated during faults. The online single ended TWFL technology relies on recording of the travelling wave received directly from the fault point and wave reflected from the other end Substation, while, the online double-ended system essentially requires recording of travelling waves at both ends and exchanging that information and then determining the fault location by comparing their arrival times.

8. He further observed that reliable communication and time synchronization are important for online TWFL. Since the communication path, including OPGW, may potentially be affected during a fault, a dedicated and secure communication arrangement should preferably be considered for critical applications. Public internet connectivity should not be relied upon directly for such applications. He also highlighted that proper configuration management is also necessary, as any change in line topology, addition of a new line/bay, modification of line parameters or change from overhead to cable sections would require corresponding changes in the TWFL system/database. The OEM furnished information also confirms that online double-ended TWFL depends upon communication architecture, data exchange, synchronization and compatibility of the travelling-wave acquisition systems.

9. The off-line system essentially operates on a de-energized line by injecting a controlled impulse and analysing the reflected travelling waves. It does not require Disturbance Recorder data generated from operation of corresponding protection-relays, GPS synchronization or elaborate set of equipment, and can be deployed from a single terminal. A single portable off-line TWFL unit can also be shifted between different line bays and substations, thereby providing greater flexibility compared to a permanently installed online system. The Committee also noted that while online TWFL is primarily intended for determination of fault location (automatically), offline TWFL apart from determining fault location (though non-automatic), has additional capabilities for diagnostic applications.

10. CE (PSE&TD), CEA highlighted that off-line TWFL has a limitation in respect of shutdown requirements, since the concerned line has to be de-energized before testing. Further,

for diagnostic applications, historical/reference travelling-wave data are important for comparison with the present condition. A useful diagnostic database, if not already available, has to be developed progressively over a period of time covering different line conditions.

11. Members from PGCIL and MSETCL highlighted that during rainy season, operation of off-line TWFL technology may sometimes be time-consuming due to the difficulties associated with earthing the same. However, it was mentioned that offline TWFL technology identifies the proper fault location.

12. The Committee also discussed the application of TWFL to overhead and underground cable Systems. CE (PSE&TD), CEA pointed out that mixed overhead-cable circuits present additional challenges because of differences in propagation velocity and characteristic impedance since cable joints, transition points and other discontinuities may produce additional travelling-wave reflections. Proper line modelling and configuration are therefore essential. OEMs submissions also indicate that these hybrid configurations are presently limited to two junctions between overhead and underground cable sections. The Committee therefore suggested that complex cable networks may require specialized or separate fault-location solutions rather than relying upon a single TWFL arrangement for every type of transmission configuration.

13. The Committee also observed the applicability of TWFL to long transmission lines and HVDC systems. The OEM submissions indicate that travelling-wave technology has been applied on long-distance transmission corridors and HVDC systems; however, the actual performance depends upon line length, attenuation, network configuration, terminations, filters and other system characteristics.

14. CE (PSE&TD Division), CEA emphasized that indigenous manufacturing capability, availability of spares, technical support, calibration facilities and long-term after-sales service should be considered while selecting the technology for large-scale deployment. It was observed that the level of indigenous manufacturing and support differs among OEMs and should accordingly be evaluated at the procurement stage.

15. The Committee thereafter deliberated on the criteria for identification of transmission lines and substations where TWFL devices should be deployed.

    a) The Committee observed that even though off-line TWFL is a more economical solution compared to on-line TWFL, the latter may still be preferred for highly important transmission corridors where rapid restoration of lines by automatic identification of fault locations is required for grid security. Off-line TWFL are more suitable where portability, multi-line utilization, diagnostic applications and lower infrastructure requirements are important considerations.

    b) For finalizing the TWFL Guidelines w.r.t. HVDC and 400 kV & above systems, the Committee considered the CEA Guidelines dated 11.05.2025 on Standard Operating Procedure for Restoration of Transmission System, which inter-alia, provides the criteria for identifying a substation as critical, and agreed that those would be ideal locations for providing Off-line TWFL Devices.

    c) W.r.t. 220 kV Network, the Committee observed that 220 kV lines exceeding 200 km are comparatively few in number in most parts of the country; hence, adopting 200 km line length as a general screening criterion would primarily identify unusually

Annexure-III

long 220 kV lines where physical fault patrolling may be difficult and restoration time may be comparatively high. As such, a general criterion of 200 km line length for could be considered for deployment of Off-line TWFL Devices. However, in locations where the lines pass through hilly, forested or otherwise difficult terrain, a lower threshold of approximately 100 km may be considered. This criterion of 200 km/ 100 km would be valid across all regions of India including North Eastern Region.

d) Considering the North-Eastern Region's distinct transmission network, difficult terrain and accessibility constraints, it was agreed that there may be a need for providing Off-line TWFL Devices in its 132 kV transmission network also. In this connection, representative of NERPC requested for adopting suitable lower threshholds considering the facts that in North-Eastern region, at 132 kV network, only one ISTS line i.e. 132 kV Imphal–Dimapur, exceeds 150 km length and all other lines are less than 150 km. Further, many lines passing through hilly or difficult terrains are having line lengths less than 100 km. Accordingly, the Committee decided to adopt 100 km as the minimum threshold for line length for stations in normal terrain and 50 km as the minimum threshold for line length for stations in difficult or hilly terrains for providing Off-line TWFL Devices in North Eastern Region.

16. After detailed deliberations, the following guidelines have been finalized for **mandatorily** providing Off-line TWFL Devices:

400 kV and above Stations (applicable across all regions in India):

(a) All 765 kV stations
(b) All stations at voltage level 400 kV and above where inter-regional lines terminate or are important for import of power by any specific state
(c) All stations which handle more than 3000 MW of power capacity
(d) All or selected stations at 400 kV and above voltage level which are essential to ensure continuity of supply to following category of loads as per information furnished by State Load Despatch Centre and DISCOMs:
  (i) State Capitals
  (ii) Railways, metro rail, airports, refineries, underground mines, defence establishments. VIP areas, Space, ports and important industries.
  (iii) Important for islanding scheme of nuclear power plants or major metropolitan areas or defence establishments

220 kV (230 kV) Stations (applicable across all regions in India):

(a) All Stations in normal terrain having any lines with line length > 200 km
(b) All Stations in difficult or hilly terrain having any lines with line length > 100 km

132 kV (110 kV) Stations (applicable across all regions in India):

(a) All Stations in normal terrain having any lines with line length > 100 km
(b) All Stations in difficult or hilly terrain having any lines with line length > 50 km

17. W.r.t. On-line TWFL Devices, it has been agreed to **mandatorily** provide the same on all HVDC Transmission lines. For remaining applicable cases, the concerned Utilities may decide upon providing the same (hence optional) in the following order of priority:

(a) All 765 kV and above transmission lines
(b) 400 kV and above transmission lines having average loading of more than 2000 MW

Annexure-III

18. It was informed that Draft Report of the Committee would be prepared based on the deliberations of the Committee, and would be circulated for comments, appropriately incorporating which, the Final Report would be submitted to NPC for necessary action.

The meeting ended with thanks to all the participants.

*****

Annexure-III

Annexure I

List of Participants

CEA

1. Sh. N.R.L.K. Prasad, Chief Engineer (PSE&TD Division)
2. Sh. Pankaj Kumar Verma, Deputy Director (PSE&TD Division)
3. Sh. Bhavesh Mahawar, Assistant Director (PSE&TD Division)
4. Sh. Manthan Sharma, Assistant Director (PSE&TD Division)

NRPC

Sh. Om Kishor, EE

NERPC

Sh. V. Muncha, Director

GRID INDIA

Sh. Deepak Kumar, Dy. Manager

POWERGRID

Sh. Anurag, GM, Engg-SS

MSETCL

Sh. Manoj Joshi, Superintending Engineer (ACI&P)

*****

Annexure-II

Power System Engineering & Technology Development Division

Central Electricity Authority

Details w.r.t. Travelling Wave based Fault Locator (TWFL) Products furnished by various OEMs

Sr. No.	Details w.r.t. Travelling Wave based Fault Locator (TWFL) Products	M/s GE VERNOVA	M/s Megger (India) Pvt. Ltd.	M/s Taurus MK Srinivasan Systems Pvt. Ltd.	M/s Qualitrol
1.	Details of the TWFL Technology	The RPV311 system uses the RA333 acquisition module, which provides three high-speed analog inputs sampled at 5 MHz (one acquisition every 200 ns) and capture traveling wave transients. Fault location is calculated by comparing the arrival time of wave-heads at different line terminals, synchronized via GPS/IRIG-B with sub-100 ns accuracy.	TWFL Technology–Megger Overhead Line Testing System (Offline Testing) TWFL (Travelling Wave Fault Location) technology used in the Megger Overhead Line Testing System enables accurate fault location on transmission lines by analyzing high-frequency travelling waves to analyze the overhead powerlines for any kind of faults. In offline testing mode, the system injects test signals into de-energized lines to verify line integrity, detect faults. TWFL (Travelling Wave Fault Location) technology in Megger's Overhead Line Testing System enables highly precise identification of the faulty phase, fault type, and	TAURUS EHT-1250 MAX-3 / MAX-4 is an Offline Travelling Wave Fault Locator developed indigenously by M K Srinivasan Systems Pvt. Ltd., Bangalore, India. The system utilizes the principles of Travelling Wave Analysis and Time Domain Reflectometry (TDR) for fault detection, fault location and health assessment of EHV transmission lines. ● **Principle of Operation** Every transmission line possesses distributed electrical parameters namely resistance (R), inductance (L), capacitance (C) and conductance (G). These parameters define the characteristic impedance and travelling wave	The TWS FL-8/FL-1 units are designed to accurately locate faults on high voltage, overhead line feeders that may include lengths of underground cable. It can give useful results on more complicated networks including some branches. The preferred location is a substation where more than one feeder is connected to the busbar. The unit depends on the measurement of current transients on the secondary side of the main protection current transformer. This method can only be applied

			exact fault distance on overhead power lines and underground cables. Key Technical Specifications: • Mains Supply: 230 V ±10%, 49–61 Hz, ≤70 VA. • Transmission Pulse Power: Nominal ≥300 W, Peak ≥7500 W. • Peak Pulse Voltage (Z = 300 Ω): ≥300 V / 1500 V. • Pulse Width: Selectable 10 µs and 20 µs. • Output Impedance: 300 Ω. • Triggering: Internal triggering with pulse repetition every 0.5 s. • Measurement Range: Up to 1000 km & More • Filter Transmission Range (≤3 dB): • 10–2000 kHz (1 MHz filter) • 10–1000 kHz (300 kHz filter) • 10–300 kHz (100 kHz filter) • 10–100 kHz (low-frequency range) These features enable precise fault location with high signal strength and configurable frequency filtering, making the system suitable for long-distance transmission lines and cable networks while significantly reducing troubleshooting and restoration times.	propagation characteristics of the line. When a fast impulse is injected into a transmission line, a travelling wave propagates along the conductor at a velocity close to the speed of light. Whenever this travelling wave encounters a discontinuity in characteristic impedance, a portion of the travelling wave is reflected back towards the point of injection. Typical impedance discontinuities include: 1. Broken conductors 2. Conductor-to-earth faults 3. Phase-to-phase faults 4. Loose jumpers 5. Corroded conductors 6. Damaged insulators 7. Tree encroachments 8. Excessive sag 9. Weak points developing along the line The TAURUS system injects a controlled high-voltage impulse into the de-energized transmission line and measures the reflected travelling waves returning from various discontinuities. The elapsed time between pulse injection and	at points on the system where current transformers are available. At substations where only one feeder connects to a transformer, it will be necessary to measure voltage transients from a suitable voltage transducer. TWS FL-1 is used to monitor a single line. TWS FL-8 is used to monitor eight line modules. It can monitor 2, 4, 6, or 8 line modules depending on the number of fault location (FL) cards mounted. A single FL card has capability to monitor two line modules. Number of transmission line monitored  The TWS-FL device is an expandable device. The minimum is 2 line modules

Annexure-II

				receipt of reflected travelling waves is measured with high precision. Based on travelling wave propagation characteristics, the distance to the discontinuity is calculated. • **Travelling Wave Signature Analysis** In addition to determining fault distance, the TAURUS system analyzes the polarity, magnitude and waveform shape of the reflected travelling waves. Different types of defects produce unique travelling wave signatures: • Open circuit faults generate positive reflections. • Short circuit faults generate negative reflections. • High resistance faults produce reduced amplitude reflections. • Progressive insulation deterioration produces gradual signature variations. • Tree encroachments and external objects alter line capacitance and generate identifiable travelling wave responses. The system therefore provides not only fault location but also fault characterization.	and can be expanded up to 8 in steps of 2. The TWS FL-8 device is a licensed product. Consequently, some features of this multifunctional device may not be available as described in this report. Additional licenses may be purchased to activate the required functionalities. Each line module is composed of 3 channels (one per phase) from external linear couplers. The signal input of these channels are coded on 12-bit ADC and can be sample at up to 20MHz. Traveling wave fault locators, which measures 3 or more power line at the same time.

Annexure-II

				• **Application for Transmission Line Diagnostics** Unlike conventional fault locators that primarily operate after a fault has occurred, the TAURUS system can be used as a diagnostic tool for assessing the health of the transmission line during maintenance shutdowns. The system is capable of identifying: a) Existing faults b) Developing faults c) Weak insulation points d) Defective insulator strings e) Abnormal conductor conditions f) Potential flashover locations This enables utilities to adopt predictive and preventive maintenance practices. • **Transmission Line Coverage** The system is designed for use on EHV and UHV transmission lines from 66 kV to 800 kV and is suitable for: • Single circuit lines • Double circuit lines (with adjacent circuit in charged condition) • Multi-circuit transmission corridors (with adjacent circuit in charged condition) • Long transmission lines up to	

				approximately 800 km ● **High Voltage Impulse Requirement** For long EHV transmission lines, travelling wave attenuation increases with distance.To ensure detectable reflected wave energy from remote locations, the TAURUS MAX-4 employs impulse injection voltages up to 20 kV .The higher injection voltage improves signal-to-noise ratio and enables reliable detection of weak reflections caused by high resistance faults, deteriorated insulation and developing defects. ● **Measurement Accuracy** The TAURUS system provides fault location accuracy of approximately ±100 metres under normal field conditions.(It is to be noted that this technology measures the conductor length and not the foot length of the fault) ● **Advantages of Offline TWFL** 1. No dependency on protection relay operation. 2. No requirement for synchronized measurements at both line ends. 3. No GPS synchronization	

				requirement. 4. Can be used after line tripping or during planned maintenance shutdowns. 5. Capable of locating both major and minor defects. 6. Useful for predictive maintenance. 7. Applicable even when SCADA and communication systems are unavailable. 8. Can be deployed from a single terminal. 9. Does not require mains power and operates on battery. (6 hour capacity) ● **Field Validation** The technology has been successfully utilized on transmission systems ranging from 66 kV to 765 kV by multiple transmission utilities including Powergrid, State Transmission Utilities and private transmission operators. Performance certificates and field reports are available demonstrating successful identification of faults and abnormal transmission line conditions leading to faster restoration of service.	

Annexure-II

				• **Indigenous Development** The TAURUS Offline Travelling Wave Fault Locator has been designed, developed, patented and manufactured entirely in India. Continuous development has been carried out since 1989 in our DSIR recognized in-house R&D unit, resulting in progressive improvements in injection voltage, measurement accuracy, diagnostic capability and data analysis features.	
2.	Indigenous availability of TWFL (product)	Currently the product is manufactured at GEV factories located in Brazil and UK.	TWFL systems are available in India through Megger India (Mumbai), with local technical support and service capabilities. While the technology and manufacturing are supported by Megger's global facilities in the UK, Germany, USA, Sweden, and India, the product is available for indigenous deployment and utility-scale applications across the country	The TAURUS EHT-1250 MAX-3 / MAX-4 Offline Travelling Wave Fault Locator is an indigenously developed product designed, engineered and manufactured in India by M K Srinivasan Systems Pvt. Ltd, Bangalore .The technology has been continuously developed over the past three decades to meet the requirements of Indian transmission utilities operating systems from 66 kV to 800 kV. The pulse generation system, travelling wave acquisition hardware, signal processing algorithms, diagnostic software and fault analysis techniques have been developed in house. The product is not based on any	Our TWFL products are not manufactured in India. However, we can quote in Indian currency through our authorised channel partners. They also have a facility to maintain spares stock

				imported licensed technology and is fully supported from India. The company possesses indigenous capabilities for design, manufacturing, calibration, testing, commissioning, training and after-sales support. Manufacturing and servicing are carried out from the company's Bangalore facility. The product has already been deployed in several Central, State and Private Transmission Utilities across India and supports the Government of India's "Make in India" initiative.	
3.	Yearly Manufacturing Capacity TWFL (Domestic & abroad)	We manufacture approximately 1500 RPV311 and RA333 per year.	200+ units/year and plant capacity available to meet 500+ units	M K Srinivasan Systems Pvt. Ltd. has established manufacturing, testing, calibration and quality assurance facilities at Bangalore, India, for production of the TAURUS Offline Travelling Wave Fault Locator (TWFL).As per the manufacturing capacity certified under our NSIC registration, the company has an annual production capacity of approximately 400 units per annum of the TAURUS Offline Travelling Wave Fault Locator. The products are manufactured in India and can be supplied to both domestic and international markets. The manufacturing capacity can be further enhanced to 1000 units annually, based on	Approx. 300 devices per year worldwide

				utility requirements and project demand. The company possesses the necessary infrastructure, technical manpower, calibration facilities and service support network to undertake large-scale deployment of the product across transmission utilities in India and abroad.	
4.	Indicative Per Unit Cost of TWFL (for use in HVAC as well as for HVDC).	TWFL is generally used as a scheme so the cost depends on number of lines in the substation.	HVAC Lines – Megger - OLTS…Approximate – 45L + Taxes	The TAURUS EHT-1250 MAX-3 / MAX-4 Offline Travelling Wave Fault Locator is available as a complete field diagnostic package comprising the travelling wave fault locator, analyzer unit, application software, accessories, training and commissioning support. The indicative cost of the TAURUS Offline TWFL system for HVAC transmission lines ranging from 66kV to 800kV is approximately Rs. 55–65 Lakhs per set, depending upon the configuration, accessories, software options, training requirements and warranty conditions. For HVDC transmission systems, the same travelling wave principle remains applicable; however, deployment requirements may	

<table>
<tr><td></td><td></td><td></td><td></td><td>vary depending on system configuration, line length and utility-specific requirements. Accordingly, the cost for HVDC applications would be finalized based on the technical scope and customization requirements.</td><td></td></tr>
<tr><td>5.</td><td>Details of the Utilities where the Product has already been supplied. The details of the lines on which TWFL has been implemented in those Utilities, viz., Name of the line, Voltage level, length of the line, Single-ended/ double-ended</td><td>GEV TWFL technology is a mature solution with an extensive global installed base. Numerous utilities across Brazil, India, Spain, and many other countries rely on this technology for their transmission networks. In India, in nearly 200+ lines, GEV TWFL equipment’s are installed.

Detailed list is provided at the end of the document as an Annexure-A.</td><td>A.UPPTCL – 400 kV Sarnath SS
<table><tr><td>400 kV Line</td><td>Approx. Length</td></tr><tr><td>–Sarnath – Anpara (L–5)</td><td>–158.341 km</td></tr><tr><td>–Sarnath – Anpara (L–6)</td><td>–262.267 km</td></tr><tr><td>–Sarnath – Prayagraj (Allahabad)</td><td>–~130 km (approx.)</td></tr><tr><td>–Sarnath – Gorakhpur</td><td>–~218 km (approx.)</td></tr><tr><td>–Sarnath – Obra</td><td>–~145km (approx.)</td></tr></table>220 kV Substations Fed from Sarnath
• 220 kV Chunar – ~35–40 km
• 220 kV Sahupuri – ~77 km
• 220 kV Ghazipur – ~60 km
• 220 kV Azamgarh – ~80 km
• 220 kV Jaunpur – 67.3 km

B. TSECL- Banduar Dvn.
<table><tr><td>132 kV Line</td><td>Circuit</td><td>Approx. Length</td></tr></table></td><td>The TAURUS EHT-1250 MAX-3 / MAX-4 Offline Travelling Wave Fault Locator was first supplied in 1990, and since then it has been continuously used by various Central, State and Private Transmission Utilities across India, including Power Grid Corporation of India Limited (PGCIL), APTRANSCO, TSTRANSCO, KPTCL, TANTRANSCO, KSEB, MPPTCL, UPPTCL, WBSETCL, DVC, HVPNL and Adani Transmission, for fault location and transmission line diagnostics.

In addition, TAURUS MAX has been successfully implemented in utilities like Nepal Electricity Authority, Bhutan Power Corporation, Belo Monte Transmissora de Energia (BMTE, Brazil) and many more,
The system is a Single-Ended Offline Travelling Wave / TDR based Fault Locator, requiring access from</td><td>Reference customers:
Public Service New Mexico(USA)
Centerpoint Energy (USA)
Dominion Virginia (USA)
ESKOM (RSA)
Saudi Electricity Company (ME)
Svenska Kraftnet (Sweden)
Scottish Power (UK)
Voltage levels covered
From 66 kV to 500 kV
Double ended analysis is performed automatically with accuracy to +/-60m with good signals, single ended analysis can be performed manually.
Taken from customer reference letters:
“Our experience so far with Qualitrol and with the TWS has been very good. They have pinpointed faults very quickly and accurately to +/- a tower span and saved</td></tr>
</table>

Annexure-II

				only one end of the transmission line and does not require synchronization with equipment installed at the remote end. Representative deployments include: (a) Power Grid Corporation of India Ltd. (PGCIL)	many man hours of sending out line patrols to locate faults." Scottish Power "The system is very accurate and has been working successfully. It has provided a very accurate location (typically within 0.1 to 0.2 miles) for each fault on those lines." Dominion Virginia Power "The TWS is our most accurate fault locator and is extremely valuable on our long 345kV transmission lines that cross the state." Nebraska Public Power District

OTPC Palatana – Banduar (Udaipur)	S/C	39 km
Banduar (Udaipur) – Rokhia GTP	S/C	47 km
Banduar (Udaipur) – Teliamura	S/C	36.5 km
Ambassa – Kamalpur	S/C	31 km
Palatana – Udaipur	S/C	12 km
Surajmani Nagar – Udaipur	D/C	50 ckm (proposed)
Surajmani Nagar – Rokhia	D/C	20 ckm

C. Department of Power (DoP), Namsai Division, Arunachal Pradesh

Major 132 kV Lines in DOP Namsai Division

- 132 kV Pasighat – Roing : ~79 km
- 132 kV Roing – Tezu : ~95 km
- 132 kV Tezu – Namsai : ~50 km

Voltage Level	Typical Line Length	Configuration
220 kV, 400 kV, 765 kV	Up to 300+ km	Single-Ended

(b) APTRANSCO, TSTRANSCO, KPTCL TANTRANSCO, KSEB, MPPTCL, UPPTCL, WBSETCL, DVC, HVPNL, TATA POWER, ADANI TRANSMISSION and Many more

Voltage Level	Typical Line Length	Configuration
66kV, 132 kV, 220 kV, 400 kV	Various	Single-Ended

Representative field cases include:

• 132 kV Panyor Lower – Itanagar Transmission Line (Arunachal Pradesh) where the fault was accurately identified and

				subsequently verified on site. • 220 kV Kadarpur – Pali Transmission Line (HVPNL) where the fault location identified by the TAURUS system was confirmed during field inspection. • 400 kV Allahabad -Singrouli Transmission Line-3 operated by Powergrid where the fault was located and the line restored successfully following field verification. Performance certificates and user feedback from various utilities are enclosed separately for reference. The TAURUS system has been deployed on transmission lines ranging from 66 kV to 765 kV and has demonstrated successful operation under diverse terrain and environmental conditions including forest areas, mountainous regions, coastal regions and long-distance transmission corridors.	
6.	Effectiveness of the TWFL product (based on feedback from respective customers)	GEV TWFL is capable of locating faults within hundreds or dozens of meters, providing significantly higher accuracy than traditional impedance-based methods. Which helps in reducing the patrolling	Customers have reported faster restoration of transmission lines, improved maintenance efficiency, and reduced operational costs compared to conventional impedance-based fault location methods. The technology has demonstrated reliable performance	The TAURUS Offline Travelling Wave Fault Locator has been in continuous field use since 1990 and has been successfully utilized by various Central, State and Private Transmission Utilities across India for fault location and transmission line diagnostics.	Example case study attached as **Annexure-B**

		distance.	on long transmission lines and mixed overhead-cable networks, with fault location accuracy typically within a few hundred meters, depending on line configuration and available synchronization. Its offline testing capability further enhances asset diagnostics and system availability. Overall, customer experience indicates that TWFL technology is an effective and mature solution for rapid fault location and network reliability improvement.	Feedback received from users indicates that the system has significantly reduced the time required for locating faults on transmission lines, particularly in difficult terrains such as forests, mountainous regions, river crossings and remote locations where conventional line patrolling is time consuming and resource intensive. Utilities have reported that the equipment enables rapid identification of fault locations, thereby reducing outage duration, minimizing manpower requirements and facilitating faster restoration of transmission lines. The system has also been effectively used for identifying developing faults, insulator-related abnormalities, tree encroachments, conductor defects and other line inhomogeneities that may not be easily detected through conventional methods. The system also plays a major role in predictive and preventive maintenance. Several utilities have issued performance certificates	

				confirming satisfactory operation of the equipment and successful fault localization under actual field conditions. The repeatability of measurements and the ability to perform testing from a single end of the transmission line have been particularly appreciated by users. Based on the feedback received over several years of operation, the TAURUS Offline Travelling Wave Fault Locator has proven to be an effective diagnostic and fault location tool for EHV transmission systems ranging from 66 kV to 765 kV.	
7.	Limitation on the effectiveness of TWFL product w.r.t. line length, remote in-feeds, intervening joints/ jumpers (on the transmission line)	• Attenuation: Wave amplitude decreases over long distances. • High Impedance Faults: May produce weaker energy transients. • Mixed Lines: Accuracy relies on precise configuration of propagation constants (K) for each line segment. • Synchronization: Accuracy is strictly dependent on GPS/IRIG-B time synchronization.	Megger's TWFL (Travelling Wave Fault Location) technology is designed for accurate fault location on overhead transmission lines and cable systems, with a measurement capability of up to 1000 km & above. Its accuracy is generally independent of fault current magnitude and is less affected by remote in-feeds compared with conventional impedance-based methods. However, certain network characteristics can influence performance: Line Length: TWFL is suitable for long transmission lines (up to	The TAURUS Offline Travelling Wave Fault Locator is based on the principle of Time Domain Reflectometry (TDR) and travelling wave reflection analysis. Since the system operates on a de-energized transmission line by injecting a controlled impulse and analysing the reflected travelling waves, the influence of remote in-feeds, load flow conditions and system operating parameters is eliminated. The system has been successfully applied on transmission lines ranging from 66 kV to 765 kV and	In an end to end circuit with Teed sections the Travelling Wave System is limited to two in circuit Teed lines. In a hybrid circuit where there is a combination of overhead line and underground cables, the travelling Wave System is limited to two junctions between overhead line and underground cable sections.

			approximately 1000 km). Extremely short lines may provide limited wave separation, while very long and complex networks may require synchronized measurements from both line ends for optimum accuracy. Remote In-feeds: Unlike impedance-based fault locators, remote in-feeds have minimal impact on fault distance calculation. Intervening Joints and Cable Sections: Cable joints, transition points between overhead lines and cables, and impedance discontinuities can generate reflected waves. These reflections may complicate wave interpretation and slightly reduce location accuracy if detailed line models are unavailable. Jumpers, T-connections, and Line Taps: Intermediate branches, jumpers, and tee-off connections can produce additional travelling wave reflections. Accurate line topology data and proper parameter settings are essential to distinguish faulty and healthy portion under offline measurements.	on transmission corridors extending over several hundred kilometres. As line length increases, travelling wave attenuation also increases, resulting in weaker reflected signals from distant discontinuities. However, the use of high-voltage impulse injection and sensitive signal acquisition techniques enables reliable detection of reflections over long transmission line lengths. Intervening jumpers, line taps, repairs, joints and other impedance discontinuities may generate identifiable reflections in the travelling wave signature. These reflections form part of the transmission line signature and can generally be distinguished from actual fault reflections through waveform analysis and comparison with reference signatures. In addition, TAURUS has developed advanced signature analysis and AI-assisted diagnostic software that analyses the complete travelling wave response and automatically differentiates between reflections caused by normal line features such as jumpers, repairs, joints, taps and other known impedance	

			Signal Attenuation and Noise: High attenuation, poor coupling, or excessive electromagnetic noise can reduce the amplitude of travelling waves, affecting sensitivity and fault location precision. - Overall, TWFL technology remains highly effective for transmission networks and is considerably less sensitive to remote in-feeds and fault resistance than conventional fault location techniques, provided that line topology and measurement infrastructure are properly configured.	discontinuities and those caused by actual fault conditions. The software filters out normal transmission line signatures and highlights abnormal reflections associated with faults or developing defects, thereby reducing interpretation complexity and improving fault identification accuracy, particularly on long transmission lines and complex network configurations. Extensive field experience across EHV transmission networks has demonstrated that the TAURUS Offline TWFL system provides reliable and repeatable fault location performance under diverse network configurations and operating conditions. The combination of travelling wave analysis and AI-assisted signature interpretation enables accurate identification of fault locations while minimizing the influence of normal line discontinuities.	
8.	Applicability and effectiveness of Online TWFL technology on long HVDC transmission lines, particularly 800 kV HVDC	The RPV311/RA333 architecture is fully optimized for HVDC applications. The 5 MHz sampling rate is designed to detect the extremely fast transients characteristic of HVDC	Megger's TWFL solution is an offline testing and fault location technology and is not intended for continuous online travelling-wave monitoring of energized HVDC transmission systems. Therefore, its applicability and effectiveness for online fault	The fundamental principle of Travelling Wave Fault Location is based on the propagation and reflection of high-frequency travelling waves caused by impedance discontinuities along a transmission line. This principle is	The Travelling wave system can be applied to HVDC transmission lines.

	systems in India.	transmission. GEV TWFL are deployed in HVDC applications globally.	location on long ±800 kV HVDC transmission lines are not established. The system is primarily designed for offline diagnostics and fault location of de-energized overhead lines and cable systems.	independent of whether the transmission system operates in AC or DC mode and is therefore applicable to both HVAC and HVDC transmission systems. The TAURUS Offline TWFL system operates on de-energized transmission lines by injecting a controlled impulse and analysing the reflected travelling wave signatures. Consequently, the system can be applied to HVDC transmission lines for fault location, line diagnostics and identification of abnormal line conditions in a manner similar to HVAC transmission lines. The technology has been supplied and utilized on several major HVDC transmission projects, including the Talcher–Kolar HVDC link, Agra HVDC system, Pugalur HVDC system and Kurukshetra HVDC system for over 15 years. In addition, the technology has been utilized on the BMTE transmission network in Brazil, including transmission corridors extending up to approximately 2544 km through the Amazon region.	

				Long HVDC transmission corridors generally exhibit lower attenuation and fewer intermediate discontinuities compared to AC networks, which can be advantageous for travelling wave propagation and analysis. However, factors such as smoothing reactors, line terminations, filters and converter station interfaces may influence travelling wave behavior and are taken into consideration during analysis. Based on extensive field experience on long EHV and HVDC transmission corridors, the travelling wave principle has demonstrated its suitability for fault location and transmission line diagnostics on long-distance HVDC systems. Accordingly, the technology is considered applicable for deployment on ±800 kV HVDC transmission systems in India, subject to utility-specific implementation requirements and operating practices.	
9.	Effectiveness of TWFL product on mixed overhead and underground cable configurations commonly	The technology is fully compatible with hybrid lines. The Reason DR Manager software allows users to define different propagation constants (K) for distinct sections (overhead vs.	Megger's TWFL (Travelling Wave Fault Location) solution is applicable to both overhead lines and underground cable systems and can be used on mixed overhead-cable networks commonly encountered near renewable energy evacuation	Mixed overhead line and underground cable systems present unique challenges for all travelling wave-based fault location technologies. The wave propagation velocity (Vp) is not constant throughout the	The travelling wave system can be applied to mix of overhead and underground cable circuits with the caveat that no more than two changes between the sections are present. If

	encountered near renewable energy evacuation systems and metropolitan areas.	underground), ensuring accurate calculation. The solution is currently limited to hybrid line made of two sections.	systems and metropolitan areas. The technology provides accurate identification of the faulty phase, fault type, and fault distance. Transitions between overhead lines and cable sections, cable joints, and impedance discontinuities may generate additional travelling wave reflections. However, with proper network modeling and parameter configuration, these reflections can be effectively distinguished, enabling reliable fault location. The solution is therefore well suited for mixed transmission configurations, although location accuracy may depend on the complexity of the network topology and the availability of detailed line and cable data	transmission corridor because overhead conductors and underground cables possess significantly different electrical characteristics, dielectric constants and surge impedances. In conventional travelling wave systems, fault location calculations are based on the propagation velocity of the travelling wave. The fault distance equation requires accurate knowledge of the wave velocity factor and assumes a reasonably uniform propagation medium. In mixed overhead line and cable networks, the travelling wave velocity changes at every overhead-to-cable transition and cable-to-overhead transition, thereby introducing uncertainties in fault location calculations if the entire network is treated as a single transmission path. Further, cable joints, terminations, bonding arrangements, sheath grounding systems and transition stations introduce additional reflections which complicate interpretation of travelling wave signatures. Consequently, accurate fault location of mixed overhead	there are more sections the travelling wave may not be large enough to trigger both ends of the line.

				and underground cable systems cannot generally be achieved from a single-end transmission line fault locator alone. For this reason, TAURUS adopts a dedicated application-specific approach. Overhead transmission line faults are addressed using the TAURUS Offline Travelling Wave Fault Locator, while underground cable faults are addressed using dedicated cable fault location systems and cable fault location vans equipped with TDR, surge generators, route tracing and pinpointing equipment specifically designed for cable networks. Accordingly, in mixed networks commonly encountered in renewable energy evacuation systems and metropolitan transmission corridors, the overhead transmission line section and underground cable section are treated as separate diagnostic entities and the appropriate specialized offline fault location system is deployed for each section to achieve optimum fault location accuracy and restoration efficiency.	
10.	TWFL products' ability to use the	The RPV311 requires a high-precision IRIG-B (004 even	Not applicable for Offline Technology.	The TAURUS Offline Travelling Wave Fault Locator operates on the	Qualitrols travelling wave system uses its own internal

Annexure-II

	existing GPS available in the substation for time synchronization	parity) signal. Existing substation GPS clocks can be utilized provided they meet the required nanosecond-level jitter performance.		principle of Time Domain Reflectometry (TDR) and single-ended travelling wave reflection analysis. Since the system performs fault location by injecting a controlled impulse into a de-energized transmission line and analyzing the reflected travelling wave signatures received at the same terminal, GPS-based time synchronization is not required for its operation. Unlike conventional online double-ended travelling wave fault location systems, which require highly accurate time synchronization between equipment installed at both ends of the transmission line, the TAURUS Offline TWFL system performs all measurements from a single end of the line. Consequently, fault location calculations are based on the measured round-trip travel time of the reflected travelling wave and do not depend upon synchronized clocks or GPS time stamps from remote terminals. Where GPS facilities are already available in substations, they may	GPS module to ensure accuracies of 100 nano seconds. It is not possible to use existing GPS available in the substation. It must use its own GPS and antenna.

				be utilized for event logging, test documentation, asset management and record correlation purposes. However, the fault location performance and accuracy of the TAURUS Offline TWFL system are independent of GPS synchronization. This eliminates dependence on communication channels, GPS availability, satellite reception and synchronization infrastructure, thereby simplifying field deployment and enabling testing from any accessible terminal of the transmission line.	
11.	Space, power supply (main and backup), and any other requirements of TWFL product for deployment at a given substation.	• Power: 100-250 Vdc / 110-240 Vac. • Space: RPV311 (3U, 19-inch rack) + RA333 (5U, half-19-inch width). • Operating Temp: -10°C to +50°C (RPV311) / -40°C to +55°C (RA33x).	Offline/ Portable Device -deployed at substation. Whenever fault occurs during that time we have use the kit. Thus, the TWFL product is a portable offline diagnostic system that can be deployed on demand at substations without requiring dedicated infrastructure or continuous power backup arrangements.	The TAURUS Offline Travelling Wave Fault Locator is a portable field diagnostic system for transmission lines from 66 kV to 765 kV and does not require permanent installation, dedicated control room space or special infrastructure at the substation. The system is supplied in three rugged waterproof carrying cases, each weighing approximately 25–30 kg and fitted with wheels for ease of transportation within substations and field locations. The system comprises a portable control unit, high-voltage impulse injection unit, specially designed hot-sticks for safe and convenient	The travelling wave system comes in a 3U high 19 inch rack chassis

				line connections, accessories and application software. The equipment is battery operated and is capable of carrying out approximately 5–6 transmission line tests on a single charge. A dedicated rechargeable battery charging unit is supplied for recharging the batteries between field operations. No GPS synchronization, communication links, remote-end equipment or dedicated power infrastructure are required. A single TAURUS TWFL kit is sufficient for testing and diagnosing all transmission lines from 66 kV to 765 kV terminating at a substation and can be easily moved from one line bay to another as required. The only requirements are access to the transmission line terminal and proper grounding during testing.	
12.	Consistency of measurements by TWFL product under repeated usage. Any limitations in this regard may also be informed	The system includes internal autocalibration and diagnostic routines. When correctly configured with site-specific line parameters, the system provides consistent and reliable fault location results.	Offline method is reliable , Megger's TWFL (Travelling Wave Fault Location) system provides repeatable and consistent measurements under repeated usage, provided that the test setup, line parameters, and operating conditions remain unchanged. The	The TAURUS Offline Travelling Wave Fault Locator provides highly repeatable and consistent results under repeated testing of the same transmission line under similar conditions. The use of calibrated impulse generation, high-speed digital signal acquisition and	Lab tests performed over thousands of triggers and weeks of long term testing shows repeated consistency of measurements.

			system employs high energy pulse injection and configurable filtering to ensure reliable travelling wave generation and detection, resulting in reproducible fault location results.	advanced signal processing ensures reliable fault location and consistent travelling wave signatures. Minor variations may occur due to changes in line conditions such as moisture, contamination, vegetation contact or temporary network changes. However, these do not materially affect the fault location capability of the system. AI-assisted signature analysis further improves consistency by filtering noise and distinguishing normal line features from fault-related reflections. The system has demonstrated reliable and repeatable performance on transmission lines from 66 kV to 765 kV over several decades of field use.	
13.	Effect of improper grounding or incorrect equipment connection during actual usage.	Proper grounding (10 mm copper strap) is mandatory. Incorrect grounding or fiber-optic installation (e.g., crossing TX/RX pairs) will prevent signal detection or cause communication loss.	Megger's TWFL system incorporates built-in ground loop detection and safety interlocks to ensure correct setup before test signal injection. In the event of improper grounding or incorrect equipment connection, the system inhibits pulse injection and provides a clear indication/alarm to the operator The equipment is provided with dual	Proper grounding and correct connection of the equipment are important for obtaining optimum measurement accuracy. To ensure reliable operation, the TAURUS Offline TWFL system is supplied with two independent 10 sq.mm high-current carrying capacity copper grounding cables. One grounding cable serves as the	Improper grounding may result in excessive nuisance triggering.

			grounding connections to ensure safe and reliable operation	primary earth connection, while the second serves as a backup earth connection to provide additional safety and reliability in the event of a poor grounding condition. In addition, the instrument incorporates an internal grounding verification feature that automatically checks the quality of the grounding connection before commencement of testing. If inadequate grounding or incorrect connection is detected, the operator is alerted to rectify the condition before initiating the test. These features significantly reduce the possibility of measurement errors arising from improper grounding or incorrect equipment connections and ensure reliable operation under field conditions.	
14.	Normal expected life span of the TWFL product	The system is designed for an industrial service life exceeding 20 years, provided that standard maintenance and operating conditions as recommended by the manufacturer.	Megger's TWFL (Travelling Wave Fault Location) system is designed as a rugged, portable diagnostic instrument intended for long-term utility applications. Under normal operating conditions and with periodic calibration and recommended preventive maintenance, the expected service life of the equipment is typically in	The TAURUS Offline Travelling Wave Fault Locator is designed for long-term field operation in utility environments. With normal usage, periodic calibration and routine preventive maintenance, the expected service life of the equipment is more than 15 years. The system has been in continuous use by various transmission utilities	15 years

			excess of 8-12 years	since 1990, demonstrating its durability and long-term reliability under field conditions. The modular design of the equipment enables replacement or upgrading of individual components, batteries and accessories whenever required, thereby further extending the operational life of the system. The product is supported by annual calibration, servicing, AMC, 24x7 technical support facility and annual training facilities ensuring continued performance throughout its service life.	
15.	In case of online TWFL product, it may be clarified whether protection relays at both ends can be of different make. Additionally, the need for having separate dedicated internet connection may also be informed (as the existing OPGW may also become non-usable during fault	• Relays: TWFL is manufacturer-agnostic. • Internet: We strongly recommend dedicated, isolated station networks. Public internet is not recommended for protection-grade applications.	Not applicable, Since Megger offers offline solutions.	The TAURUS product is an Offline Single-Ended Travelling Wave Fault Locator and therefore does not require protection relays, synchronized measurements, communication links or equipment installation at the remote end of the transmission line. Consequently, the issues relating to relay make compatibility, communication protocols and internet connectivity are not applicable to the TAURUS Offline TWFL system. In general, for online double-ended	Protection relay type has no bearing on Qualitrols Travelling Wave solution.

	occurrence)			travelling wave fault location systems, interoperability between protection relays of different manufacturers depends upon the communication architecture, data exchange protocols, time synchronization methodology and compatibility of travelling wave data acquisition systems. These aspects are typically addressed by the respective online TWFL solution provider. Similarly, dedicated internet connectivity is not required for operation of the TAURUS Offline TWFL system. Fault location is performed locally from a single end of the de-energized transmission line through controlled impulse injection and travelling wave analysis. Therefore, operation of the system is independent of OPGW availability, communication channels, internet connectivity or remote terminal equipment.	
16.	Future developmental efforts w.r.t. Integrating the TWFL product with the Protection Relays.	Integrating Traveling Wave Fault Location (TWFL) into standard relays is difficult because relays sample at 4–16 kHz, while TWFL requires 1–5 MHz to capture high-frequency transients.	Megger's TWFL solution is an offline, portable fault location and diagnostic system and does not require integration with protection relays for its intended operation	As part of our future development roadmap, we propose the integration of the proven TWFL Offline Fault Locator with an Online Continuous Transmission Line Monitoring and Health Monitoring System. This integrated solution	Qualitrol are working on a software called Grid Assist that will integrate protection relay fault records with Qualitrols Travelling Wave fault location system and present

				will combine the precise fault location capabilities of the Offline Fault Locator with continuous real-time monitoring of transmission line health, thereby providing utilities with immediate visibility of line condition while retaining the capability for detailed fault analysis and diagnostics. The technical feasibility of this concept was successfully demonstrated through a Proof of Concept (POC) conducted in 2016 in collaboration with Power Grid Corporation of India Limited (PGCIL) at Maithon Substation on both 220 kV and 400 kV transmission lines. The POC validated continuous online transmission line monitoring, health assessment, travelling-wave-based monitoring principles, fault detection, line signature acquisition, and identification of line abnormalities under live operating conditions. The proposed Online Transmission Line Monitoring System operates by continuously injecting controlled travelling-wave pulses into the transmission line through	this information on a map based application for fast and easy review.

				the PLCC channel and analyzing the reflected signals using high-speed sampling and advanced signal processing techniques. Owing to the high sampling rate employed in the system, faults and transmission line abnormalities can be detected and identified within approximately 2 to 3 milliseconds of their occurrence. This enables real-time monitoring of transmission line health, rapid identification of developing faults, line inhomogeneities, and abnormal operating conditions before they result in outages or equipment damage. It will significantly reduce response time during fault events by making critical line condition information immediately available without the need for emergency deployment of field personnel and equipment. The successful POC established the technical foundation for future deployment of an integrated Online Monitoring and Fault Location System, supporting transmission asset management, grid modernization initiatives, improved system reliability, and potential future integration as an independent backup layer to	

				conventional protection systems. We would be pleased to submit additional technical data and are also willing to conduct a detailed Proof of Concept (POC) demonstration for CEA to further validate the capabilities and performance of the proposed integrated Online Transmission Line Monitoring and Fault Location System.	
17.	The effectiveness of Online/Offline Travelling Wave Fault Locator (TWFL) technologies for subsea cables. If effective, the maximum length up to which TWFL technology remains effective may be furnished. Further, the differences in required equipment and configurations for subsea cable applications as compared to land-based Transmission		Megger is the only solution provider for such critical application and have successfully executed the project for one of the longest subsea cable projects - Vikling Project connecting from UK to Denmark having a length of 761 km. The common challenges in Subsea cable: 1. Cable length is longer 2. Higher cable capacitance 3. High discharge unit for safety operation 4. Pinpointing in sea 5. Pre-location - very important to find fault distance - depends on nature of the fault To overcome the above challenges, Megger Germany have customized proven solutions like high power	Transmission lines and power cables require different approaches for travelling-wave-based fault location due to differences in their electrical characteristics, propagation behavior, attenuation, and reflection properties. The TWFL technology offered by us has been extensively developed and validated for overhead transmission line applications. Subsea cable systems represent a specialized application area that would require optimization of equipment configuration, signal injection methodology, and analysis techniques based on the specific cable characteristics and installation environment. Our R&D team is highly interested in exploring the applicability of the technology for subsea cable	Travelling Wave Fault Location (TWFL) technology is applicable to subsea cable systems because travelling waves propagate along cable conductors in the same manner as overhead transmission lines. However, compared to overhead lines, subsea cables exhibit significantly higher attenuation and frequency-dependent dispersion of the travelling wave signal. As a result, the practical performance and maximum achievable distance are dependent on cable construction, voltage level, jointing arrangements, and the sensitivity of the fault location equipment.

Annexure-II

	line		prelocation methods, higher discharge capability, high power generators, ROV fault traces and high voltage bridge.	systems and would welcome an opportunity to undertake studies, testing, and validation on a suitable subsea cable installation. Such an exercise would enable us to further enhance the technology and establish the optimum configuration and performance parameters for subsea cable fault location and monitoring applications.	For the Qualitrol TWS-FL system, travelling wave fault location can be applied to cable circuits and hybrid overhead/cable circuits. Based on practical application experience and the attenuation characteristics of cable systems, Qualitrol typically recommends a maximum cable section length of approximately 50 km between measurement points. Beyond this distance, attenuation of the high-frequency travelling wave components may reduce signal amplitude and make reliable automatic detection more challenging. One thing to be aware of when it comes to cable sections is the propagation velocity of the travelling wave. • The travelling wave propagation velocity in a cable is significantly lower than in an overhead line (typically around 45–60% of overhead-line velocity

Annexure-II

					depending on cable construction). • The correct cable velocity factor must therefore be configured within the fault location software to maintain accuracy.

Annexure-II

Annexure-A

Detailed list of GEV TWFL equipment's installed in India

Sub-Station	Sub-Region	Feeders Description	Feeders Count
Agra	NR-III	Agra - Jhatikara, Agra - Fatehpur I, Agra - Fatehpur II, Agra - Gwalior-I, Agra - Gwalior-II	5
Ajmer	NR-I	Ajmer-Chittorgarh-I & II	2
Angul	Odisha	Angul-Jharsuguda I, Angul-Jharsuguda II, Angul-Srikakallam - I & II	4
Anupur	WR-II	Anupur-Jabalpur -I, Anupur-Jabalpur -II	2
Aurangabad	WR-I	Wardha - Aurangabad I, Wardha - Aurangabad II, Wardha - Aurangaba III, Wardha - Aurangabad IV	4
Balia	NR-III	Balia - Biharshariff-I, Balia - Biharshariff-II, Lucknow(New) - Ballia, Varanasi-Ballia, Gaya-Ballia, Patna - Balia-I, Patna - Balia-II, Patna - Balia-III, Patna - Balia-IV	9
Banaskantha	WR-II	Bhuj-Banaskantha-I/II, Chittorgarh-I/II	4
Bareilly	NR-III	Lucknow (New)- Bareilly (New)	1
Bhinmal	NR-I	Bhinmal - Zerda	1
Bhiwani	NR-I	Bhiwani-Jaipur(Phagi) I, Bhiwani-Jaipur(Phagi) II, Meerut - Bhiwani, M - Bhiwani	4
Bhuj	WR-II	Bhuj-Banaskantha-I/II	2
Biharshariff	ER-I	Balia - Biharshariff-I, Balia - Biharshariff-II, Biharsherif-Varanasi-I & II	4
Bilaspur	WR-I	Bilaspur - Seoni I, Bilaspur - Seoni II	2
Bina	WR-II	Bina - Indore,Bina - Gwalior-I, Bina - Gwalior-II, Bina - Gwalior-III, Seor Bina, Satna - Bina I, Satna - Bina II, Jabalpur PS - Bina I, Jabalpur PS - Bina II	9
Bongaigaon	NER	New Siliguri - Bongaigaon-I, New Siliguri - Bongaigaon-II	2
Chandrapur (Badhrawati)	WR-I	Ramagundam - Chandrapur-I, Ramagundam - Chandrapur-II	2
Chittorgarh	NR-I	Ajmer-Chittorgarh-I & II, Chittorgarh-Banaskantha-I/II	4

Annexure-II

Dharamjaygar	WR-I	Ranchi - Dharamjaygarh II, Ranchi - Dharamjaygarh I, Jharsugudha - Dharamjaygarh I, Jharsugudha - Dharamjaygarh II, Dharamjaygarh-Jabalpur-I & II	6
Fatehpur	NR-III	Agra - Fatehpur I, Agra - Fatehpur II, Varanasi-Fatehpur-I	3
Gaya	ER-I	Gaya - Varanasi I, Gaya - Varanasi II, Gaya-Ballia	3
Gazuwaka	SR-I	Jeypore - Gazuwaka-I, Jeypore - Gazuwaka-II	2
Gwalior	WR-II	Gwalior-Jaipur(Phagi) I, Gwalior-Jaipur(Phagi) II, Bina - Gwalior-I,Bina Gwalior-II, Bina - Gwalior-III, Agra - Gwalior-I, Agra - Gwalior-II, Satna - Gwalior I	8
Indore	WR-II	Bina - Indore, Indore-Vadodra	2
Jabalpur	WR-II	Jabalpur PS - Bina I, Jabalpur PS - Bina II, Dharamjaygarh-Jabalpur-I & Jabalpur-Vindyachal-I/II & Jabalpur- Gadawara-I/II	8
Jaipur	NR-I	Bhiwani-Jaipur(Phagi) I, Bhiwani-Jaipur(Phagi) II, Gwalior-Jaipur(Phag Gwalior-Jaipur(Phagi) II	4
Jeypore	Odisha	Jeypore - Gazuwaka-I, Jeypore - Gazuwaka-II	2
Jharsugudha	Odisha	Raigarh - Jharsuguda I, Raigarh - Jharsuguda II, Jharsugudha - Dharamjaygarh I, Jharsugudha - Dharamjaygarh II, Angu Jharsuguda I, Angul-Jharsuguda II, Jharsugudha-Raigarh-III & IV	8
Jhatikara	NR-I	Agra - Jhatikara	1
Kankroli	NR-I	Kankroli - Zerda	1
Kanpur	NR-III	Varanasi-Kanpur I, Varanasi-Kanpur II	2
Kishanpur-400	NR-II	Kishanpur-Wanpoh I,II,III	3
Kishenpur	NR-II	Moga - Kishenpur-I, Moga - Kishenpur-II	2
Koteshwar	NR-I	Koteshwar - Meerut I, Koteshwar - Meerut II	2
Kurnool	SR-I	Kurnool - Nellore PS I, Kurnool - Nellore PS II, Raichur - Kurnool	3
Lucknow	NR-III	Lucknow(New) - Ballia, Lucknow (New)- Bareilly (New)	2
Meerut	NR-I	Meerut - Bhiwani, Moga-Meerut,Koteshwar - Meerut I, Koteshwar - Meerut II	4
Moga	NR-II	Moga - Bhiwani, Moga-Meerut, Moga - Kishenpur-I, Moga - Kishenpu	4
Nellore	SR-I	Kurnool - Nellore PS I, Kurnool - Nellore PS II	2

Annexure-II

New Siliguri	ER-II	New Siliguri - Bongaigaon-I, New Siliguri - Bongaigaon-II	2
New Wanpoh	NR-II	Kishanpur-Wanpoh I,II,III	3
Patna	ER-I	Patna - Balia-I, Patna - Balia-II, Patna - Balia-III, Patna - Balia-IV	4
Raichur	SR-I	Raichur - Kurnool , Raichur - Solapur	2
Raigarh	WR-I	Raigarh - Jharsuguda I, Raigarh - Jharsuguda II, Raigarh-Jharsugudha-III & IV	4
Raigarh (Kotra	WR-I	Raipur PS (Durg) - Raigarh (Kotra) I, Raipur PS (Durg) - Raigarh (Kotra)	2
Raipur	WR-I	Raipur PS (Durg) - Raigarh (Kotra) I, Raipur PS (Durg) - Raigarh (Kotra) Raipur PS (Durg) - Wardha I, Raipur PS (Durg) - Wardha II , Wardha-Raipur-III & IV	6
Ramagundam	SR-I	Ramagundam - Chandrapur-I, Ramagundam - Chandrapur-II	2
Ranchi- 765kV	ER-I	Ranchi - Dharamjaygarh I, Ranchi - Dharamjaygarh II	2
Ranchi-400	ER-I	Ranchi - Sipat-I,Ranchi - Sipat-II	2
Sasan	WR-II	Satna - Sasan I, Satna - Sasan II	2
Sasaram	ER-I	Fatehpur-Sasaram	1
Satna	WR-II	Satna - Bina I, Satna - Bina II,Satna - Gwalior I , Satna - Sasan I, Satna - Sasan II, Satna-Vindyachal PS I&II	7
Seoni	WR-I	Seoni - Wardha I, Seoni - Wardha II, Seoni - Bina, Bilaspur - Seoni I, Bilaspur - Seoni II	5
Sipat	WR-I	Ranchi - Sipat-I, Ranchi - Sipat-II	2
Solapur	WR-I	Raichur - Solapur	1
Srikakulam	SR-I	Vindyachal-Srikakulam-I/II	2
Vadodra	WR-II	Vadodara-Indore	1
Varanasi	NR-III	Varanasi-Fatehpur-I, Varanasi-Kanpur I, Varanasi-Kanpur II, Varanasi-Ballia, Gaya - Varanasi I, Gaya - Varanasi II, Biharsherif-Varanasi-I & II	8
Vindyachal	WR-II	Vindyachal-Jabalpur-I/II, Vindyachal-Srikakulam-I/II	4

Annexure-II

Wardha	WR-I	Wardha - Aurangabad I,Wardha - Aurangabad II,Wardha - Aurangabad Wardha - Aurangabad IV, Seoni - Wardha I, Seoni - Wardha II, Raipur PS (Durg) - Wardha I, Raipur PS (Durg) - Wardha II , Wardha-Raipur-III & IV	10
Zerda	WR-II	Kankroli - Zerda, Bhinmal - Zerda	2

Annexure-II

Annexure-B

Example Case Study of Qualitrol for Effectiveness of the TWFL product (based on feedback from respective customers)

North American utility installed TWS on a 500 kV line (39.8 miles) on wooden poles (high impedance faults) as locating faults on it has been challenging

Actual location	TWS miles	Relay miles	DFR miles	FALLS miles	Aspen miles	Date	Time	Cause
19.8	19.8		17.5			12/3/2008	0:18:00.000	Conductor burned off
13.4	13.6		12.6			1/18/2009	21:26:50.568	Car hit guy support
Unknown	18.4					6/23/2009	1:27:55.150	Undefined
2.33	2.4					6/25/2010	18:56:00.872	Snake
32.3	31.5				29.75	8/30/2009	12:46:24.309	Found buzzard feathers
17.64	17.8/ 17.9	14.8	17			3/18/2010	2:25:00.000	Car hit pole
Unknown	18.7	16.9	18.3		18	5/4/2010	18:56:00.000	Unknown
18.2	18.2	16.57	17.8			6/22/2010	4:21:00.000	Arrester
Unknown	18.5	16.9	18.3			8/9/2010	15:55:32.841	Unknown
37.15/34.96 (?)	33.6			32.06		7/6/2011	18:41:32.122	Two blown arrestors

Conclusions:

1. TWS consistently provided accurate fault location
2. Accuracy good regardless of fault type
3. Utility is installing TWS on all new 500 kV Transmission Lines

Annexure-III

DirectorII < dir2-psetd@gov.in >

Re: Minutes of the Second Meeting of the Committee to prepare Guidelines/ Procedure for Implementation of Travelling Wave Fault Locator on Critical Transmission Lines for 220 kV and above (132 kV and above for NER) Voltage levels [TC-TWFL] – reg.

Chief Engineer (PSE&TD), CEA < ce-psetd@gov.in >

Thu, 10 Sep 2026 8:04:13 PM +0530

To "Omkishor sahu"<omkishor.sahu@gov.in>,"veerendranath muncha"<veerandranath.muncha@gov.in>,"purnprakash"<purnprakash@grid-india.in>,"anurag"<anurag@powergrid.in>,"deepakkr"<deepak.kr@grid-india.in>,"seprotection"<seprotection@mahatransco.in>

Cc "Member System"<memberpscea@nic.in>,"PRASAD N R L K"<prasad.nrlk@gov.in>,"Director II"<dir2-psetd@gov.in>

Corrigendum

Sir,

In the Minutes of the Second meeting of the TC-TWFL Committee issued vide CEA letter dated 02.09.2026, in the Point No.16, **"132 kV (110 kV) Stations (applicable across all regions in India)"** shall be read as **"132 kV Stations (applicable only to North-Eastern Region)".**

With regards,

O/o Chief Engineer,
PSE&TD Division, CEA.

From: Chief Engineer (PSE&TD), CEA <ce-psetd@gov.in>
To: "Omkishor sahu"<omkishor.sahu@gov.in>, "veerendranath muncha"<veerandranath.muncha@gov.in>, "purnprakash"<purnprakash@grid-india.in>, "deepakkr"<deepak.kr@grid-india.in>, "anurag"<anurag@powergrid.in>, "seprotection"<seprotection@mahatransco.in>
Cc: "Member System"<memberpscea@nic.in>, "Chief Engineer (PSE&TD), CEA"<ce-psetd@gov.in>, "PRASAD N R L K"<prasad.nrlk@gov.in>, "Pankaj Kumar

Annexure-III

Verma"<kvermap@nic.in>, "Director II"<dir2-psetd@gov.in>
Date: Wed, 02 Sep 2026 15:07:41 +0530
Subject: Minutes of the Second Meeting of the Committee to prepare Guidelines/ Procedure for Implementation of Travelling Wave Fault Locator on Critical Transmission Lines for 220 kV and above (132 kV and above for NER) Voltage levels [TC-TWFL] – reg.

Sir,

Second meeting of the Committee to prepare Guidelines/ Procedure for implementation of Travelling Wave Fault Locator on critical transmission lines for 220 kV and above (132 kV and above for NER) voltage levels [TC-TWFL] was held on 27.08.2026 at 15:00 Hrs at Manthan Conference Hall of CEA, Sewa Bhawan, R K Puram, Sector-I, New Delhi.

The minutes of the second meeting of the Committee is enclosed for your information and necessary action.

With Regards,
O/o Chief Engineer,
PSE&TD Division, CEA

1 Attachment(s)

TC-TWFL-M2-Minutes(02.09.2…
470.8 KB

Annexure-VI_18th NPC

भारत सरकार/Government of India

विद्युत मंत्रालय/Ministry of Power

केन्द्रीय विद्युत प्राधिकरण/Central Electricity Authority

विद्युत प्रणाली अभियांत्रिकी एवं प्रौद्योगिकी विकास प्रभाग

Power System Engineering & Technology Development Division

दिनांक: 15.09.2026

Subject: Report of the Committee on ERS Set Standardization and ERS Training Facility - reg.

महोदया/महोदय,

A committee has been constituted vide CEA letter No. CEA-PS-14-121/1/2026-PSETD Division, dated 15.05.2026, on Emergency Restoration System (ERS) Tower Requirement Standardization and Setting up ERS Training Facility at NPTI under the chairmanship of Chief Engineer (PSE&TD), CEA with representatives from NPC Secretariat, PGCIL, GETCO, CPRI, CSIR-SERC and NPTI.

The Committee has conducted two meetings on 15.06.2026 and 31.08.2026, and has also made two site visits (Raipur S/S of PGCIL and HLTC, Bengaluru) to cover the issues referred. Based on the deliberations held, site visits made, and all relevant information made available, the Draft Report of the Committee has been prepared and circulated to the Committee Members vide email dated 11.09.2026 for furnishing comments. After appropriately incorporating the comments received, the finalized Report is submitted herewith please.

भवदीय,

Digitally signed by
N.R.L.K. Prasad
Date: 15-09-2026
14:40:39

(एन.आर.एल.के. प्रसाद /N.R.L.K. Prasad)

मुख्य अभियन्ता/ Chief Engineer

To:

Chairperson, CEA

Copy to:

SA to Member (Power System), CEA

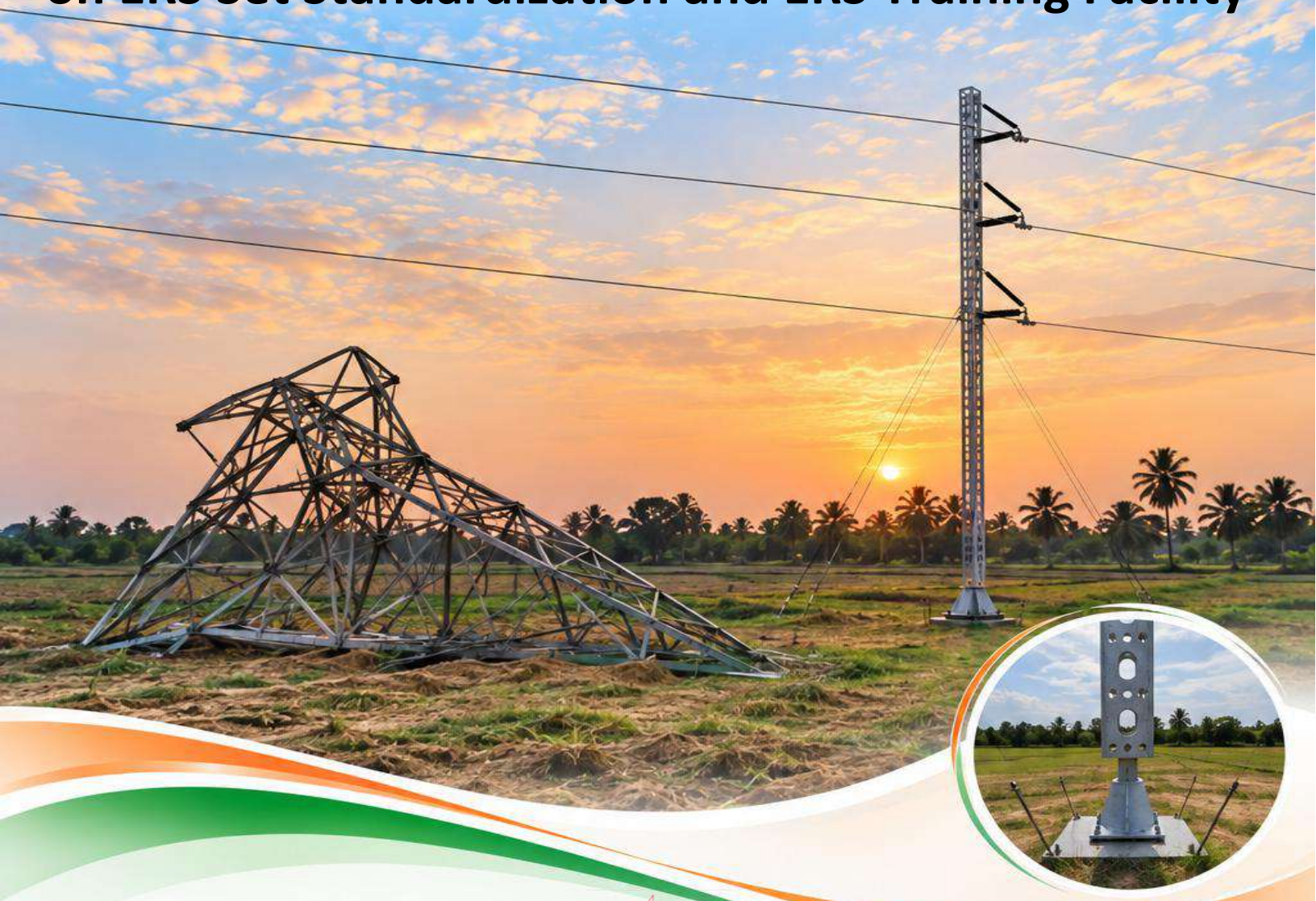
Copy to (All Committee Members):

SN	Name	Organisation	Email
1	Sh. Shishir Pradhan	NPC Secretariat	sk.pradhan15@gov.in
2	Sh. Chandra Kant	Powergrid	chandra.kant@powergrid.in
3	Sh. R. M. Patel	GETCO	serandm.getco@gebmail.com
4	Sh. A. A. Joshi	GETCO	eeengg2.getco@gebmail.com
5	Dr. M Selvaraj	CPRI	msraj@cpri.in
6	Sh. K. Vijay Kumar	CPRI	vijayakumar@cpri.in
7	Dr. Rokade Rajendra Pitamber	CSIR-SERC	rokade.serc@csir.res.in
8	Dr. R. Balagopal	CSIR-SERC	balagopal.serc@csir.res.in
9	Dr. K.P.S. Parmar	NPTI	kpsparmar@npti.gov.in

सत्यमेव जयते

Report of the Committee

on ERS Set Standardization and ERS Training Facility



केविप्रा
cea

Government of India
Ministry of Power
Central Electricity Authority
Power System Engineering & Technology Development Division
September, 2026

Table of Contents

1. Introduction 3
1.1 Background 3
1.2 Committee Constitution 4
1.3 Terms of Reference (ToR) of the Committee 5
1.4 Proceedings of the Committee 5
2. Requirement of ERS 8
3. Present Status of ERS availability with utilities 10
4. Manufacturing Eco-system and Associated Details of ERS 12
4.1 Steel-based ERS 12
4.2 Aluminium-based ERS 12
4.3 Manufacturing Eco-system 12
5. Minimum Local Content (MLC) and Cost-Weight Comparison 14
5.1 Minimum Local Content (MLC) requirements for both Steel based ERS and Aluminium based ERS 14
5.2 Cost and Weight Comparison of Steel based ERS and Aluminium based ERS 15
6. Standardization of Minimum Number and Configuration of Towers to be maintained in an ERS Set 16
6.1 Regulatory & Safety Requirements for ERS 16
6.2 Guiding Philosophy 17
6.3 Standardization of an ERS Set 17
6.4 Requirement of ERS Sets 18
6.5 ERS Survey and Site Assessment 18
7. Deployment of ERS System through Rental Arrangements 20
7.1 Details of the Vendors Offering ERS on Rental Basis 20
7.2 General Frame-work for ERS Rental Arrangements 21
8. Establishment of ERS Training Facility 23
8.1 Need for ERS Training Facility 23
8.2 Space requirements 24
8.3 Basic Training 25
8.4 Advanced Training 27

List of Annexures

Annexure-I: Constitution of Committee on ERS letter dated 15.05.2026

Annexure-II: Minutes of I meeting of the committee on ERS dated 17.07.2026

Annexure-III: Minutes of II meeting of the committee dated 06.09.2026

Annexure-IV: Ministry of Power Guidelines dated 05.12.2014

Annexure-V: Central Electricity Authority (CEA) Standard Operating Procedure (SOP) for restoration of the Transmission system dated 11.05.2025

Annexure-VI: Checklist for Survey for Installation of ERS (Emergency Restoration System)

Annexure-VII: Lay-Out Diagram of Proposed ERS Training Facility Location at HLTC, Bengaluru

1. Introduction

1.1 Background

The reliable and continuous operation of the transmission system is essential for maintaining grid security and ensuring uninterrupted supply of electricity. In the event of failure or collapse of transmission line towers due to natural calamities, extreme weather events, accidents, or other unforeseen circumstances, timely restoration of the affected transmission line is critical to minimize the duration of outage and maintain the reliability of the power system. In this context, the Emergency Restoration System (ERS) plays an important role as a temporary structural arrangement for expeditious restoration of power supply until permanent restoration of the affected portion of the transmission lines and tower structures.

An ERS is a portable and modular system of uniquely designed mast structures and associated accessories that can be quickly transported to the failure site and rapidly erected to temporarily support the conductors, thereby facilitating early restoration of power supply and re-energization of the affected transmission line by by-passing the failed portion of the transmission line. And this arrangement would be in place till the failed portion of the transmission Line is restored on permanent basis (by re-erecting the failed tower structures and conductors)

With the continued expansion of the transmission network, and the ever increasing load growth, the need for ensuring power supply without interruption has become paramount. However, since the transmission lines may get affected due to natural calamities and extreme weather events, the need for having temporary alternative arrangements such as ERS to cater to the needs of the failed portion of the affected transmission lines has become all the more important. The importance of maintaining adequate ERS arrangements for temporary restoration of transmission lines ensuring grid reliability has been recognized in the regulatory and operational framework governing the transmission sector through Central Electricity Authority (Grid Standards) Regulations, 2010, Ministry of Power Guidelines dated 05.12.2014 and the Central Electricity Authority (CEA) Standard Operating Procedure (SOP) for restoration of the Transmission system dated 11.05.2025.

The Central Electricity Authority (Grid Standards) Regulations 2010, stipulate that each transmission licensee shall have an arrangement for restoration of transmission lines of 400 kV and above and strategic 220 kV lines through the use of Emergency Restoration System in order to minimize the outage time of the transmission lines in case of tower failures.

The Guidelines issued by Ministry of Power vide letter dated 05.12.2014 (**Annexure-IV**) inter-alia specify the number of ERS Sets to be maintained by each utility as under:

- One (1) set of ERS for Transmission Line Lengths up to 5,000 Ckt-kms
- Two (2) set of ERS for Transmission Line Lengths of about 5,000 to 10,000 Ckt-kms
- Three (3) set of ERS for Transmission Line Lengths of about 10,000 to 15,000 Ckt-kms and so on.

Further, these Guidelines also provide for a Transmission Utility with line length less than 500 ckm (of 400 kV) may be given option either to procure ERS or have arrangement with other Transmission utilities for providing ERS on mutually agreed terms, when need arises.

The Standard Operating Procedure (SoP) issued vide CEA letter dated 11.05.2025 (**Annexure-V**) for restoration of transmission lines also specifies the ERS tower requirement for restoration of transmission lines.

Even though all these Regulations, Guidelines and SoP clearly point to the need for maintaining sufficient no. of ERS Sets, it has been observed that the same is yet to be complied with by many utilities. Further, the no. of Towers and their configuration to be maintained in an ERS set is also observed to be not uniform across the utilities. In view of the evolving requirements of the transmission system, there is a need to review and standardize the minimum number and configuration of ERS towers required to be maintained by transmission utilities so that the adequate number of ERS towers, along with appropriate configuration including the requisite proportion of suspension and tension towers, are maintained by them.

Effective deployment of ERS also requires personnel having practical knowledge of handling of ERS equipment and adequate field experience in erection, operation, dismantling, maintenance etc. In this context, the need for having dedicated **ERS Training Facilities** at suitable national-level Institutes such as **National Power Training Institute (NPTI)** to impart systematic training and capacity building to personnel from transmission utilities also becomes important. This is especially so considering the need for transmission utilities to maintain sufficient no. of skilled manpower to handle ERS related operations/ activities.

Further, considering the specialized nature of ERS equipment and the significant capital expenditure involved in procurement and maintenance of complete ERS sets, the feasibility of making ERS systems available through rental arrangements also assumes importance. Such arrangements may provide greater flexibility to transmission utilities, for whom maintaining dedicated ERS sets may not be economically viable or operationally feasible.

1.2 Committee Constitution

Considering the critical role of the Emergency Restoration System (ERS) in expeditious restoration of transmission systems and maintenance of grid reliability during emergency and contingency conditions, National Power Committee (NPC) in their 17th meeting held on 27.02.2026 has deliberated on various issues pertaining to ERS such as their standardization, making them available on rental arrangements, and establishing ERS Training Facility at Institutes such as NPTI, and referred the following matters to PSE&TD Division of CEA for proper redressal:

(i) To examine and standardize the minimum number of towers required to be maintained in an ERS set considering tension and suspension tower numbers.
(ii) To examine the feasibility of deploying ERS systems through rental arrangements.
(iii) To coordinate with suppliers, vendors and manufactures for establishment of ERS set up at training institute of NPTI for imparting training on use and deployment of ERS to power sector professionals.

Accordingly, a Committee was constituted vide CEA letter dated 15.05.2026 **(Annexure-I)** under the Chairmanship of Chief Engineer (PSE&TD), CEA comprising the following members:

1.	Sh. N.R.L.K Prasad, Chief Engineer (PSE&TD), CEA	Chairman

2.	Sh. Shishir Pradhan, Deputy Director, NPC Secretariat	Member
3.	Sh. Chandra Kant, Sr. DGM, PGCIL	Member
4.	Dr. M Selvaraj, Additional Director, CPRI	Member
5.	Sh. K. Vijay Kumar, Joint Director, CPRI	Member
6.	Dr. Rokade Rajendra Pitamber, Scientist F, CSIR-SERC	Member
7.	Dr. R. Balagopal, Scientist F, CSIR-SERC	Member
8.	Sh. R. M. Patel, SE, GETCO	Member
9.	Sh. A. A. Joshi, AE, GETCO	Member
10.	Dr. K.P.S. Parmar, Deputy Director, NPTI	Member
11.	Smt. Kavita Jha, Director (PSE&TD), CEA	Member Convener

1.3 Terms of Reference (ToR) of the Committee

ToR of the Committee are as under:

a) The Committee shall standardize the minimum number and configuration of towers, including both suspension and tension towers, to be maintained in an ERS set.
b) The Committee shall examine the feasibility of deploying ERS systems through rental arrangements.
c) The Committee shall examine the feasibility for establishment of ERS training set up at institutes such NPTI and CPRI for imparting training to power sector professionals on deployment, operation, and maintenance of ERS.

1.4 Proceedings of the Committee

The Committee on *Emergency Restoration System (ERS) Tower Requirement Standardization and Setting up ERS Training Facility at NPTI* (TC-ERS) was constituted with the objective of examining and recommending measures for strengthening the preparedness of transmission utilities for expeditious restoration of transmission lines in the event of tower failures. The Committee was primarily entrusted with examining (i) standardization of the minimum number and configuration of ERS towers, including suspension and tension towers, to be maintained in an ERS set; (ii) feasibility of deployment of ERS through rental arrangements; and (iii) feasibility of establishing ERS training facilities at institutes such as NPTI and CPRI for imparting training to power-sector personnel in the deployment, operation and maintenance of ERS. The Committee conducted two meetings to deliberate on the matters.

The **first meeting of the Committee** was held on 15.06.2026, wherein regulatory and operational requirements for adequate ERS arrangements, including the provisions of the CEA (Grid Standards) regulations 2010, MoP Guidelines dated 05.12.2014 and CEA SOP for restoration of the Transmission system dated 11.05.2025 were deliberated upon. A detailed presentations on the status of availability and adequacy of Emergency Restoration Systems (ERS) across transmission utilities in various regions across the country was made by NPC Secretariat.

Based on the presentation, the Committee observed a significant nationwide shortfall in availability of ERS sets vis-à-vis the prescribed ERS Norms. Further, the no. of Towers and their

configuration to be maintained in an ERS set was also observed to be not uniform across the utilities.

In addition to the above, the Committee deliberated on various aspects relating to the Emergency Restoration System (ERS), including the existing manufacturing ecosystem both domestic and international for steel-based and aluminium-based ERS, the Minimum Local Content (MLC) of ERS systems, comparative cost and weight advantages of aluminium-based ERS vis-à-vis steel-based ERS, ongoing indigenous development of ERS towers by CPRI, standardization of the minimum number and configuration of towers including suspension and tension tower, to be maintained in an ERS set, applicable design standards and the existing practices in the transmission sector regarding rental arrangements for ERS towers. The possibility of transmission utilities entering into suitable rental arrangements with ERS manufacturers/service providers was also discussed.

The Committee further deliberated on the establishment of ERS training facilities at institutes such as NPTI, CPRI and PGCIL for imparting training to power sector professionals on the deployment, operation and maintenance of ERS, including the nature and scope of training courses to be offered. Based on the deliberations, the Committee opined that site visit to an existing ERS training facility of PGCIL would be useful for gaining practical insights and better understanding of the deployment and training requirements. Accordingly, a site visit to the PGCIL ERS training facility was proposed. The Minutes of the meeting, issued vide PSE&TD letter dated 17.07.2026, are given at **Annexure-II**. Subsequently, the Committee conducted a site visit to the ERS training facility of PGCIL at Raipur on 03.08.2026.

The **second meeting of the Committee** was held on 31.08.2026. The Committee took forward the deliberations of their first meeting, particularly on the standardization of the minimum number and configuration of ERS towers, feasibility of deployment of ERS through rental arrangements, and establishment of ERS training facilities at institutes such as NPTI and CPRI. The Committee also deliberated upon the outcome of their site visit to Existing ERS training facility of PGCIL at Raipur. It was deliberated that ERS training facility should not merely be a demonstration facility but should provide practical exposure covering the complete ERS deployment cycle. The tentative framework for basic and advanced training to be conducted at the proposed training facility was deliberated upon.

The Committee also deliberated upon the Minimum Local Content (MLC) requirements for Steel-based ERS and Aluminium-based ERS and noted the status of the ERS Manufacturing ecosystem. The Committee emphasized that the standardization exercise should provide sufficient flexibility to cater to different transmission-system configurations while clearly defining the minimum ERS requirements. Minutes of the meeting issued vide PSE&TD letter dated 06.09.2026 are given at **Annexure-III.**

Further, to finalize site for the proposed training facility at NPTI/ HLTC, Bengaluru, a joint inspection by PGCIL and NPTI Officials was arranged on 03.09.2026.

Based on the deliberations held and site visits made, and all relevant information made available, the Report has been structured to cover the following aspects pertaining to ERS:

- Requirement of ERS

- Present status of ERS availability with utilities
- Manufacturing Eco-system and associated details of ERS
- MLC and Cost-Weight comparison
- Standardization of Minimum Number and Configuration of Towers to be maintained in an ERS Set
- Deployment of ERS System through Rental Arrangements
- Set up of Training Facility

The ensuing Sections discuss the above in sufficient detail.

2. Requirement of ERS

India has one of the largest A.C. synchronous transmission grids in the world, comprising an extensive network of transmission lines which forms the backbone of the Indian Power System. The sustained and secure operation of this transmission network is essential for ensuring reliable supply of electricity and maintaining the security and stability of the Grid. During natural disasters and other adverse conditions, damage to transmission infrastructure, particularly failure of transmission towers, can result in prolonged outages and severe constraints in meeting the power demand. Such failures also pose challenges in maintaining the safety, reliability and security of the Grid.

In the event of transmission line failures occurring due to high wind loading, storms, rock slides, mud slides, erosion of foundations, corrosion of towers, vandalism and sabotage etc., restoration through conventional means involves removal of the damaged tower, rectification of the foundation, transportation of materials to the site and erection of the new tower, which requires considerable time depending on the extent of damage. This also results in significant economic costs to transmission utilities due to loss of transmission added up with associated penalties.

Under such emergency and contingency conditions, availability of an effective mechanism for emergent restoration of transmission lines in the shortest possible time is of utmost importance. Immediate and temporary restoration of transmission networks is possible through deployment of the Emergency Restoration System (ERS). ERS therefore provides an important means for restoring power transmission lines on an emergency basis following tower failures and other damage to transmission infrastructure.

ERS provides a reusable and modular arrangement for temporary restoration of transmission lines. It enables the damaged transmission infrastructure to be bypassed and power transmission to be resumed much faster than through conventional restoration methods. ERS has therefore been useful in minimizing the outage period and facilitating early restoration of the transmission system.

As per the Central Electricity Authority (Grid Standards) Regulations, 2010, each transmission licensee shall have an arrangement for restoration of transmission lines of 400 kV and above and strategic 220 kV lines through the use of Emergency Restoration System, with the objective of minimizing the outage time of transmission lines in case of tower failures. Thus, provision of procurement of ERS arrangements forms an important component of preparedness for emergency restoration of the transmission system.

In this connection, the Ministry of Power, vide D.O. letter dated 05.12.2014 **(Annexure-IV),** has stipulated criteria for determining the number of ERS sets to be arranged by a Transmission Utility. The requirement has primarily been linked with the transmission line length in circuit-kilometres (Ckt-kms). The criteria are as follows:

- One (1) set of ERS for Transmission Line Lengths upto 5,000 Ckt-kms
- Two (2) set of ERS for Transmission Line Lengths of about 5,000 to 10,000 Ckt-kms
- Three (3) set of ERS for Transmission Line Lengths of about 10,000 to 15,000 Ckt-kms and so on.

For a Transmission Utility having line length of less than 500 Ckt-kms at 400 kV, an option may be given either to procure ERS or to have an arrangement with other Transmission Utilities for providing ERS on mutually agreed terms, whenever the need arises.

In addition to the transmission line length, other relevant factors for determining the requirement of ERS include the importance of the transmission line from the perspective of Grid security, areas prone to tower failures and the failure pattern in different areas, the command area of the Transmission Utility, and the transportability of ERS across its command area.

The requirement for strengthening ERS preparedness has also been reinforced through the Standard Operating Procedure (SOP) for restoration of the transmission system issued by CEA vide letter dated 11.05.2025 **(Annexure-V).** The objective of the SOP is to establish a structured plan for quickly restoring damaged transmission system, protecting personnel and strengthening power system resilience. The SOP applies to substations and associated transmission infrastructure, including transmission lines, transformers, switchyards, protection and control systems, and communication systems, located in high-risk or vulnerable zones.

The SOP further provides for identification of ERS requirements, diversion of the nearest available ERS along with an ERS specialist gang, and deployment of Emergency Restoration Systems during restoration of transmission lines. In cases involving partial damage, replacement of damaged insulators and conductors is also envisaged. Thus, ERS deployment forms an integral part of the structured restoration mechanism for damaged transmission infrastructure.

The assessment presented before the Committee indicates that ERS requirements vary with voltage levels and across regions. It further reveals a gap between the ERS sets required in accordance with the prevailing Government norms and the sets presently available with the utilities. The regional assessment covers ERS requirements for transmission systems at different voltage levels, including 220 kV, 400 kV, 765 kV and HVDC systems.

Considering the critical role of ERS in expeditious restoration of transmission systems and maintenance of Grid reliability during emergency and contingency conditions, there is a need for standardization of the minimum number and configuration of ERS towers, including both suspension and tension towers, to be maintained in an ERS set. This requirement has formed one of the principal areas of examination by the Committee.

The Committee has also considered that the standardization of ERS requirements should provide sufficient flexibility for different transmission-system configurations while ensuring that the minimum requirement is clearly defined.

The Committee has accordingly examined the requirement of ERS in relation to actual tower failure scenarios and the restoration methodology generally employed, with the objective of ensuring that the ERS arrangements maintained by utilities are adequate for effective and timely emergency restoration.

3. Present Status of ERS availability with utilities

The status of availability and adequacy of ERS across transmission utilities in various regions across the country has been presented to the Committee by NPC Secretariat. The region-wise availability and shortfall of ERS, as presented are summarized below:

Summary of ERS in all regions				
Region	**Voltage Level**	**ERS Required as per the Govt. norms (as per present requirement)**	**No. of ERS set (tower) available**	**Shortfall**
WR	66kV, 132kV, 220kV, 400kV, 765kV, HVDC-32kV, 500kV, 800kV	61	42	19
SR	220kV, 400kV & 765kV	34	23	11
NR	220kV, 400kV, 765kV, HVDC-500kV, 800kV	64	46	18
ER	66kV, 132kV, 220kV, 400kV, 765kV, HVDC-320kV, 500kV, 800kV	32	-	-
NER	132kv, 400kV, 765kV, HVDC-320kV, 500kV, 800kV	14	6	8

The statistics presented by the NPC Secretariat indicate that, across various regions of the country, the availability of ERS sets with utilities has not been commensurate with the requirement prescribed under the Government guidelines. The region-wise assessment has highlighted considerable gaps in ERS availability, particularly in the Western, Southern, Northern and North Eastern Regions. The statistics showed 42 sets available in the Western Region against the 61 sets of ERS requirement assessed as per Government norms, 23 sets available against 34 sets assessed in the Southern Region, 46 sets available against 64 sets assessed in the Northern Region, and 6 sets available against 14 sets assessed in the North Eastern Region.

It is pertinent to mention that Power Grid Corporation of India Limited (PGCIL) has largely maintained adequate ERS set inventories across all the regions. The availability of ERS sets at

various locations of PGCIL has provided an important support mechanism for emergency restoration of transmission lines. The Committee has also noted that certain private transmission utilities, such as Adani Energy Solutions Limited, which operate transmission networks across multiple regions in the country, has maintained ERS sets for meeting their emergency restoration requirements. However, it has been observed that many State Transmission Utilities (STUs) and other Private Transmission Service Providers (TSPs) have not given the required attention to procurement and maintenance of the required ERS sets. Consequently, substantial gaps have been observed between the ERS requirement and the ERS sets presently available with a number of utilities. This situation has resulted in gaps in emergency restoration preparedness, particularly in the event of failure of towers in Extra High Voltage (EHV) transmission lines.

The region-wise assessment has further indicated that the extent of ERS availability varies considerably among utilities. In several cases, utilities have either initiated procurement processes or have proposed additional ERS sets, while in certain cases, ERS availability has been made dependent upon arrangements with other utilities or availability of centrally located ERS sets. The assessment has therefore indicated that the present level of preparedness is not uniform across utilities and regions.

Although the existing Regulations, MoP Guidelines and the Standard Operating Procedure indicate the need for maintaining sufficient ERS sets, the same is yet to be complied with by many utilities. Further, the number of towers and their configuration maintained in an ERS set have also been observed to be non-uniform across utilities. The Committee has therefore considered standardization of the minimum number and configuration of ERS towers as an important requirement for strengthening the emergency restoration preparedness across the transmission sector.

The observed gaps in ERS availability assume greater significance in view of the requirement for expeditious restoration of transmission systems following tower failures. The availability of adequate ERS sets at appropriate locations is essential for enabling timely deployment and restoration of affected transmission lines. The Committee has accordingly emphasized that utilities need to maintain sufficient ERS inventory commensurate with their transmission network requirements, while ensuring that the ERS sets maintained are capable of meeting the required restoration scenarios.

4. Manufacturing Eco-system and Associated Details of ERS

Emergency Restoration System (ERS) used for transmission line restoration are broadly available in Steel-based and Aluminium-based configurations. The choice of material has a direct bearing on the weight of the system, transportation and handling requirements, erection methodology, structural configuration, manufacturing process and overall cost. Both Steel-based and Aluminium-based ERS systems have evolved as viable solutions for emergency restoration, with their respective advantages and limitations.

4.1 Steel-based ERS

Steel-based ERS systems have traditionally been used for emergency restoration of transmission lines and are available in different configurations and voltage classes. Each ERS Tower comprises modular steel based mast sections & foundation assembly, insulated cross-arms, insulator attachment arrangements, guying components and associated hardware fittings, which can be assembled at site to form a temporary transmission tower structure.

Steel offers relatively high strength and stiffness and is capable of withstanding the mechanical loads associated with temporary transmission-line restoration. Steel-based ERS components are, however, comparatively heavier.

4.2 Aluminium-based ERS

Aluminium-based ERS systems comprise modular Aluminium based mast sections & foundation assembly, insulated cross-arms, insulator attachment arrangements, guying components and associated hardware fittings, which can be assembled at site to form a temporary transmission tower structure.

Aluminium has a substantially lower density than steel. However, Aluminium material used in ERS has a higher material cost per unit weight than Steel material used in ERS.

4.3 Manufacturing Eco-system

The ERS manufacturing ecosystem comprises both Steel-based and Aluminium-based ERS, with manufacturers available from both domestic and international manufacturers.

The major manufacturers in the field of ERS manufacturing are as follows:

a. Steel Based ERS Manufacturers

- DNV, Netherlands
- Cobra IS, Spain

b. Aluminium Based ERS Manufacturers

- M/s Hi-Tech Services & Systems Ltd., Kolkata
- M/s Advait Energy Transitions Limited, Ahmedabad
- M/s IAC Electricals Pvt. Ltd., Kolkata

- Lindsay, USA
- SBB, Canada
- Tower Solutions Canada

It was further indicated by PGCIL that following **domestic available firms** have participated in its latest ERS procurement process:

- Hi-Tech Systems and Services limited- Kolkata
- Advait Energy Transitions Limited- Ahmedabad
- IAC Electrical Pvt. Ltd.- Kolkata
- Madhav Engineers Pvt. Ltd.- Mumbai

Out of the above listed domestic firms, Hi-Tech Systems & Services Ltd., Advait Energy Transitions Ltd. and IAC Electricals Pvt. Ltd. are observed to be operating with technical know-how license from CSIR-SERC for manufacturing the Aluminum base ERS, and are having significant annual production capacities for ERS masts. The details of the manufacturers and their indicated annual production capacities are as follows:

- M/s Advait Infratech Ltd., Ahmedabad – Annual Capacity 300-350 ERS Masts, 90% MLC
- M/s Hi-Tech Services & Systems Ltd., Kolkata – Annual Capacity 300 ERS Masts & 90 % MLC
- M/s IAC Electricals Pvt. Ltd., Kolkata – Annual Capacity 200 ERS Masts & 90% MLC

The Committee noted that, except for the software-related component, the above three manufacturers are sourcing all major components and sub-components of ERS manufactured indigenously. These components include ERS suspension/running-angle and tension towers, foundation/base plates, anchor assemblies, insulator strings and hardware fittings, earth wire/OPGW fittings, guys and guy hardware, guy insulators, structural cables and hardware, erection and installation tools and tackles, containers and associated software.

With regard to indigenous technology development by other players, it is noted that CPRI has developed a 66 kV double-circuit transmission tower with insulated cross-arms using Fibre Reinforced Polymer (FRP) material. The tower has a modular configuration, with a base footprint of approximately 1 m × 1 m, a height of about 17 m and an overall weight of around 800 kg. The tower has successfully undergone mechanical strength as well as electrical performance testing. It is also noted that the developed design can be suitably modified and adapted for ERS applications.

5. Minimum Local Content (MLC) and Cost-Weight Comparison

All the components and sub-components that constitute an ERS Tower have been considered by the Committee to derive MLC% and Cost-Weight comparison of Steel based ERS and Aluminium based ERS. The major components and sub-components used in the Emergency Restoration System have been noted as under:

a. ERS Suspension/ Running Angle & Tension Towers incl. articulated base (gimbal), mast sections, box sections, guy plates/swivels, bolts & nuts.
b. Foundation / Base Plates
c. Anchor Assemblies
d. Insulator Strings along with hardware fittings
e. Earthwire/OPGW fittings
f. Guys & guy hardwares
g. Guy Insulators
h. Structure cables & hardwares
i. Erection/ Installation Tools & Tackles
j. Software (PLS-CADD, PLS Tower, PLS Pole and Software for ERS)
k. Containers

5.1 Minimum Local Content (MLC) requirements for both Steel based ERS and Aluminium based ERS

The Committee has noted that the domestic ERS manufacturing ecosystem has developed considerably in recent years. It is also noted that for both the types of ERS, viz., Aluminium-based ERS and Steel-based ERS, domestic as well as foreign vendors exist.

With regard to Minimum Local Content (MLC), it is noted that the three domestic manufacturers of Aluminium-based ERS, operating with technical know-how licence from CSIR-SERC, have already achieved MLC levels of about 90%. As informed by them, except for the Software component, all other components and sub-components are being procured indigenously. It is further noted foreign players have also achieved MLC levels of more than 50%.

It may be noted that Minimum Local Content (MLC) has so far not been specified for ERS Towers/Sets under the Ministry of Power's Public Procurement (Preference to Make in India) Order dated 16.11.2021. Accordingly, in case MLC is proposed to be specified for ERS Towers/Sets, the MLC levels presently being achieved by both domestic and foreign manufacturers may be taken into consideration while determining the initial threshold. This would help ensure a level playing field and promote fair competition among suppliers. The threshold may thereafter be enhanced progressively in a phased manner.

Considering the established domestic manufacturing base for ERS and the high levels of MLC already being achieved by domestic ERS suppliers, it is suggested the initial MLC threshold may be quickly brought to 90% within a period of two years, based on assessment of availability of adequate competition.

In this regard, it is also opined that the MLC regime may not be made applicable to ERS services provided on a rental basis, since such arrangements do not involve actual procurement of ERS Towers/Sets. Nevertheless, it is noted that the ERS sets offered by vendors on rental services

already have high levels of MLC, due to their being sourced from domestic manufacturers having high MLC content.

5.2 Cost and Weight Comparison of Steel based ERS and Aluminium based ERS

The comparative Cost and Weight aspects of Steel-based ERS and Aluminium-based ERS have also been considered by the Committee. It is noted that the per kg cost of Aluminium material employed in an ERS Tower is generally more than two times the per kg cost of Steel material employed in an ERS Tower. It is further noted that both Aluminium and Steel materials are used in significant quantities in Aluminium-based ERS, whereas Steel material is predominantly used in Steel-based ERS.

Accordingly, it is observed that a weight reduction by more than 30–40% is required in Aluminium-based ERS to bring price parity between Aluminium based ERS and Steel-based ERS. Thus, cost effectiveness of Aluminium-based ERS would depend significantly on the extent of weight optimization achieved through its design and manufacturing.

Since the desirable qualities of an ERS include both lower cost and lower weight, comparison between Steel-based and Aluminium-based ERS should be undertaken accordingly for complete ERS set, taking into account not only the procurement cost and overall weight but also transportation, handling, erection requirements, manufacturing and fabrication costs, maintenance and other lifecycle considerations.

6. Standardization of Minimum Number and Configuration of Towers to be maintained in an ERS Set

The detailed deliberations on the minimum number and configuration of ERS towers to be maintained in an ERS set have been held by the Committee. The agreed philosophy and methodology for determining the requirements are guided by the actual failure scenarios of transmission towers and the restoration methodologies generally employed for restoration of the transmission system. Further, the ERS deployed should also meet stipulated regulatory & safety requirements. Details are given in the ensuing paras.

6.1 Regulatory & Safety Requirements for ERS

ERS is essentially a temporary restoration system and is intended to be deployed for a limited period during emergency restoration. Further, it is also not a proper lattice or pole structure. Therefore, the requirements applicable to permanent transmission structures need to be appropriately interpreted for temporary ERS structures, without compromising essential structural and electrical safety.

The Committee noted that the technical practices presently being followed include:

a) IS 802 for design and loading considerations relating to ERS tower structures
b) IEEE 1070 for testing of ERS structures and associated structural components such as box sections, guy plates, gimbals, bolts, nuts and washers
c) Relevant Indian/ International standards for line materials, hardware fittings, earth-wire accessories and insulators.

In particular, the following have been emphasized:

1. Required electrical clearances shall be maintained as per relevant safety regulations
2. Right of Way (RoW) requirements shall not be compromised and the requirement for the same shall be calculated considering the structure as pole structure. However, lower RoW requirements (up to 0.8 to 0.9 times) of the RoW required for conventional Pole structures can be employed. In this regard, it may however be mentioned that Guy wires anchoring requirement could go up to 50 m around the ERS Tower.
3. The design span for ERS tower shall be considered as 400 m. However, the ERS configuration and span shall be selected based on actual site conditions. It is also agreed that the standard restoration span of about 300 m may be adopted, while higher/ lower spans may be accommodated, justified by site conditions and structural analysis.
4. Structural stability shall be verified for the actual configuration, loading, span and site conditions
5. Periodic testing and inspection shall be undertaken to ensure that ERS components remain adequate for deployment.
6. The temporary nature of ERS should be clearly recognized while finalizing the applicable design and testing requirements.
7. Proper upkeep (operation and maintenance practices) is required

6.2 Guiding Philosophy

a) The mast is the primary common structural component of an ERS tower. It comprises modular sections of standardized dimensions, and the number of mast sections/ modules assembled determines the overall height of the ERS tower which can be varied in accordance with voltage level and as per actual site condition.
b) ERS towers are generally are used for restoration of (i) all three phases of Single-Circuit (S/C) Twin conductor configuration, or (ii) One phase of Single-Circuit (S/C) Quad & above conductor configuration.
c) The conductors required for restoration activities are not normally part of the ERS package and shall be arranged separately by the concerned transmission utility or transmission licensee.
d) There is no fundamental distinction between suspension and tension type ERS towers with respect to the mast structure. Both configurations utilize the same modular mast components. The difference arises primarily from the ancillary components and arrangements adopted to meet specific loading and operational requirements, such as the number and configuration of guy wires, insulator cross-arms (ICA), stringing arrangements, requirements, and the number of mast modules employed to achieve the desired tower height and mechanical performance.
e) Since in Transmission lines, Section Length is kept as 3 km to 5 km, with Design span of 300 m – 400 m, even though actual failure is confined to only one or two towers, the possibility of adjacent Suspension Towers falling (due to pulling effect) is very real, and the total no. of simultaneously fall of Towers could go up to 10 Towers in some cases.
f) Since ERS Towers are employed for restoration of power supply on emergency basis, the priority should be to restore at least one of Circuit, if the fallen Towers carry more than one Circuits.
g) For the Transmission lines up to Twin-configuration, each ERS Tower is used for restoring complete Circuit. For transmission lines that employ higher configurations such as Quad/ Hexa/ Octa, each ERS Tower is used for restoring One Phase of a Circuit.

6.3 Standardization of an ERS Set

In view of the above considerations, it is essential that an ERS Set should at least be capable of catering to the requirement for **restoration of failure of five D/C towers simultaneously**, i.e. towers carrying two circuits. Accordingly, for restoring one circuit, the minimum requirement of an ERS Set has been set as five (5) Suspension Towers and three (3) Tension Towers.

With due consideration to above, the minimum requirement of Suspension and Tension Towers in an ERS Set considering all possible Cases have been finalized as under:

a) For 400 kV & below Transmission lines up to D/C Twin Configuration, 10 no. of Suspension Towers and 6 no. of Tension Towers constitute one ERS Set.
b) For 400 kV and 765 kV Transmission lines with higher configurations such as Quad and Hexa, 15 no. of Suspension Towers and 9 no. of Tension Towers constitute one ERS Set.
c) For HVDC lines, due to use of Herringbone structures in restoration, 15 no. of Suspension Towers and 9 no. of Tension Towers have been considered as constituting one ERS Set.

In order to optimize the number of ERS Sets, which a Utility should possess for their transmission lines at different voltage levels, the following are recommended:

(i). For 400 kV & below Transmission lines up to Quad Configuration, 15 no. of Suspension Towers and 9 no. of Tension Towers constitute one ERS Set (If the Utility has only up to Twin configuration, and does not possess any Quad Configuration, then 10 no. of Suspension Towers and 6 no. of Tension Towers shall be taken as constituting one ERS Set).

(ii). For 765 kV and HVDC Transmission lines, 15 no. of Suspension Towers and 9 no. of Tension Towers constitute one ERS Set.

6.4 Requirement of ERS Sets

With an ERS Set to be employed for use at different Voltage levels & Configurations as given at 6.3 above, the no. of such ERS Sets to be maintained by a Utility are guided by the MoP Guidelines dated 05.12.2014 as given under:

a) One (1) set of ERS for Transmission Line Lengths up to 5,000 Ckt-kms
b) Two (2) set of ERS for Transmission Line Lengths of about 5,000 to 10,000 Ckt-kms
c) Three (3) set of ERS for Transmission Line Lengths of about 10,000 to 15,000 Ckt-kms and so on.

*The above requirement is to be met **separately** for both (400 kV & below transmission lines taken together) and (765 kV & HVDC transmission lines taken together).*

6.5 ERS Survey and Site Assessment

A systematic survey is required before installation and deployment of the Emergency Restoration System (ERS) to assess the damaged section, site conditions, restoration requirements and feasibility of ERS installation. The survey process includes topography of the route profile and tower schedule of the damaged transmission line, soil condition, identification of the damaged tower locations and nearest approach roads, and obtaining the necessary permits and Right of Way (RoW) clearances before accessing the site. The voltage level, conductor configuration and recent power-flow data at the time of failure of tower/information are also required to be assessed. The survey team and necessary equipment, including DGPS/Total Station and safety PPE, are required to be arranged.

During the site survey, the exact location, number and type of damaged towers and the extent of the damaged section are required to be established. The span length to be restored, terrain conditions, soil conditions and the presence of underground utilities or pipelines are required to be assessed. Nearby forests, structures, villages, roads, religious places and waterbodies are required to be identified and marked along with the existing transmission line route. The availability of safe working clearances, accessibility for transportation and storage of ERS materials, availability of cranes and other equipment, and environmental and safety constraints are also required to be examined.

Based on the survey findings, the ERS restoration route is to be finalized, initially through plotting on Google Earth followed by field verification using DGPS/Total Station. The appropriate conductor configuration, such as Single, Twin or Quad, is required to be finalized based on the power-flow

requirement and phase arrangement. The number and type of ERS towers, including Tension, Delta and Running Angle towers, are required to be determined based on the span and loading conditions. The proposed ERS section is required to be properly plotted in PLS-CADD, and the required tower heights are to be verified to ensure compliance with statutory clearances.

The final spotting of ERS towers is required to be carried out using GPS coordinates, with verification of span lengths and adequate ground clearances. The location and anchoring direction of ERS towers are required to be assessed using PLS-Pole software at the time of design validation. The anchor locations are required to be planned so that they do not overlap with the restoration area of the conventional transmission line. The Checklist for Survey for Installation of ERS (Emergency Restoration System) is given at **Annexure-VI**.

7. Deployment of ERS System through Rental Arrangements

The Committee discussed the feasibility of deploying Emergency Restoration System (ERS) through rental arrangements, particularly for utilities for whom procurement and maintenance of a dedicated ERS set may not be economically viable or operationally feasible. Such rental arrangements may be particularly useful for utilities having relatively small transmission networks, where procurement and maintenance of dedicated ERS inventory may not be economical, or where maintaining ERS inventory at multiple locations is not operationally feasible.

It is noted that the effectiveness of an ERS rental arrangement primarily depends upon the availability of sufficient vendors and their ability to mobilize the required ERS within the stipulated response time. Accordingly, factors such as availability of ERS inventory, geographical coverage, transportation and logistics, manpower support, and timely mobilization are important for ensuring effective deployment of ERS through rental arrangements.

In general, the Committee is of the view that procurement of ERS is preferable to deployment of ERS through rental arrangements. Accordingly, Utilities may give preference to the procurement and maintenance of ERS Towers/Sets in accordance with the standardized requirements. However, rental arrangements may be considered in cases where procurement and maintenance of dedicated ERS Sets are not economically or operationally viable.

7.1 Details of the Vendors Offering ERS on Rental Basis

In this regard, an attempt has been made to obtain the details of the vendors who are willing to provide ERS on rental basis. The Committee considered the availability of such vendors and their respective deployment bases, servicing areas and ERS inventory while examining the feasibility of rental arrangements. The details of the responses received from the vendors are tabulated below:

S.N.	Name	ERS Deployment Bases	Servicing Areas	Inventory/ Blockage Charges
1	M/s Hi-Tech Services & Systems Ltd., Kolkata	Baroda, Bhubaneswar, Nagpur, West Bengal	Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Madhya Pradesh, Maharashtra, Meghalaya, Manipur, Mizoram, Nagaland, Odisha, Rajasthan, Sikkim, Tripura, West Bengal	a) 25 ERS towers suitable for applications up to 400 kV b) 12 ERS towers suitable for applications up to 220 kV c) 400 kV ERS system is scalable for 765 kV applications The above rental range may be considered as a blockage charge for maintaining dedicated ERS inventory for a particular utility/location.

2	M/s Advait Energy Transitions Limited, Ahmedabad	Mehsana, Gujarat	Able to provide the Service reliably across all States and Union Territories (UTs) of India, duly considering the logistical requirements and emergency response timelines associated with ERS.	Indicative costs may vary from client to client, depending on their technical specifications and the location where the ERS is required to be deployed.
3	M/s Ramelex	Pune, Maharashtra — HQ, establishment in Rajasthan can be done under a framework / standing contract.	Maharashtra and Rajasthan	a) 5 ERS towers suitable for applications up to 400 kV b) 5 ERS towers suitable for applications up to 220 kV c) 5 ERS towers suitable for applications up to 132 kV

It is noted that other vendors such as M/s Madhav Engineers Pvt. Ltd. are also available to provide ERS services on rental basis.

Even though the ERS stock available with the above Vendors for providing rental services appears to be on lower side, the same is expected to be scaled up ERS Rental Arrangement is formally put in place, and is seriously pursued by various transmission utilities.

7.2 General Frame-work for ERS Rental Arrangements

A general frame-work for ERS Rental Arrangements, which a Utility and a Vendor can mutually agree upon, should cover the following:

1. **Standard commercial break-up:**
   Quoting under separate heads rather than a single composite rate keeps pricing transparent and comparable: The cost heads should include ERS rental; mobilisation and demobilisation; transportation; erection and dismantling; conductor stringing; specialised manpower; technical supervision; cranes and machinery; vehicles; idling and standby; approach-road and site-access works; and other site-specific activities.

2. **Clear definition of the rental period:**
   The framework should fix unambiguously the event at which rental starts and the one at which it ends — a common basis being site-ready availability through to formal release n by the utility.

3. **Standardised transportation basis:**
   Transport can be referenced to the declared staging location and the actual site, with a base distance built into the quoted rate and any excess payable separately under the utility approved Schedule of Rates (SOR) or rate analysis.

4. **Idling and standby provision:**
   A fair mechanism for idling/standby is needed where deployed manpower, vehicles, cranes, tools or ERS sets sit unproductive through no fault of the agency — shutdown delays, ROW constraints, site non-readiness, or non-availability of conductor or material.

5. **Long-duration rental structure:**
   Where permanent restoration is delayed by foundations, ROW, procurement or monsoon, separate (daily, monthly and long-duration) rates keep the commercials rational for both brief emergencies and extended deployments.

6. **Risk, custody, damage and insurance:**
   As the ERS remains the agency's property, the framework should define custody, security, accidental damage, loss or theft, third-party liability, insurance responsibilities and the condition in which equipment is returned — the usual sources of dispute in long deployments.

7. **Utility site-readiness responsibilities:**
   To hold the committed restoration timeline, the utility's responsibilities should be defined up front. These should include ROW and land access, crop compensation, shutdown and electrical clearances, statutory and local permissions, site security, approach access, local coordination, and line drawings and site data.

8. **Conductor and line-specific material:**
   The utility providing line-specific conductor, earth wire/OPGW and consumables on a free-issue or returnable basis lets agencies keep standard, reusable ERS inventory without stocking every conductor configuration in use across utilities.

9. **Standard emergency data sheet:**
   A standard sheet accompanying each emergency call — voltage, tower type and function, circuit configuration, conductor/bundle details, spans, number of damaged towers, terrain and access, crossings, ROW, photographs or drone images, foundation condition and expected deployment duration — speeds up engineering and configuration selection.

10. **Simplified emergency deployment order:**
    A standard Emergency Deployment Order under the framework should permit immediate mobilisation once contractual and financial approvals are in place, with detailed reconciliation following under the pre-agreed commercial terms — not waiting on the full procurement cycle.

11. **Defined mobilisation SLA:**
    Agencies declare measurable SLAs for call acknowledgement, engineering response, dispatch,

8. Establishment of ERS Training Facility

8.1 Need for ERS Training Facility

When an ERS Set is procured, training covering the pertinent aspects of ERS deployment and operation is generally provided by the ERS Vendor to the personnel of the procuring Utility. However, such vendor-specific training is generally limited to a few personnel and may not adequately address the overall manpower requirement for undertaking ERS-related activities at the utility level. Accordingly, there is a need for establishing ERS training facilities at both the utility and national levels. In this regard, NPTI, being a national-level training institute for power sector personnel and professionals, can host a dedicated ERS training facility for developing skilled manpower in transmission utilities for handling various ERS-related activities.

In this regard, the need for establishing such a facility at the national level can be seen by considering the shortage of adequately trained manpower for handling ERS-related activities. The manpower requirement could be roughly pegged at around 1,500 personnel, considering a minimum requirement of about 50 personnel per Utility for ERS-related activities and an indicative coverage of about 30 Utilities.

In this context, it is noted that PGCIL has already got considerable experience in imparting ERS training comprising both classroom and hands-on field training. It is also noted that PGCIL imparts such training, not only to its own personnel but also to personnel of State and Private Transmission Utilities on specific requests. Accordingly, the Committee has undertaken a site visit to the existing ERS training facility of PGCIL at Raipur, Chhattisgarh, on 03.08.2026, with the objective of obtaining first-hand information regarding the technical and operational aspects involved in establishing and operating an ERS Training Facility.

During the site visit, it has been noted that the ERS training facility at Raipur is manufacturer-specific, with the existing setup based on SBB, Canada. It has been further noted in general that all the ERS training centers of PGCIL are manufacturer-specific. It is however noted that training received for ERS of one specific make would come in handy for handling ERS of different makes. Accordingly, the proposed ERS Training facility at NPTI can initially be established based on ERS equipment of any one manufacturer, and ERS of other makes can be covered at a later time based on the requirement.

The Committee emphasized that the proposed facility should not merely function as a demonstration facility, but should provide adequate practical exposure covering the complete ERS deployment cycle. The training is therefore required to cover activities including survey, finalization of ERS configuration, erection, stringing, dismantling and loading/unloading of ERS components. Such hands-on exposure is intended to facilitate development of practical skills required for actual ERS restoration activities.

Although the ERS Training Facility is presently proposed to be established at NPTI, its model can be replicated subsequently by other organizations, including CPRI and other Central, State and Private Transmission Utilities, based on their requirements.

Based on the discussions regarding space requirements and the modules and activities to be covered under classroom as well as hands-on field training, it is proposed to have two levels of training, namely:

- *Basic Training*, intended for Technicians and Executives involved in ERS restoration activities
- *Advanced Training*, intended for Executives, esp. those involved in planning, studying and validating different ERS Tower configurations under various scenarios using relevant software.

In this regard, it is also clarified that these two training programs, by their nature, can be conducted independently and need not necessarily be linked with each other. Further, the two Programs can be imparted at different Premises/ Offices of NPTI, as considered appropriate.

8.2 Space requirements

The space requirements for establishing the hands-on ERS training facility have been by the Committee. The facility is required to provide for the following:

a) Building for Classroom training
b) Open area for field training, i.e., for erection of ERS towers, stringing, destringing and dismantling
c) Storage/yard facility for ERS Sets (Components)

It is suggested that for hands-on field training, a minimum of three towers, with span between two consecutive Towers as 150 metres, is required. Further, since the guy wires extend up to about 50 metres, a general clearance of 50 metres around each tower location is required to be considered. Accordingly, the land area required for the hands-on training facility would be around **400 m × 100 m**. Out of the three towers, the two end towers shall be Tension Towers and the middle tower shall be a Suspension Tower. And all the three towers are required to be erected in near straight line to simulate/ carry out various restoration scenarios.

For ascertaining the availability of land parcels suiting to above requirements at HLTC, Bengaluru, a joint site inspection was conducted by a team of PGCIL and NPTI Officials on 03.09.2026. As confirmed by them, the finalized site at HLTC, Bengaluru meets the stipulated requirements as given under:

- The proposed site has the required area of approximately 400 m × 100 m for erection of three ERS towers, comprising two Tension Towers with one Suspension Tower in between, to be erected in a straight line.
- A span of 150 m between ERS-1 and ERS-2 and 160 m between ERS-2 and ERS-3 is available within the proposed area.
- The required clear area of 50 m radius around each tower, free from obstructions, is available at the proposed site.
- The site meets the prescribed space and span requirements for carrying out hands-on ERS training activities.

- However, it is noted that one 11 kV line and associated switchyard and substation building is situated within the proposed ERS area. An alternative arrangement for the 11 kV line is therefore required. Necessary action for shifting/relocation of the line through underground cabling is required so that the proposed ERS facility area is made free from overhead

obstructions and suitable for the intended ERS training activities. NPTI confirmed vide mail dated 09.09.2026 that the existing site constraints, including the 11 kV overhead line, will be suitably addressed by shifting/converting the same through an underground cable system.

- Adequate space is also available for storage of ERS tools and equipment, with approximately 35 metres width x 100–150 metres length of extendable/ usable space available for the ERS Tools storage as required.
- The site diagram showing Layout of the proposed location and available space for setting up the ERS facility at HLTC, Bengaluru as provided by NPTI is given at **Annexure-VII**.

Based on the field inspection conducted, and the details furnished by NPTI, it has been noted that the proposed site at HLTC, Bengaluru is found suitable for establishment of ERS Training Facility.

8.3 Basic Training

After detailed deliberations, the Committee has suggested the following 5-Day schedule for imparting ERS Basic Training covering both Class-room and Hands-on/ Field Sessions:

Date	Activity	Description of Activity
Day 1	Inauguration of Training program	• Inauguration of ERS Training program
Day 1 (First half)	Classroom Training	• Need of ERS system • Basic principles of ERS • ERS components and their functions • Different ERS configurations • Foundations/ base plates • Mast and module sections • Guy arrangements • Insulators and hardware • Tools and tackles
Day 1 (First half)	Classroom Training	• Survey for ERS installation • Different factors such as selection of type & no. of tower, type of conductor, selection of anchoring, etc.
Day 1 (First half)	Classroom Training	• Methodology of erection of ERS • Step by step procedure of erection of ERS • Different methods of erection of ERS • Different configuration of towers suitable for ERS • Different Bypass methods for erection of ERS
Day 1 (second half)	Material Identification and Shifting from Stores to Site	• Safety Aspects in ERS • Material identification for erection of ERS towers • Familiarization of Storage for (ERS) towers • Protection of Container

		• Inventory management • Transportation of ERS material to identified site
Day 2 (First half)	Foundation plate and guying arrangement	• Installation of base plate along with gimbal arrangement and arrangement of various guy • Guying arrangements and anchoring • Stability considerations
Day 2 (Second half)	Erection of ERS tower	• Erection of ERS tower through ball point ginpole/ sliding gin pole. • Erection of 2 nos towers (1 nos tension and 1 no running/suspension tower)/ Arrangement of different fittings • Assembly of modules • Stability considerations • Erection methodology • Safety precautions during erection
Day 3	Fixing of insulators/ hard-wares/ post insulators/ top plates, etc.	• Installation of suitable insulators and hard-wares along with top plates with stringing arrangements
Day 4 (First half)	Stringing activity	• Stringing activity • Maintenance of required clearances • Conductor handling • Tensioning arrangements
Day 4 (Second half)	De-stringing activity	• De-stringing activity • Maintenance of required clearances • Conductor handling • Tensioning arrangements
Day 5 (First half)	Dismantling activity and shifting of material to store	• Removal of insulators / hard-wares, etc. • Dismantling activity along with safe transportation of material back to store • Dismantling sequence • Safe removal of conductors and hardware • Dismantling of ERS structures • Inspection of components • Preparation of inventory • Loading and transportation
Day 5 (Second half)	Closing	• Case Study (finding out ERS Solution for different Failure Scenarios) • Assessment • Feedback

To ensure adequate attention to individual participants and maintain the requisite quality of the training, the Committee suggested that the batch strength for the above training programme be kept in the range of **18–24 participants**.

The participants would comprise Engineers/ Executives as well as Technicians involved in ERS erection and restoration activities, thereby providing representation from personnel associated with both planning and field-level ERS activities.

It is also suggested that the hands-on training for erection of ERS Towers be designed to provide exposure to different soil conditions, including sandy land, marshy land, rocky land, etc., so that the participants gain practical experience in handling ERS erection under varied site conditions.

8.4 Advanced Training

The Advanced Training is primarily a Class-room based training program, and is intended for Engineers and Executives, esp. those involved in planning, studying and validating different configurations of ERS Towers under various scenarios through relevant software. The Advanced Training program would primarily cover the following aspects:

- ERS planning
- Analysis of various failure scenarios
- Selection of appropriate ERS configuration
- Determination of number and height of ERS towers
- Preparation of site-specific configuration
- Structural stability checks
- Span and loading considerations
- Inventory planning
- Use of relevant software
- Verification of restoration arrangements

It is noted that the course involves the use of software such as PLS-CADD and PLS-Pole. Accordingly, prior knowledge of these software by the participants attending the training programme is considered necessary. It is also suggested that NPTI should have at least five licenses of the said software to facilitate simultaneous training of five groups within a Batch.

The Committee suggested the following three-day schedule for imparting Advanced Training:

Day 1	**Day 2**	**Day 3**
• Inauguration • Familiarity with various Software Features (PLS CADD and PLS-Pole) • One failure scenario exercise	• Three to Four failure scenario exercises	• Two to Three Failure scenarios exercises • Assessment • Feedback

In order to ensure adequate attention to the participants and maintain the requisite quality of the training, the Committee suggested that the batch strength for the above Advanced Training programme be kept in the range of **10–20 participants**.

*****

Annexure-I

भारत सरकार/Government of India
विद्युत मंत्रालय/Ministry of Power
केन्द्रीय विद्युत प्राधिकरण/Central Electricity Authority
विद्युत प्रणाली अभियांत्रिकी एवं प्रौद्योगिकी विकास प्रभाग
Power System Engineering & Technology Development Division

दिनांक: 15.05.2026

Office Order

विषय: Constitution of Committee on Emergency Restoration System (ERS) Tower Requirement Standardization and Setting up ERS Training Facility at NPTI - reg.

महोदया/महोदय,

Considering the critical role of the Emergency Restoration System (ERS) in expeditious restoration of transmission systems and maintenance of grid reliability during emergency and contingency conditions, there is a need to standardize the minimum number and configuration of towers, including both suspension and tension towers, to be maintained in an ERS set. Further, to enhance preparedness and technical capabilities of power sector professionals, it is necessary to establish ERS demonstration and training facilities at suitable institutes such as NPTI for imparting training on the deployment, operation, and maintenance of ERS.

2. Accordingly, a Committee, comprising the following members is hereby constituted:

1	Chief Engineer (PSE&TD), CEA	Chairman of the Committee
2	Representative from NPC Secretariat	Member
3	Representative from PGCIL	Member
4	Representative from GETCO	Member
5	Representative from CPRI	Member
6	Representative from CSIR-SERC	Member
7	Representative from NPTI	Member
8	Director (PSE&TD), CEA	Member Convener

3. The TOR of the Committee are as under:

a) The Committee shall standardize the minimum number and configuration of towers, including both suspension and tension towers, to be maintained in an ERS set.
b) The Committee shall examine the feasibility of deploying ERS systems through rental arrangements.
c) The Committee shall examine the feasibility for establishment of ERS training set up at institutes such NPTI and CPRI for imparting training to power sector professionals on deployment, operation, and maintenance of ERS.
d) The Committee after due deliberations shall submit report within two months of its constitution (by July, 2026).

2. The Committee may invite any Experts or co-opt additional Members as may be considered necessary.

This issues with the approval of Competent Authority.

भवदीय,

(कविता झा /Kavita Jha)
निदेशक/Director

तीसरा तल सेवा भवन, रा माकृष्ण पुरम, सेक्टर -1, नई दि ल्ली -110 066, ई-मेल: ce-psetd@gov.in, फ़ोन: 01126732392
3rd Sewa Bhawan, R. K. Puram, Sector-1, New Delhi-110 066, E-mail: ce-psetd@gov.in. Tel: 01126732392

Annexure-I

To,

Member Secretary, NPC	rishika@nic.in
Chairman & Managing Director, PowerGrid Corporation of India, Gurugram, Saudamini, Plot No. 2, Sector-29, Gurgaon- 122001	cmd@powergrid.in
Managing Director, Gujarat Energy Transmission Corporation Ltd. Sardar Patel Vidyut Bhawan, Race Course, Vadodara- 390007	md.getco@gebmail.com
Director General, Central Power Research Institute Prof. Sir C.V. Raman Road, Post Box No: 8066, Sadasiva Nagar, Bengaluru- 560080	dgcpri@cpri.in
Director General, CSIR- Structural Engineering research Centre, CSIR Rd, CSIR Campus, Tharamani, Chennai- 600113	dgcsir@csir.res.in director.serc@csir.res.in director@serc.res.in
Director General, National Power Training Institute, NPTI Complex, Bypass Road, Sector 33, Faridabad, Haryana-121003	dg@npti.gov.in

Copy to (for information):

1. SA to Chairperson, CEA
2. SA to Member (PS), CEA
3. PS to Chief Engineer (PSE&TD), CEA

Annexure-II

भारत सरकार/Government of India
विद्युत मंत्रालय/Ministry of Power
केन्द्रीय विद्युत प्राधिकरण/Central Electricity Authority
विद्युत प्रणाली अभियांत्रिकी एवं प्रौद्योगिकी विकास प्रभाग
Power System Engineering & Technology Development Division

दिनांक: **17.07.2026**

सेवा में,

<As per Address List>

विषय: **Minutes of First meeting of the Committee on Emergency Restoration System (ERS) Tower Requirement Standardization and Setting up ERS Training Facility at NPTI - reg.**

महोदया/महोदय,

The first meeting of the Committee (TC-ERS) **on Emergency Restoration System (ERS) Tower Requirement Standardization and Setting up ERS Training Facility at NPTI** was held under the Chairmanship of Chief Engineer (PSE&TD), CEA, on 15.06.2026 at 11:00 a.m. in Manthan Conference Hall, 2nd Floor, Sewa Bhawan, R.K. Puram, New Delhi, 110066, through hybrid mode.

The minutes of the meeting are enclosed herewith for kind reference and necessary action by all concerned please.

Encl: as above

Digitally signed by Kavita Jha
Date: 17-07-2026 18:42:27

भवदीय,

(कविता झा/Kavita Jha)
निदेशक/Director

Copy to (for information):

1. SA to Chairperson, CEA
2. SA to Member (PS), CEA
3. PA to Chief Engineer (PSE&TD), CEA

Annexure-II

Address List:

SN	Name	Designation	Organization	Email
1	Sh. Shishir Pradhan	Deputy Director	NPC Secretariat	sk.pradhan15@gov.in
2	Sh. Chandra Kant	Sr. DGM	Powergrid	chandra.kant@powergrid.in
3	Sh. R. M. Patel	SE	GETCO	serandm.getco@gebmail.com
4	Sh. A. A. Joshi	EE	GETCO	eeengg2.getco@gebmail.com
5	Dr. M Selvaraj	Additional Director	CPRI	msraj@cpri.in
6	Sh. K. Vijay Kumar	Joint Director	CPRI	vijayakumar@cpri.in
7	Dr. Rokade Rajendra Pitamber	Scientist F	CSIR-SERC	rokade.serc@csir.res.in
8	Dr. R. Balagopal	Scientist F	CSIR-SERC	balagopal.serc@csir.res.in
9	Dr. K.P.S. Parmar	Deputy Director	NPTI	kpsparmar@npti.gov.in

Power System Engineering & Technology Development Division
Central Electricity Authority

Minutes of the first meeting of the Committee (TC-ERS) on Emergency Restoration System (ERS) Towers Requirement, Standardization and Setting up ERS Training Facility at NPTI

A. Introduction

1. The first meeting of the Committee (TC-ERS) on Emergency Restoration System (ERS) Tower Requirement, Standardization, and Setting up ERS Training Facility at NPTI was held under the Chairmanship of Chief Engineer (PSE&TD), CEA, on 15.06.2026 at 11:00 a.m. in Manthan Conference Hall, 2nd Floor, Sewa Bhawan, R.K. Puram, New Delhi through hybrid mode. The list of the participants is given at **Annexure-I.**

2. Chief Engineer (PSE&TD), CEA welcomed all the participants to the meeting, and informed that the Committee was constituted vide CEA letter dated 15.05.2026 (i) to standardize the minimum number and configuration of towers, including both suspension and tension towers, to be maintained in an ERS set, (ii) to examine the feasibility of deploying ERS systems through rental arrangements, and (iii) to examine the feasibility for establishment of ERS training set up at institutes such as NPTI and CPRI for imparting training to power sector professionals on deployment, operation, and maintenance of ERS.

3. Chief Engineer (PSE&TD), CEA referred the Central Electricity Authority (Grid Standards) Regulations 2010 which stipulates that each transmission licensee shall have an arrangement for restoration of transmission lines of 400 kV and above and strategic 220 kV lines through the use of Emergency Restoration System in order to minimize the outage time of the transmission lines in case of tower failures. He further referred the Guidelines issued by Ministry of Power vide letter dated 05.12.2014 (**Annexure-II**) which among other things specifies the number of ERS Sets to be maintained by each utility as under:
   - One (1) set of ERS for Transmission Line Lengths up to 5,000 Ckt-kms
   - Two (2) set of ERS for Transmission Line Lengths of about 5,000 to 10,000 Ckt-kms
   - Three (3) set of ERS for Transmission Line Lengths of about 10,000 to 15,000 Ckt-kms and so on.

4. It was stated that these Guidelines also provide for a Transmission Utility with line length less than 500 Ckt kms (of 400 kV) may be given option either to procure ERS or have arrangement with other Transmission utilities for providing ERS on mutually agreed terms, when need arises.

5. In this regard, he also referred to the Standard Operating Procedure (SoP) issued vide CEA letter dated 11.05.2025 **(Annexure-III)** for restoration of transmission lines which also specifies the ERS tower requirement for restoration of transmission lines.

6. Even though all these Regulations, Guidelines and SoP clearly point to the need for maintaining sufficient no. of ERS Sets, it has been observed that the same is yet to be complied with by many utilities. Further, the no. of Towers and their configuration to be maintained in an ERS set is also observed to be not uniform across the utilities. Also there is a need to ensure every utility

maintains sufficient no. of skilled manpower to handle ERS related operations/ activities; accordingly, in line with the TOR of the Committee, the feasibility of setting up ERS training facility at Institutes such as NPTI would be discussed in the meeting.

7. Then, Agenda Items were taken up one by one for detailed deliberations.

B. NPC Presentation

1. The Representative of the NPC Secretariat presented the status of availability and adequacy of Emergency Restoration Systems (ERS) across transmission utilities in various regions across the country **(Annexure-IV).** The region-wise availability and shortfall of ERS, as presented by NPC, are summarized below:

Region	ERS sets Required as per Govt. norms	ERS Sets Available	Shortfall
Western Region (WR)	61	42	19
Southern Region (SR)	34	23	11
Northern Region (NR)	64	46	18
North Eastern Region (NER)	14	6	8
Eastern Region (ER)	32	-	-

2. Based on the presentation, the Committee observed a significant nationwide shortfall in availability of ERS tower vis-à-vis the prescribed Government norms. It was noted that Power Grid Corporation of India Limited (PGCIL) has largely maintained adequate ERS set inventories across regions. Certain private transmission utilities, such as Adani Energy Solutions Limited, which operate transmission networks across multiple regions of the country, have also maintained ERS sets. However, many State Transmission Utilities (STUs) and other Private Transmission Service Providers (TSPs) have not given the required attention in procuring the required ERS sets, resulting in substantial gaps in emergency restoration preparedness in case of failure of towers in EHV Transmission lines.

C. Domestic Manufacturing Eco-system for both Steel based ERS and Aluminium based ERS:

1. Chief Engineer (PSE&TD), CEA sought information on the manufacturers of both steel-based and aluminium-based Emergency Restoration Systems (ERS).
2. In response, POWERGRID informed the Committee about the major ERS manufacturers based on the type of material used as under:
   - Steel Based ERS
     - **DNB, Netherlands**
     - **Cobra IS, Spain**
   - Aluminium Based ERS

- **M/s Advait Energy Transitions Limited, Ahmedabad**
- **M/s Hi-Tech Services & Systems Ltd., Kolkata**
- **M/s IAC Electricals Pvt. Ltd., Kolkata**
- **Lindsay, USA**
- **SBB, Canada**

3. POWERGRID further informed that the following domestic available firms participated in its latest ERS procurement process:

   - **Hi-Tech Systems and Services limited- Kolkata**
   - **Advait Energy Transitions Limited- Ahmedabad**
   - **IAC Electrical Pvt. Ltd.- Kolkata**
   - **Madhav Engineers Pvt. Ltd.- Mumbai**

   It was informed that out of the above, Hi-Tech Systems & Services Ltd., Advait Energy Transitions Ltd., and IAC Electricals Pvt. Ltd. have been awarded various ERS packages. As per the undertakings of these firms, all of them are meeting the MLC requirement for Class-I local supplier.

4. The Committee also deliberated on the comparative cost and weight advantages of Aluminium-based ERS over Steel-based ERS tower. POWERGRID stated that Aluminium based ERS could result in a reduction of approximately 10–20% in both cost and weight. However, representative from CSIR-Structural Engineering Research Centre (CSIR-SERC) informed that Aluminium-based ERS could potentially achieve up to 70% reduction in cost and around 30% reduction in weight, depending on design and application.

5. With regard to domestic manufacturing capability and Minimum Local Content (MLC), CSIR-SERC informed the Committee that the following licensed domestic manufacturers possess the indicated annual production capacities:

   1. M/s Advait Infratech Ltd., Ahmedabad – Annual Capacity 300-350 ERS Masts, 90% MLC
   2. M/s Hi-Tech Services & Systems Ltd., Kolkata – Annual Capacity 300 ERS Masts & 90 % MLC
   3. M/s IAC Electricals Pvt. Ltd., Kolkata – Annual Capacity 200 ERS Masts & 90% MLC

6. With regard to indigenous technology development, the representative from Central Power Research Institute informed the Committee that CPRI has developed a 66 kV double-circuit transmission tower with insulated cross-arms using Fibre Reinforced Polymer (FRP) material. The tower has a modular configuration, with a base footprint of approximately 1 m × 1 m, a height of about 17 m, and overall weight of around 800 kg. The tower has successfully undergone both mechanical strength and electrical performance testing. He further suggested that, in view of the ongoing efforts towards indigenous development of Emergency Restoration Systems (ERS), the design could be suitably modified and may be adapted for ERS applications.

7. The Committee noted that adequate indigenous manufacturing capacity is available in the country and the domestic manufacturers licensed by CSIR-SERC are capable of meeting > 90% MLC requirements.

8. The Committee noted the details of all components and sub-components used in the ERS as under:

   a. ERS Suspension/ Running Angle & Tension Towers incl. articulated base (gimbal), mast

sections, box sections, guy plates/swivels, bolts & nuts
b. Foundation / Base Plates
c. Anchor Assemblies
d. Insulator Strings along with hardware fittings
e. Earthwire/OPGW fittings
f. Guys & guy hardwares
g. Guy Insulators
h. Structure cables & hardwares
i. Erection/ Installation Tools & Tackles
j. Software (PLS-CADD, PLS Tower, PLS Pole and Software for ERS)
k. Containers

It was noted as per information provided by manufacturers, all the above components except PLS software are procured indigenously.

D. Standardization of minimum number and configuration of towers, including both suspension and tension towers, to be maintained in an ERS set

1. The Committee has deliberated on the need for standardization of Emergency Restoration System (ERS) towers. It was noted that ERS towers are basically designed as modular structures and are typically configured for single-circuit twin moose conductor arrangements.

2. Technical Standards being followed for ERS are noted as follows:
   - **For design of ERS**: IS 802 is being specified in line with lattice/pole structures.
   - **For testing of ERS structure & associated structural components/ box sections/ guy plates/ gimbals/ bolts, nuts & washers :** IEEE standard 1070
   - **For testing of line materials: respective Indian/ International standards are followed hardware fittings, earthwire accessories and insulators (composite long rod insulators & post insulators):** IS-2486, IS-2121, IS-16784, IEC 61952 and IEC 61462

3. It was also noted that ERS towers are generally designed for a span length of about 300 metres, with modular sections available in standard lengths, typically 7 feet, 14 feet, 21 feet and 10 feet, to facilitate flexibility in assembly and deployment. The basic components and sub-components used in the ERS, majorly include the following:
   a. ERS Suspension/ Running Angle & Tension Towers incl. articulated base (gimbal), mast sections, box sections, guy plates/swivels, bolts & nuts
   b. Foundation / Base Plates
   c. Anchor Assemblies
   d. Insulator Strings along with hardware fittings
   e. Earthwire/OPGW fittings
   f. Guys, Guy Insulators & guy hard-wares

4. The Committee further observed that there is no fundamental difference in the mast (module) sections used for suspension and tension ERS towers. The distinction primarily arises from the number and arrangement of guy wires, the stringing configuration and the number of modules used to achieve the required tower height and loading requirements.

5. During the discussions, the representative from CPRI suggested that the standardization of ERS tower requirements should be undertaken considering key design parameters such as wind zone, span length, and associated loading conditions. It was explained that this approach would facilitate the development of standardized and interoperable ERS tower solutions suitable for deployment across different regions of the country.

6. SERC informed that the minimum quantity of ERS towers in a set may be taken as 10, with the following bifurcation:
   - Suspension tower configuration (0°-2°) – 5 numbers
   - Light to Small angle tower configuration (2°-15°) – 3 numbers
   - Medium – Large angle tower configuration (15°-60°) and dead-end towers - 2 numbers

7. PGCIL informed the following w.r.t. standardization requirements of ERS:
   a) For up to 400 kV (Twin) lines- 16 ERS towers [10 suspension and 6 tension]

   i) Circuit wise restoration is carried out. Thus, each ERS tower carries all the 3 phases & upto one earthwire/ OPGW.

   ii) Standard Restoration span considered: 300 m

   iii) Restoration scenarios-

   - For restoration of 5 nos. towers of upto 400kV D/C (twin) config. 3 nos of tension and 5 nos of suspension ERS towers for each circuit. So, for D/C, 6 nos of tension &10 nos of suspension towers are required.
   - For restoration of 10 no. suspension towers of upto 400kV D/C (twin) config. Only one circuit restoration envisaged. This requires 4 nos of tension and 12 nos of suspension ERS towers. (2 tension towers are used as suspension towers)

   b) For 400kV(Quad)/ 765kV/ 500kV/ 800kV HVDC-24 ERS towers [15 suspension & 9 tension]

   i) Phase-wise restoration is carried out. Thus, each ERS tower carries one phase/ pole & upto one earthwire/ OPGW.

   ii) Standard Restoration span considered: 300 m for upto 765kV & 500kV HVDC; Reduced span for 800kV HVDC (as per ERS design)

   iii) Restoration scenarios-

   - For restoration of 5 nos. towers of upto 765kV config.: 3 nos of tension and 5 nos of suspension ERS towers for each phase. So, for S/C, 9 nos of tension &15 nos of suspension towers are required.
   - For restoration of 5 no. suspension towers of lines HVDC config. 3 nos of tension and 5 nos of suspension ERS towers required for each pole. So, minimum 6 tension & 10 suspension towers required for Bipole. However, as often, Herringbone Suspension structures and additional structure for jumper attachment are also required, procurement quantity for HVDC line is also kept same i.e. 15 suspension & 9 tension towers

8. In this regard, the Committee also noted the following:

   a) The mast is the primary common structural component of an ERS tower. It comprises modular sections of standardized dimensions, and the number of mast sections/ modules assembled determines the overall height of the ERS tower which can be varied in accordance with voltage

level and as per actual site condition.

b) ERS towers are generally designed for a Single-Circuit (S/C) Twin Moose conductor configuration.

c) The conductors required for restoration activities are not normally part of the ERS package and shall be arranged separately by the concerned transmission utility or transmission licensee.

d) There is no fundamental distinction between suspension and tension type ERS towers with respect to the mast structure. Both configurations utilize the same modular mast components. The difference arises primarily from the ancillary components and arrangements adopted to meet specific loading and operational requirements, such as the number and configuration of guy wires, insulator cross-arms (ICA), stringing arrangements, requirements, and the number of mast modules employed to achieve the desired tower height and mechanical performance.

9. In the light of above discussion, the Committee primarily noted the following w.r.t. standardization of ERS Set:
   a) an ERS Set should at least be capable of handling 5 Tower Collapses for 400 kV D/C (Twin) line or 765 kV S/C configuration, or 500 kV HVDC Bi-Pole configuration.
   b) Catering to the requirement of Network up to 400 kV level, one or more no. of ERS Sets should be maintained.
   c) Catering to the requirement of Network at 765 kV and HVDC, one or more no. of ERS Sets (separate from that maintained for below 765 kV Network) should be maintained.
   d) The Circuit-km criteria already stipulated by the MoP/ CEA for deciding the no. of ERS Sets should be complied with.

E. Deployment of ERS systems through rental arrangements

1. Chief Engineer (PSE&TD), CEA enquired about the existing practices being followed in the transmission sector for rental arrangements of ERS towers.

2. In response, PGCIL informed that they enter into Memorandum of Understanding (MoUs) with various utilities for the provision of ERS on a rental basis whenever required.

3. PGCIL however highlighted certain challenges associated with such rental arrangements, particularly the delay in the returning of ERS materials, policy for funding etc. by the hiring utility after restoration activities are completed. In this regard, incorporation of suitable penalty provisions in the MoUs to address delays in the returning of ERS equipment and to adhere compliance with agreed timelines was discussed.

   PGCIL in this regard suggested that since ERS requirement quite often arises simultaneously for both them and the Utilities with which they enter into rental arrangement, utilities in general should be better off having their own ERS sets to cater to their network needs.

4. The Committee also discussed the growing requirement for ERS support for Generators (conventional & RE) for their dedicated lines. It was observed that private RE developers may also require access to ERS tower for emergency restoration of their dedicated transmission lines connecting between generating stations to pooling substations. Accordingly, the possibility of extending ERS support to these RE developers through suitable rental arrangements was deliberated upon, considering the need to ensure quick restoration of transmission infrastructure in order to maintain grid reliability.

5. In this regard, the possibility of utilities entering into appropriate rental arrangements with suitable ERS Manufacturer was also discussed. Considering the underlying benefits associated with the same, it was decided to discuss the issue further after ascertaining the willingness of the ERS manufacturers for the same. It was noted that by entering into such arrangements with suitable ERS manufacturers, the varied needs of the utilities for ERS towers/ sets can be suitably met at competitive prices. It was however noted that the logistics issues involved in this kind of arrangement need to be addressed properly to derive the envisaged benefits.

F. Establishment of ERS training set up facility at institutes such as NPTI, CPRI and PGCIL for imparting training to power sector professionals on deployment, operation, and maintenance of ERS

1. The Committee deliberated in detail on the availability of training infrastructure and capacity-building arrangements for Emergency Restoration Systems (ERS).

2. PGCIL representative has informed that dedicated ERS gangs are generally not maintained exclusively for ERS deployment. However, they have trained their manpower for ERS tower restoration activities, and training is imparted at identified POWERGRID substations through both classroom sessions and practical hands-on exercises. PGCIL further informed that it also extends ERS training support to personnel from State Transmission Utilities (STUs) and Transmission Service Providers (TSPs), including classroom and field-based training, upon receipt of specific requests from such organizations.

3. During the discussions, the Chief Engineer (PSE&TD) enquired about the minimum land area requirement for establishing an ERS training facility, particularly for hands-on training setup. The Committee noted that the same as three regular spans (3 x 300 m) for Pole Structures in a transmission line.

4. CPRI representative informed that CPRI does not presently possess dedicated infrastructure for ERS training. However, new testing facilities for transmission lines are being established at Nagpur, and the possibility of setting up ERS training facility there could be explored.

5. NPTI representative informed that NPTI is well known for imparting Training and Capacity building program in various field of power sector. As such, NPTI may be considered as a potential institution for conducting ERS training programmes including hands-on sessions/ exercises for power sector professionals.

6. SERC representative informed the following:
   - Establishment of ERS training set-up at dedicated institute such as NPTI in initial stages is required to train utility employees, ERS manufacturing professionals, ERS erection gangs' members, ERS planning and configuration check engineers with following courses:
     - Certificate courses to develop certified ERS technicians in following specialization
       a) Fabrication
       b) Erection
       c) Testing
     - PG Diploma Course to ERS Planning Engineers – Specialized course to train power line engineers for drafting ERS tender specification, for tendering and procurement process, for planning of ERS configuration as per Transmission Line (TL) tower failure scenario, checking its structural stability, making inventory for transportation at failure site and planning, erection execution and stringing and charging bypass corridor using ERS at failure site etc.

- PG Diploma Course to ERS Manufacturing Engineers – Specialized course to train engineers for ERS manufacturing, tender submission process, supply chain management, ERS component testing, checking ERS configuration structural stability, ERS erection training/demonstration and site-specific erection etc.

He also informed that CSIR-SERC would actively collaborate with CEA & NPTI for above courses (in formulating courses, course syllabus, resource persons as guest faculty and training resource persons)

7. In this regard, it has been proposed that a curriculum for structured training framework and certification may be developed with three levels of competency, namely:
   1. Basic Level
   2. Intermediate Level
   3. Specialist Level

   The Committee also agreed that the training curriculum should be tailored to different categories of personnel involved in ERS deployment and maintenance, including:
   - Technicians
   - Supervisory Personnel and
   - Engineers.

8. The Committee noted the suggestions and recommended that a comprehensive training framework, including course curriculum, practical exposure requirements, competency assessment criteria, certification methodology, and infrastructure requirements, may be developed for further consideration. Considering the experience of PGCIL in this area, they have been requested to liberally share all relevant inputs that can contribute to setting up ERS training set up at Institutes such as NPTI, and in designing course curricula as discussed above.

9. The Committee also requested to NPTI to arrange a visit for all Members to their premises for ascertaining setting up ERS Training facility.

G. Conclusion

It was agreed to further carry on the discussion on TOR issues, and all Committee members have been requested to share relevant material/ view points on the issues considering this meeting deliberations so that conclusive views can be taken in the next meeting on the same.

Meeting ended with vote of thanks to all the participants.

*****

Annexure-I

List of Participants

CEA

1. Sh. N.R.L.K. Prasad, Chief Engineer (PSE&TD)
2. Smt. Kavita Jha, Director (PSE&TD)
3. Smt. Jyoti Singh, Deputy Director (PSE&TD)

NPC Secretariat

1. Sh. Shishir Pradhan, Deputy Director

CPRI

1. Dr. M Selvaraj, Additional Director

CSIR-SERC

1. Dr. Rokade Rajendra Pitamber, Scientist F

NPTI

1. Dr. K.P.S. Parmar, Deputy Director

POWERGRID

1. Sh. Amit kumar, GM (AM)
2. Sh. Chandra Kant, Sr. DGM
3. Sh. Ashish Kumar Singh, Chief Manager (Engg-TL)

GETCO

1. Sh. R. M. Patel, SE, GETCO

प्रदीप कुमार सिन्हा
सचिव
भारत सरकार
PRADEEP K. SINHA
Secretary
Government of India

सत्यमेव जयते

Ministry of Power
Shram Shakti Bhawan
New Delhi - 110001

विद्युत मंत्रालय
श्रम शक्ति भवन
नई दिल्ली–110001
Tele : 23710271/23711316
Fax : 23721487
E-mail : secy-power@nic.in

D.O. No.20/6/2014-OM

05.12.2014

Dear Shri Negi,

As you are aware, India has one of the largest A.C. Synchronous Transmission Grids in the world with more than 3 lakhs circuit kms of 220kV and above lines which form the backbone of the Indian Power System.

2. However, this huge network needs to be operated in a sustained and secure manner, particularly, during the time of natural disasters. Failure to do so leads to severe constraints not only in meeting the power demand but also poses serious problems in maintaining safety and security of the Grid. Difficult situations came to light in the wake of recent natural disasters, such as, floods in J&K and Phailin as well as Hud-Hud cyclone in Odisha and Andhra Pradesh. These disasters caused extensive damage to transmission networks resulting in wide spread disruption of many important transmission links and substations affecting power supply for long periods due to the time taken in restoration.

3. You would appreciate that under such adverse situations, the availability of an effective mechanism for emergent restoration of transmission lines in the shortest possible time is of utmost importance. Immediate and temporary restoration of transmission networks is possible by deploying the "Emergency Restoration Systems (ERS)." Grid Standards notified by the Central Electricity Authority(CEA) stipulate that every Transmission Licensee shall have an arrangement for restoration of transmission lines of at least 220kV and above through the use of ERS. However, presently the States do not possess such ERS infrastructure. Consequently, POWERGRID becomes the last resort whose ERS infrastructure is also limited.

4. Therefore, deployment of adequate ERS infrastructure with the States is necessary. In this connection, CEA had recently convened a meeting of the representatives from State Utilities, CTUs and RPCs to deliberate and review their preparedness to effectively restore transmission networks in times of emergency. Based on the inputs received, an indicative requirement of ERS for States has been assessed which is at Annex-I. Further, CEA has also formulated guidelines for planning, deployment and procurement of such ERS infrastructure (Annex-II).

5. I would, therefore, request you to please issue necessary directives to Transmission Utilities/ Transmission licensees operating in your State to take stock, procure appropriate number of ERS infrastructure and place them at strategic locations. Action taken by the Utilities in this regard may be informed to the CEA and the Ministry of Power, at the earliest.

With regards,

Yours sincerely,

(Pradeep K. Sinha)

Encl : as above

Shri Ramesh Negi
Chief Secretary
Govt of **Arunachal Pradesh**
Itanagar

Distt:- As per list attached.

RIGHT TO INFORMATION

स्वच्छ भारत
एक कदम स्वच्छता की ओर

Annexure-II

ANNEX-I

Availability and Proposed Plan for deployment of ERS

Sl. No.	Region	State Utilities / PGCIL	Availability of ERS sets	Additional ERS set to be procured	Remark
I	Northern Region				
	PGCIL	NR1	3	1	
		NR2	1		
	1	Haryana	-	1	
	2	HP	-	1	Hilly terrain
	3	J&K	-	1	-do-
	4	Punjab	-	2	
	5	Rajsthan	-	3	
	6	Uttar Pradesh	-	3	
	7	Uttarakhand	-	1	
	8	Chandigarh	-	-	
	9	Delhi	-	1	DTL is procuring 2 ERS sets
	10	POWERLINKS	2		1 set each is located in NR and ER; each setting having 14 towers of 400 kV
	Total		6	14	
II	Western Region				
	PGCIL	WR1	2	1	
		WR2	2		
	10	Gujarat	-	3	

	11	MP	1	2	
	12	Chhattisgarh	-		
	13	Maharashtra	2	2	
	14	Goa	-	1	
	15	D&NH	-	-	
	16	Daman& Diu	-	-	
	Total		7	9	
III	Southern Region				
	PGCIL	SR1	1	2	
		SR2	1		
	17	AP	-	3	(To be located at Vishakahapatnam, Vijawada, Nellore)
	18	Telengana	-	1	
	19	Karnataka	-	2	
	20	Kerala	-	1	
	21	Tamil Nadu	-	2	
	22	Lakshadweep	-	-	
	23	Puducherry	-	-	
	Total		2	11	
IV	Eastern Region	PGCIL			
	PGCIL	ER1	1	-	
		ER2	2		
	24	Bihar	2	2	
	25	Jharkhand	-	1	
	26	Orissa	3	2(comprising of 12 nos. of 400kV towers which is in the process of procurement)	Existing ERS located at Bhubaneswar, Chatrapur and Budhipada (each with 14 ERS towers)
	27	West Bengal	-	2	
	28	DVC	-	1	

Annexure-II

	29	A&N Island	-	-	
	30	Sikkim	-	-	
	Total		8	8	
V	North Eastern Region		-		
	PGCIL	NER	1		
	31	Assam	4	2	
	32	Manipur	-		
	33	Meghalaya	-		
	34	Nagaland	-		
	35	Tripura	-		
	36	Ar. Pradesh	-		
	37	Mizoram	-		
	Total		5	2	
	Total All India		28	44	

Note: POWERGRID has informed that they are procuring 6 additional sets of ERS for different regions.

Strategy adopted

1. The primary criterion for deciding number of ERS to be arranged by a transmission utility has to be the length of transmission line (ckt-kms) at different voltage levels (e.g 220 kV, 400 kV, 765 kV and +/- 500kV HVDC). Other factors to be taken into account while deciding the number of ERS are

   - Importance of the line considering security of Grid
   - Areas prone to tower failure and failure pattern in different areas
   - Command area of the transmission utility and transportability across the command area

2. For any transmission utility, one set of ERS has been planned to cater to failure of towers for transmission line lengths of up to 5000 Ckt. Kms.. Accordingly, two (2) sets of ERS have been planned for transmission line lengths of about 5000 to 10,000 Ckt. Kms. and three (3) sets for more than 10,000 Ckt. Kms and so on.

3. The transmission Utility with line length less than 500 ckt kms (of 400kV lines) may be given option either to procure ERS or have agreement with other transmission utilities for providing ERS on mutually agreed terms, when need arises.

Annexure-II

ANNEX-II

GUIDELINES FOR PLANNING, PROCUREMENT AND DEPLOYMENT OF EMERGENCY RESTORATION SYSTEM (ERS)

1. One set of ERS should include all accessories [structures (Aluminum Alloy), polymer insulators & hardware, anchor assembly, guy wires, foundation plates, guy plate, other equipment & fittings, special Tools & Plants required for erection & stringing of ERS and trailer mounted detachable containers (without engine) for storage & transportation of ERS hardware / material etc.] and associated software.

2. One set of ERS shall be capable of restoring few numbers of suspension towers and tension towers of the transmission line corresponding to the highest transmission voltage in operation in the utility with required type of conductors. The same ERS can be used for lower voltage lines as well. The number of suspension, tension towers, insulators and associated hardware etc., to be included under one set of ERS, may be decided by the utilities at the time of procurement depending on their requirement.

3. Proper management of ERS and training of personnel for erection of towers on ERS and use of associated software is essential. A dedicated and specialized erection & commissioning gang, which is properly trained to execute such work, would be required.

4. ERS should be utilized only for emergency purposes and the line should be restored on normal towers as early as possible. It should not be a practice to run transmission line on ERS for a long time instead of shifting to normal towers. Moreover, ERS should not be used in new lines under construction. Otherwise, the very purpose of ERS will be defeated.

5. The deployment of ERS by any transmission utility / licensee should be reported to concerned RLDC and RPC.

6. The transmission utilities may approach Appropriate Commission for approval and initiate procurement process on urgent basis to comply with Grid Standards. Utilities may also approach State Disaster Management Authorities for funding.

7. The funding for procurement of ERS could be considered from PSDF for North Eastern States and a proposal be submitted by Member Secretary, NERPC.

Annexure-II

Annex

List of Chief Secretaries of State and UTs

S. No.	State	Name and Address	Telephone/ Fax/Email
1.	Andhra Pradesh	Shri I.Y.R. Krishna Rao Chief Secretary Government of Andhra Pradesh, Secretariat, Hyderabad-500022	Tel: 040-23453620 040-23455340 Fax: 040-040-23453700, 23451133, 23451144
2.	Arunachal Pradesh	Shri Ramesh Negi Chief Secretary & Principal Secretary (Relief & Rehabilitation & Disaster Management) Arunachal Pradesh Civil Secretariat, Government of Arunachal Pradesh, Itanagar- 791 111	Tel: 0360-2212595 Fax: 0360-2212446, 2215719 M: 9436040035
3.	Assam	Shri Jitesh Khosla Chief Secretary Government of Assam, Assam Sachivalaya, Block C, 3rd Floor, Dispur, Guwahati-781006	Tel: 0361-2261120, 2261403 Fax:-0361-2260900
4.	Bihar	Shri Anjani Kumar Singh Chief Secretary Government of Bihar Old Secretariat, Patna-800015	Tel: 0612-2215804 Fax: 0612-2217085
5.	Chattisgarh	Sh. Vivek Kumar Dhand Chief Secretary Government of Chattisgarh, DKS Bhawan, Mantralaya, Raipur-492001	Tel: 0771-2221207/8 Fax: 0771-2221206
6.	Goa	Shri R.K. Srivastava Chief Secretary Govt. of Goa Secretariat Porvorim	Tel: 0832-2419402 Fax: 0832-2415201
7.	Gujarat	Shri D.J. Pandian Chief Secretary Government of Gujarat New Sachivalaya Gandhingar-382010	Tel: 079-23220372, 079-23250301-3 Fax: 079-23250305
8.	Haryana	Shri. P.K. Gupta Chief Secretary Government of Haryana, Room No.-4, 4th floor, Harayana, Civil Secretariat, Sector-1, Chandigarh-160009	Tel: 0172-2740118 Fax: 0172-2740317
9.	Himachal Pradesh	Shri P. Mitra Chief Secretary Government of Himachal Pradesh Secretariat, Shimla- 171002	Tel: 0177-2621022 Fax: 0177-2621813

Annexure-II

10.	Jammu & Kashmir	Sh. Mohammad Iqbal Khandey Chief Secretary Government of J &K Jammu Secretariat, Jammu	Tel: 0191-2546773, 2544338 (Jammu) Fax: 0191-2546188
11.	Jharkhand	Shri Sajal Chakrabarty Chief Secretary Government of Jharkhand Secretariat, Ranchi-834004	Tel: 0651-2400240, 2400250 Fax: 0651-2400255
12.	Karnataka	Shri Kaushik Mukherjee Chief Secretary Government of Karnataka 3rd Floor, R. No. 320, Vidhan Sauda, Secretariat, Bangalore-560001	Tel: 080-22252442, 22092476 Fax: 080-22258913
13.	Kerala	Ms E K Bharat Bhushan Chief Secretary Government of Kerala Secretariat, Thiruvananthapuram-695001	Tel: 0471-2333147, 2327376 Fax: 0471-2327176
14.	Madhya Pradesh	Shri Anthony J C Desa Chief Secretary Government of Madhya Pradesh Mantralaya, Vallabh Bhawan, Bhopal-462004	Tel: 0755-2441370, 2441848 Fax: 0755-2441521
15.	Maharashtra dscsoffice @gmail.com	Shri Swadheen S Kshatriya Chief Secretary Government of Maharashtra Mantralaya, Mumbai-400032	Tel: 022-22852626 22025042,22028762 22793762 Fax: 022-22028594
16.	Manipur	Shri P.C. Lawmkunga Chief Secretary Government of Manipur Manipur Secretariat, Imphal-790001	Tel: 0385-2451144, 2450064 Fax: 0385-2452629
17.	Meghalaya	Shri P B O Warjri Chief Secretary Government of Meghalaya,Meghalaya Civil Secretariat, Shillong-793001 Email: barkos.warjri@nic.in	Tel: (O)0364-2224801, 222250, Mob:-9774033922 (R)-0364-2534629 Fax: 0364-2225978
18.	Mizoram	Shri Lalmalsawma Chief Secretary Government of Mizoram, Block C, Civil Secretariat, Aizwal- 796001	Tel: 0389-2322411 Fax: 0389-2322745
19.	Nagaland	Shri M.T. Aier Chief Secretary Government of Nagaland Nagaland Civil Secretariat, Kohima-790001	Tel: 0370-2270082, 2270076 Fax: 0370-2270057
20.	Orissa	Shri Gokul Chandra Pati Chief Secretary Government of Orissa Secretariat, Bhubaneshwar- 751001	Tel: 0674-2534300, 2536700 Fax: 0674-2536660
21.	Punjab	Shri Sarvesh Kaushal Chief Secretary Government of Punjab Punjab Secretariat, Chandigarh-160017	Tel: 0172-2740156, 2740860 Fax: 0172-2742488, 2740936

Annexure-II

22.	Rajasthan	Shri C.S. Rajan Chief Secretary Government of Rajasthan Secretariat, Jaipur-302001	Tel: 0141-2227254 Fax: 0141-2227114
23.	Sikkim	Smt. Rinchen Ongmu Chief Secretary Government of Sikkim Secretariat, Gangtok- 737101	Tel: 03592-202315, 204323 (fax) Fax: 03592-222851 03592-204323
24.	Tamil Nadu	Shri. K. Gnanadesikan Chief Secretary Government of Tamil Nadu Secretariat, Chennai-600009	Tel: 044-25671555 Fax: 044-25672304
25.	Tripura	Shri G. Kameswara Rao Chief Secretary Government of Tripura Civil Secretariat, Agaratala-799001	Tel: 0381-2323200, 2324392 Fax: 0381-2324013
26.	Uttar Pradesh	Shri Alok Ranjan Chief Secretary Government of Uttar Pradesh Secretariat, Lucknow-226001	Tel: 0522-2621599 0522-2238212 0522-2238212 Fax: 0522-2239283
27.	Uttarankhand	Shri N. Ravi Shanker Chief Secretary Government of Uttarakhand 4, Subhash Road, Secretariat, Dehradun-248001	Tel: 0135-2712094 0135-2712100, 2712200 Fax: 0135-2712113 0135-2712500
28.	West Bengal	Shri Sanjay Mitra Government of West Bengal Secretariat, Writers Building Kolkata-700001	Tel: 033-22145858 Fax: 033-22144328
29.	Andaman & Nicobar	Sh. Anand Prakash Chief Secretary Secretariat & Administration, Government of Andaman & Nicobar Islands, Port Blair	Tel: 03192-233110, 234087 Fax: 03192-231100, 03192-232656
30.	Chandigarh	Shri K.K. Sharma Advisor to Administrator Union Territory of Chandigarh, Punjab Raj Bhawan, Sector – 6 Chandigarh-160017	Tel: 0172-2740154 Fax: 0172-2740317 0172-2740165
31.	Dadra & Nagar Havelli	Shri Ashish Kundra Administrator Government of Dadra & Nagar Havelli, Secretariat, Silvassa-396230	Tel: 0260-2230700 2642777 Fax: 0260- 2230775 0260-2642702
32.	Daman & Diu	Shri Ashish Kundra Administrator Secretariat Daman, Government of Daman & Diu, Daman & Diu	Tel: 0260-2230770, 2230700 Fax: 0260-2230775

33.	Delhi	Shri D.M. Spolia Chief Secretary Govt of NCT Delhi, Delhi Secretariat, I.P. Estate, New Delhi- 110002	Tel: 011-23392100 Fax: 011-23392102
34.	Lakshadweep	Shri H. Rajesh Prasad Administrator Union Territory of Lakshadweep, Kavaratti, Lakshadweep-682555	Tel: 04896-262255, 262279 Fax: 04896-262184
35.	Puducherry	Shri Chetan B Sanghi Chief Secretary Puducherry Administration, Chief Secretariat, 1 Beach Road, U.T. of Puducherry, Puducherry- 605001	Tel: 0413-2334145 0413-2335512 Fax: 0413-2337575
36.	Telangana	Dr. Rajiv Sharma, Chief Secretary, Govt. of Telangana, Hyderabad.	

भारत सरकार/Government of India
विद्युत मंत्रालय/Ministry of Power
केन्द्रीय विद्युत प्राधिकरण/Central Electricity Authority
विद्युत प्रणाली अभियांत्रिकी एवं प्रौद्योगिकी विकास प्रभाग
Power System Engineering & Technology Development Division

Dated the 11th May, 2025

To,

As per attached list

Subject: Standard Operating Procedure (SOP) for restoration of the transmission system – reg.

Sir,

I am directed to circulate a Standard Operating Procedure (SOP) to all Transmission Companies to quickly restore damaged transmission systems, protect personnel, and strengthen power system resilience.

2. In this regard, it is mentioned that objective of the aforesaid SOP is to establish a structured plan to quickly restore damaged transmission systems, protect personnel, and strengthen power system resilience. The SOP shall apply to all substations and associated transmission infrastructure—including transmission lines, transformers, switchyards, protection & control systems, and communication systems—located in high-risk or vulnerable zones.

3. Accordingly, the aforesaid SOP is enclosed herewith for necessary compliance by all Transmission Companies/SLDCs.

4. This issues with the approval of Chairperson, CEA.

Encl: As above.

भवदीय,
Signed by Pankaj Kumar Verma
Date: 11-05-2025 21:23:04
(पंकज कुमार वर्मा /Pankaj Kumar Verma)
उप-निदेशक/Dy. Director

Copy to:

1. Joint Secretary (Trans), MoP
2. SA to Chairperson, CEA
3. SA to Member (PS), CEA

Standard Operating Procedure for Restoration of the Transmission System

Contents

1.OBJECTIVE....4
2.SCOPE....4
3. EMERGENCY PREPAREDNESS....4
4. CRISIS RESPONSE TEAM (CRT)....5
5. CRISIS MANAGEMENT STAGES....6
6. SUPPORT FUNCTIONS....8
7. MESSAGE FORMAT AND FREQUENCY....8

1.OBJECTIVE

To establish a structured plan to quickly restore damaged transmission systems, protect personnel, and strengthen power system resilience.

2.SCOPE

This SOP applies to all substations and associated transmission infrastructure—including transmission lines, transformers, switchyards, protection & control systems, and communication systems—located in high-risk or vulnerable zones.

3. EMERGENCY PREPAREDNESS

1. **Manpower Availability**
    - Ensure presence of Substation In-charges, Transmission Line Engineers, Control Centre Operators, and Circle/Division Heads at their respective locations.
2. **Access Control**
    - Regulate entry at all Substations, Headquarters, Control Centres, and other critical offices.
    - Only authorized personnel with valid gate passes, government-issued IDs, and approval from respective in-charges should be permitted.
3. **Emergency Contact Display**
    - Prominently display essential contact numbers, including Police, District Administration, Hospitals, and Fire Stations at all key locations.
4. **Inventory and Spares Readiness**
    - Maintain adequate stock of critical spares including ICTs, Reactors, GIS spares, and other essential equipment.
5. **System Health and Resource Availability**
    - Ensure the following
        - Protection systems, DG sets, and firefighting systems.
        - Sufficient diesel for at least 7 days operation of DG sets and firefighting pumps.
        - Critical spares, Tools & Plants (T&P) in operational condition.
        - 24x7 availability of at least two executives in substations without residential colonies.
        - Adequate stock of food supplies, medicines, and first-aid kits.
        - Manpower, fitters, and vehicles on standby for emergency deployment.

6. **Mock Drills and Coordination**
    - Substation In-charges to coordinate with District Authorities, SDMA/NDMA etc. for conducting regular mock drills and preparedness exercises.
    - Identify critical substations (criteria at annexure) for prioritising the preparatory actions.
7. **Emergency Response Teams**
    - Identify and ensure availability of at least: 5 erection gangs, 2 stringing gangs, and 2 foundation gangs.
8. **Vendor Readiness**
    - Identify and empanel vendors/agencies for:
        - Hiring of Hydra/Crane
        - Material transportation
        - Restoration of towers, ERS, transformers, and reactors
        - OEM service support engineers

4. CRISIS RESPONSE TEAM (CRT)

Each utility shall form a CRT responsible for managing emergency situations and ensuring rapid system restoration. The CRT shall comprise the following key roles:

- **Team Head** – To be designated at the level of Chief Engineer or Director or CMD; responsible for overall command and decision-making.
- **Technical Head** – Minimum rank of Superintending Engineer; responsible for assessing damage and leading technical restoration efforts.
- **Logistics Coordinator** – Head of Procurement; responsible for timely availability and movement of critical equipment and spares.
- **Safety & Security Officer** – Head of Safety; responsible for ensuring site safety, personnel security, and risk mitigation.
- **Communications In-Charge** – Head of Communications; responsible for internal and external communication, including media coordination.
- **Liaison Officer** – Head of HR; responsible for coordination with external agencies and addressing staff welfare during emergencies.

All respective functional heads shall provide full support to the **Technical Head** to enable the fastest possible restoration of infrastructure and services.

5. CRISIS MANAGEMENT STAGES

5.1 Damage Assessment and Initial Response (Responsibility: Substation/Line Incharge)

A. Immediate Actions (within 0–1 hours of incident, depending on the site condition):

- Isolate substation and trip affected lines (if required) via remote/local SCADA.
- Initiate ground assessment using Camera or local teams (as per site condition).
- Inform Corporate Emergency Command Centre (At Head Quarters) and Head of CRT.
- Deploy Assessment Teams with PPE (Personnel Protective Equipment) and GPS after obtaining necessary clearances.
- Declare Level of Emergency:
    - *Level I*: Localized damage (e.g., one bay, single transformer, single location)
    - *Level II*: Partial damaged (e.g., switchyard + comms; without element outage)
    - *Level III*: Major substation/area-wide damage (multiple tower locations/ multiple equipment)

B. Damage Reporting:

- Photograph and geotagged reports
- Categorization of damage:
    - *Structural* – foundation, gantries
    - *Electrical* – transformers, CT/PT, breakers, isolators
    - *Communication* – PLCC, OPGW, routers
    - *Transmission lines* – towers, conductors, insulators

5.2 Resource Mobilization (6–12 hours) (Responsibility: Technical Head)

A. Spares Availability Check (within 3 hours):

- Regional stores: Transformer banks, CT/PT, Breakers
- Fetch real-time spares availability
- Contact Vendor for balance items

B. T&P and Machinery (through already identified sources)

- Mobile Cranes, Jacking Systems
- High-Capacity Oil Filtration Units
- Hydraulic Tools, Welding Units
- Manlift etc

C. Transportation and Logistics:

- Coordinate with state authorities for clear corridor.
- Liaison with authorities for movement permissions
- Arrange Transportation through identified sources, accompany with escorts

D. Manpower Mobilization:

- Identification, retention and mobilisation planning for Hired Fitters/Labors
- Safety briefing and emergency response training to be given
- Emergency shift roster (3x8 hrs) (as applicable)

5.3 Restoration and Commissioning Plan (Station Incharge) (24 hrs–15 days)

A. Transformers:

- Visual check for tank rupture, bushings, OLTC and extent of damage
- Replace from Hot Spare(If Available)
- In case of partial damage (bushing etc), replace from available spares (bushing etc)
- In case of non availability of Hot spare, arrange for Diversion of the nearest available spare.

B. Switchyard Equipment:

- Replace damaged CT/PT/CB/LA from available spares
- Relay coordination and settings validation

C. Communication Systems:

- Re-terminate OPGW if cut
- Replace damaged routers, switches, PLCC equipment from spares stock
- If Remote Control Centre communication is out, start 24x7 shift operations
- If RLDC/SLDC data is affected, communicate the exceptions on regular basis.

D. Transmission Lines:

- Identify ERS requirement

- Divert nearest ERS and ERS specialist Gang
- Deploy Emergency Restoration Systems (ERS)
- In case of partial damage, replace damaged insulators and conductors

5.4 Testing, Energization and Monitoring (Station Incharge) (24 Hrs-15 days)

- Minimum required pre-energization checks as per requirement
- Test charging of transformers and bays in isolation
- Monitor loading, temperatures, harmonics
- Reinforce security at site
- Setup CCTV/remote surveillance if damaged

6. SUPPORT FUNCTIONS

6.1 Documentation and Reporting (Technical Head)

- Reporting of damage to Head Quarter and Control Centre for onwards reporting to Government/RLDC.
- Daily restoration bulletin to Head Quarter
- Incident log to be maintained

6.2 Coordination with Stakeholders (Liaison Officer)

- Defence and Civil Authorities for access/security
- State Discoms for load shedding support
- OEMs and Vendors for fast-track supply and remote guidance

7. MESSAGE FORMAT AND FREQUENCY

Update Type	Responsibility	Frequency	Recipients
Initial Incident Alert	Substation/Line Incharge	Within 15 mins	CRT, applicable board level executives and Chairman
Damage Assessment Report	Substation /Line Incharge	Within (1-6 hrs)	CRT, Control Centre
Restoration Progress	Head of Region/Division	Twice Daily	CRT, applicable board level executives and Chairman
Security and	Head of	Daily (till	All senior stakeholders

Update Type	Responsibility	Frequency	Recipients
Safety Summary	Regional HR	restoration)	

Note: The above document shall be read in conjunction with the Disaster Management Plan.

Annexures:

1. **Criteria for Critical Substations**
2. **List of Spare Transformers**
3. **List of Spare Reactors**
4. **List of ERS towers available.**
5. **List of GIS Spares**
6. **List of CRT members with Contact details.**

Criteria for specifying a station as critical station

A power station shall be specified as " Critical Power Station" if it falls under one of the below mentioned classification:

1. 400 kV and above Substations falling within 100 km of the border.

2. Important for Grid security:
   i. The converter stations of all HVDC links along with their associated HVAC station.
   ii. All 765 kV Stations.
   iii. All stations at voltage level 400 kV and above where inter-regional lines terminate or are important for import of power by any specific state
   iv. All stations which handle more than 3000 MW of power capacity.

3. Falling in disaster prone areas/border areas and probable to be affected by floods, cyclones, landslides, movement of air force, war etc.

4. All or selected stations at 400 kV and above voltage level which are essential to ensure continuity of supply to following category of loads as per information furnished by State Load Despatch Centre and DISCOMs:
   i. State capitals
   ii. Railways, metro rail, airports, refineries, underground mines, defence establishments. VIP areas, Space, ports and important industries.
   iii. Important for islanding scheme of nuclear power plants or major metropolitan areas or defence establishments

Availability of Spare Transformers

Sl No.	Voltage	Capacity	Phase	Total	Location

Availability of Spare Reactors

Annexure-III
Annexure-II

Sl No.	Voltage	Capacity	Phase	Total	Location

Availability of ERS

Total ERS TOWERS					
State	**Voltage Level**	**Total ERS towers**	**ERS Towers available location wise**	**ERS set**	**Location**

Annexure-III
Annexure-II

Availability of GIS Spares

GIS Spares					
State	**Voltage Level**	**Make**	**Section Type(Isolator/Bus/etc)**	**Nos**	**Location**

****

Address List:

Sl. No.	Address	Tele/Fax No./Email
1.	Spl. Chief Secretary (Energy) Government of Andhra Pradesh AP Secretariat Velagapudi : 522003 Andhra Pradesh Ph.0863-2442309	secvenergyap@gmail. com
2.	Commissioner-cum-Secretary (Power), Government of Arunachal Pradesh, Civil Secretariat Itanagar 791111	secvpower.arn@gmail.com commissionerpower.arn@gmail.com
3.	Pr. Secretary (Power) Government of Bihar Urja Vibhag,	energv@bihar.gov.in energvbihar@gmail.com

	Daroga Prasad Rai Path Patna - 800001	
4.	Secretary (Power) Government of Assam Assam Sachivalaya Dispur - 781006	nv.principalsecretaryassam@gmail.com prsecv-cm@assam.gov.in power.assam@gov.in
5.	Secretary (Power) Government of Chhattisgarh Mantralaya, Atal Nagar Naya Raipur-492002	chairman@cspc.co.in secy-cmo.cg@gov.in
6.	Secretary (Power) Government of Goa Secretariat Porvorim-403521	sect-cmo.goa@nic.in, cs-goa@nic.in
7.	Principal Secretary (Energy) Government of Gujarat Block No.5/5, New Sachivalaya Gandhinagar-382010	secepd@guiarat.gov.in
8.	Addl. Chief Secretary (Energy) Government of Haryana New Secretariat, Sector-17 Chandigarh - 160017	pscmofficehry@gmail.com acspowerhrv@gmail.com
9.	Chief Secretary Government of Himachal Pradesh H.P. Secretariat Shimla - 171002	powersecv-hp@nic.in
10.	Secretary (Do WR,RD&GR) Shram Shakti Bhawan, Rafi Marg, New Delhi - 110001	Secy-mowr@nic.in

11.	Addl. Chief Secretary (Energy) Government of Jharkhand MDI Building, Dhurwa Ranchi - 834004	psec.energy@gmail.com
12.	Addl. Chief Secretary (Energy) Government of Karnataka Vikas Soudha, Dr. Ambedkar Road, Bangalore - 560001	prs-energy@karnataka.gov.in prs.energy@gmail.com
13.	Principal Secretary (Power Government of Kerala Secretariat, Thiruvananthapuram - 695 001	Secy.pwr@kerala.gov.in
14.	Addl. Chief Secretary (Energy) Government of Madhya Pradesh Mantralaya, VallabhBhawan Bhopal - 462001	secvenergy@mp.gov.in urjavibhag@yahoo.co.in
15.	Addl Chief Secretary (Energy) Government of Maharashtra Mantralaya Mumbai 400032	secenergy@maharashtra.gov.in psec.energy@maharashtra.gov.in
16.	Secretary (Power) Government of Manipur New Secretariat Imphal 795001	kh.raghumani@nic.in secy.powermnp@gmail.com
17.	Commissioner & Secretary (Power) Government of Meghalaya Meghalaya Civil Secretariat, Shillong - 793001	eddiekharbhih@gmail.com sanjaygoyal.ias@gmail.com
18.	Secretary (Power) Government of Mizoram Mizoram Secretariat Aizwal 796001	spower.mizo@gmail. com

19.	Principal secretary (Energy) Room no 16 2nd Floor Dr B.R Ambedkar Telengana Secretariat Hyderabaad-500022	Prlsecv_enery@telangana.gov.in Prlsecy.energy@gmail.com
20.	Secretary Power Development & Non- Renewal Energy Department. The Administration of UT of Ladakh-494101	Secy.pddnre@gmail.com, cepdladakh@gmail.com
21.	Commissioner & Secretary (Power) Government of Nagaland New Secretariat Complex Kohima 797004	secrevpower-ngl@nic.in Nagaland.dopn@gmail.com
22.	Principal Secretary (Energy) Government of Odisha Secretariat Bhubaneshwar 751001	energy@nic.in secy.energy@odisha.gov.in
23.	Principal Secretary (Energy) Government of Punjab Punjab Civil Secretariat Sector-9, Chandigarh 160009	secy.power@puniab.gov.in
24.	Addl. Chief Secretary (Energy) Government of Rajasthan Secretariat Jaipur - 302005	prsecretary@gmail.com ps.energy@rajasthan.gov.in
25.	PCE-cum-Secretary (Power) Government of Sikkim Secretariat, Kazi Road	secypower.sikkim@gmail.com acepowersikkim@gmail.com

	Gangtok 737101	
26.	Pr. Secretary (Energy) Government of Tamil Nadu Secretariat Chennai - 600009	enersec@tn.gov.in
27.	Spl. Chief Secretary (Energy) Government of Telangana Dr. B.R. Ambedkar Telangana Secretariat Hyderabad - 500033	Prlsecy_enegy@telangana.gov.in
28.	Secretary (Power) Government of Tripura New Secretariat Complex Agartala - 799010	secv.power-tr@gov.in secvpower.tr2023@gmail.com
29.	Addl. Chief Secretary (Energy) Government of Uttar Pradesh U.P. Secretariat, Bapu Bhawan Lucknow - 226001	psecup.energy@nic.in acsenergyup@gmail.com
30.	Secretary (Energy) Government of Uttarakhand Secretariat, Subhash Road Dehradun 24800	energy.secy.uk@gmail.com pssecretary76@gmail.com
31.	Secretary (Power) Govt, of West Bengal Vidyut Unnayan Bhawan Salt Lake City, Kolkata 700098	powersecv@wb.gov.in

32.	Secretary (Power) Andaman & Nicobar Administration Secretariat Port Blair 744101	secretary201ani@gmail.com
33.	Secretary (Power) Chandigarh UT Administration UT Secretariat, Sector-9D Chandigarh 160009	fs-chd@nic.in fsutchd@gmail.com
34.	Secretary (power) UT Admn. of Dadra & Nagar Haveli and Daman & Diu Secretariat Moti Daman - 396220	secretarypower2020@gmail.com elec-dmn-dd@nic.in
35.	Secretary (Power) Government of NCT of Delhi Delhi Secretariat, I.P. Estate New Delhi - 110002	pspowen@nic.in
36.	Pr. Secretary (Power) Government of Jammu & Kashmir Civil Secretariat Jammu - 180001	jkpdd9@gmail.com, pdd-jk@nic.in
37.	Secretary (Power) Union Territory of Lakshadweep Secretariat Kavarati 682555	vikranth.raja@nic.in mdldcl2278@gmail.com lk-ktelect@nic.in

38.	Member Secretary, Northern Regional Power Committee, Shaheed Jeet Singh Marg, Katwaria Sarai, New Delhi-110 016	ms-nrpc@nic.in
39.	Member Secretary, Western Regional Power Committee, Plot No. F-3 MIDC, Area, Marol, Opp. SEEPZ, Central Road, Andheri(East), Mumbai- 400093	ms-wrpc@nic.in
40.	Member Secretary, Southern Regional Power Committee, 29, Race Course Cross, Road, Bangaluru- 560009.	mssrpc-ka@nic.in
41.	Member Secretary, Eastern Regional Power Committee 4, Golf Course Road, ERPC Building, Tollygunj, Kolkata- 33.	mserpc-power@nic.in
42.	Member Secretary, North Eastern Regional Power Committee NERPC Complex, Dong Parmaw, Lapalang, Shillong - 793006 (Meghalaya)	ms-nerpc@gov.in
43.	Member Projects, National Highway Authority of India, Ministry of Road, Transport & Highways , Govt, of India, G 5&6, Sec-10, Dwarka, New Delhi-110075	Email: chairman@nhai.org; mk.proiects@nhai.org

44.	Chairman & Managing Director, Powergrid Corporation of India Ltd., SAUDAMINI, Plot No.2, Sector-29, Gurgaon, Haryana- 122001.	Email: cmd@powergrid.in
45.	Chief Operating Officer, CTU India Ltd., Saudamini, Plot No. 2, Sector-29, Gurgaon-122001 (Haryana)	Email: coo-ctu@ctuil.in, ashok@powergrid.in
46.	Chairman BBMB, sector-19 B Madhya Marg, Chandigarh- 160019	Email: cman@bbmb.nic.in, cets@bbmb.nic.in, power@bbmb-nic.in, spsecy@bbmb.nic.in, secy@bbmb.nic. in
47.	Chairman & Managing Director, Damodar Valley Corp. Head Quarter, DVC Towers, VIP Road Kolkata - 700054	Email: chairman@dvc.gov.in
48.	Chairman & Managing Director	cmd@nlcindia.in

	Neyveli Lignite Corporation Limited Corporate Office, Block - 1, Neyveli-607801	
48.	Chairman & Managing Director, Delhi Transco. Ltd., Shakti Sadan, Kotla Marg, New Delhi- 110002	md@dtl.gov.in gmoml.dtl@gmail.com
49.	Chief Engineer (Elect.) Goa Electricity Department Vidyut Bhawan, Panaji, Goa	cee-elec.goa@nic.in, eel-elec.goa@nic.in
50.	Chairman Haryana Vidyut Prasaran Nigam Ltd. Shakti Bhawan,Sector No. 6 Panchkula - 134 109, Haryana	chairman@hvpn.org. in
51.	Managing Director, Jammu & Kashmir Power Transmission Corporation Ltd. Exhibition Ground, Srinagar(J&K)-190 009	md@ikspdcl.com, mdikptcll@gmail.com
52.	Chairman Karnataka Power Corporation Ltd. Shakti Bhawan, 82 Race Course Road Bangalore-560 001..	mdkpcl@gmail.com, md@kptcl.com
52.	Chairman Kerala State Electricity Board Board, Secretariat, Vidyuthi Bhavanam, Pattom Thiruvananthapura m- 695 004	cmdkseb@kseb.in
53.	Chairman & Managing Director Maharashtra State Electricity Transmission Company Ltd.,	md@mahatransco.in, dirop@mahatransco.in

	C-19, E-Block, Prakashganga, Bandra-Kurla Complex Bandra(E), Mumbai 400 051	
54.	Chief Engineer (P) Manipur Electricity Department Govt, of Manipur, Manipur Sectt. South Block, Imphal, Manipur- 795 001.	snandei@gmail.com, md.mspcl@gmail.com ed.tech.mspcl@gmail.com
55.	Chairman & Managing Director, Meghalaya Energy Corporation Ltd.. Lumjingshai Short Round Road Shillong- 793 001	meecl.webportal@gmail.com, directormeptcl@gmail.com, cetranzemeptcl@gmail.com, apborkharpan@gmail.com
56.	The Engineer-in- Chief, Power and Electricity Deptt., Govt, of Mizoram, Power House, Bara Bazar, Aizwal- 796 001, Mizoram	eincpower@gmail.com, eincplanning@gmail.com, mizoplan@gmail.com
57.	Chief Engineer, Nagaland Deptt. of Power, Kohima 797 001. Nagaland	secvit-ngl@nic.in, vizol23@gmail.com, cetransgen@gmail.com, asang.dcare@gmail.com
58.	Chairman & Managing Director Punjab State Transmission Corporation Ltd., The Mall, Mall Road, Patiala- 147 001, Punjab	cmd@pstcl.org
59.	Chairman & Managing Director Rajasthan RajyaVidyutPrasara n Nigam Ltd. VidyutBhawan, Janpath . . Jaipur (Rajasthan)- 302 005	cmd.rvpn@gmail.com, dir.oper@rvpn.co.in
60.	Managing Director	sikkim.serc@gmail.com

	Sikkim Power Development Corporation Ltd. 31-A, N.H. Way, Gangtok- -737 101	
61.	Chairman & Managing Director Uttar Pradesh Power Transmission Corporation Ltd. Shakti Bhawan, 14- A, Ashok Marg, Lucknow- 226001	cmd@upptcl.org
62.	Commissioner- cum-Secretary (P) Andaman and Nicobar Electricity Department, Secretariat, Andaman and Nicobar Islands, Port Blair- 744 101	secvship14@gmail.com secretary201ani@gmail.com
63.	Secretary Dadra & Nagar Haveli Electricity Department, Dadar Nagar Secretariat, Silvassa- 396230	tapasvaraghav@gmail.com
64.	Secretary, Daman & Diu Electricity Department, Dadar Nagar Secretariat, Moti Daman- 396220	secretarvpower2020@gmail.com
65.	Secretary Lakshyadeep Elecy Department, U.T. of Lakshyadeep Kavaratti- 682555	lk-ktelect@nic.in
66.	Secretary ' Puducherry Elecy. Department Secretariat, Puducherry- 605001	secycs.pon@nic.in ' secytran.pon@nic.in

67.	Chairman & Managing Director Orissa Power TransmissionCorpo ration Ltd. Janpath, Bhubaneswar- 751 022.	cmd@optcLco.in, dir.operation@optcl.co.in
68.	Chairman Jharkhand, Urja Sancharan Nigam Ltd. Engineering Building, HEC, Dhurwa, Ranchi- 834 004	mddjusnl@gmail.com,
69.	Chairman West Bengal State Electricity Transmission Company Ltd (WBSETCL) Vidyut Bhawan, Block-DJ, Sector-II, Bidhan Nagar, Kolkata- 700 091.	md@wbsetcl.in
70.	Managing Director Bihar State Power Transmission Company Limited, 4th Floor, Vidyut Bhawan, Baily Road, Patna- 800 021	mdcellbsptcl@gmail.com
71.	Chairman and Managing Director Gujarat Energy Transmission Corporation Ltd. Sardar Patel Vidyut Bhawan, Race Course , Vadodara- 390 007	md.getco@gebmail.com
72.	Managing Director Madhya Pradesh, Power Transmission Company Ltd. Block No. 2, Shakti Bhawan,	md@mptransco.nic.in

	Rampur, P.O. Vidyut Nagar Jabalpur-482 008(MP)	
73.	Managing Director Himachal Pradesh Power Transmission Corporation Ltd. Near, Shimla Bypass (below Old MLA Quarters, Tutikandi, Panjari, Himachal Pradesh 171005.	md@hpptcl.in
74.	Chief Engineer (Power) Department of Power Govt, of Arunachal Pradesh Itanagar (Arunachal Pradesh) - 791 111.	vidvutarunachal@rediffmail.com, vidyutarunachal@gmail.com
75.	Chief Engineer(Transmission) Transmission Corporation of Andhra Pradesh Ltd. VidyutSoudha, Gunadala Eluru Road, Vijaywada Andhra Pradesh - 520 004	surendrababu.karreddula@aptransco.co.in, ce.trans@aptransco.gov.in
76.	Chairman & Managing Director Transmission Corporation of Telangana Ltd. Vidyut Soudha, Khairatabad, Hyderabad - 500082	cmd@tstransco.in
77.	Managing Director Assam Electricity Grid Corporation Ltd., Bijulee Bhawan, Paltan Bazar Guwahati- 781 001	managing.director@aegcl.co.in, md_aegcl@yahoo.co.in.
78.	Chairman & Managing Director Tripura State Elecy. Corporation Ltd.	cmd.tsecl@rediffmail.com

	Govt, of Tripura, Bidyut Bhawan Agartala-799 001.	
78.	Managing Director Power Transmission Corporation of Uttarakhand Ltd. Vidyut Bhawan, Saharnpur Road, Near I.S.B.T. Crossing, Dehra Dun, Uttarakhand - 248002	md.ptcul@rediffmail.com, md@ptcul.org
79.	Managing Director TANTRANSCO, 10th Floor/NPKRR Malikai, No. 144 Anna Salai, Chennai- 600002	mdtantransco@tnebnet.org
80.	Managing Director Chhattisgarh State Power Transmission Company Ltd., Dangania, Post Sunder Nagar Raipur - 492013.	chairman@cpsc.co.in mdtransco@cspc.co.in
81.	Shri E.V. Rao, KEC International Limited, RPG House, 463, Dr. Annie Besant Road, Worli, Mumbai-4000 030	kecindia@kecrpg.com
82.	Shri Kaushal Thakkar, Manager, Kalpataru Power Transmission Ltd., Plot No. 101, Part III,GIDC Estate, Sector 28, Gandhinagar-382028, Gujarat	kaushal.thakkar@kalpatarupower.com thakkarkaushal86@yahoo.com
83.	Shri Chanchai Kumar, Managing Director,	md@nhidcl.com, edl@nhidcl.com

	National Highways & Infrastructure Development Corporation Ltd(NHIDCL), 3rd Floor, PTI Building, 4-Parliament Street, New Delhi - 110001	
84.	Head- Corporate Affairs & Business Devpt. Sterlite Grid Limited, The Mira Corporate Suite, Plot No. 1 & 2, C Block, 2nd Floor,Ishwar Nagar, Mathura Road, New Delhi 110 065	tan.reddy@sterlite.com kamlesh.garg@sterlite.com arun.sharma1@sterlite.com
85.	Sekura Energy Ltd CEO, Windsor, 504 & 505, Off, CST Road, Kalina, Santacruz (E, Mumbai, Maharashtra 400098	Neeraj.Verma@energy-sel.com Nimish.Sheth@energy-sel.com
86.	Essar Power Sh. Partha Bhattacharya, 27th KM, Surat Hazira Road, District Surat, Hazira, Gujarat 394270	Tamendra.Kumar@essarpower.co.in, Rajive.Tiwari@essarpower.co.in, Raiat.Bajpai@essarpower.co.in, khilendra.pant@essarpower.co.in,
87.	CEO, Suzlon Energy Ltd Suzlon House, 5 Shrimali Society, Navrangpura, Ahmedabad 380009, India.	Email: mca@suzlon.com; info-india@suzlon.com;
88.	Mr. Vijay Chhibber, Director General, Electric Power Transmission association, Core 6- A, Ground Floor India, Habitat Centre, Lodi Road, New Delhi - 110 003.	epta.dg@gmail.com, dg.epta@epta.in,
89.	CMD,	isrmivaskumar@meilgroup.in

	M/s Megha Engineering & Infrastructures Ltd., S-2, Technocrat Industrial Estate, Balanagar, Hyderabad - 500 037	
90.	Chairman & Managing Director Reliance Power, Reliance Centre, Ground Floor, 19, Walchand Hirachand Marg, Ballard Estate, Mumbai 400001	reliancepower.ipo@relianceada.com
91.	Kalpataru Power Transmission Ltd., 101, Kalpataru Synergy, Opp. Grand Hyatt, Vakola , Santacruz (E), Mumbai 400055. India.	milind.nene@kalptarupower.com kaushal.thakkar@kalpatarupower.com thakkarkaushal86@yahoo.com ajay.tripathi@kalpatarupower.com
92.	Director, Torrent Power Ltd., Electricity House, Lal Darwaja, Ahmedabad - 380 001.	NAMANSHAH@torrentpower.com kaushal.thakkar@kalpatarupower.com kashyapdesai@torrentpower.com MAYANKGUPTA@torrentpower.com VATSALPATEL@torrentpower.com BIPINBSEIAH@torrentpower.com
93.	Chairman & Managing Director, KEC International Limited,. RPG House, 463, Dr. Annie Besant Road,Worli, Mumbai - 400030	kecindia@kecrpg.com

94.	Chairman and Managing Director, M/s Juniper Green Transmission Private Limited F-9 First Floor, Manish Plaza-1, Plot No. 7, MLU, Sector 10, Dwarka, New Delhi South West Delhi DL 110075	rohit.gera@junipergreenenergy.com rohit.gera91@gmail.com
95.	Chairman & Managing Director, M/s ReNew Transmission Ventures Private Limited ReNew , Commercial Block-1, Zone 6, Golf Course Road DLF City Phase-V, Gurugram-122009, Haryana	mohit.jain@renewpower.in, anuj.iain@renewpower.in amit.kumar1@renewpower.in
96.	Chairman & Managing Director, M/s Apraava Energy Private Limited 7th Floor, FULCRUM, Sahar Road, Andheri (East), Mumbai - 400 099. India.	sumit.sinha@apraava.com naveen.munjal@apraava.com roshni.shah@apraava.com
97.	L&T Infrastructure Development Projects Limited (L&T ID PL), L&T campus TCTC building , First Floor, Mount Poonamalle Road, Manapakkam, Chennai-600089, Tamil Nadu, India.	contactus@lntidpl.com csr@lntecc.com
98.	Chairman & Managing Director, Tata Power, NDPL House, Hudson Lines, Kingswa	vrshrikhande@tatapower.com BD@tatapower.com nitin.kumar@tatapower.com neeraj.srivastava@tatapower.com

		piyushkumar@tatapower.com
99.	Director, M/sGR Infraproject Limited G R INFRAPROJECTS LIMITED2nd Floor, Novus Tower, Plot No. 18, Sector 18,Gurugram, Haiyana - 122015, India	modassar.a@grinfra.com ashwin@grinfra.com akul.s@grinfra.com
100.	MD & CEO Adani Transmission Ltd 3rd Floor, South Wing, Adani Corporate House,ADANI Shantigram, S. G. Highway, Ahmedabad - 382 421.	MolavKumar.Maitra@adani.com sameer.ganiu@adani.com, Narendran.Qiha@adani.com sunnykumar.singh@adani.com
101.	Head & VP - Regulatory & Contracts) Regulatory & Contracts) IndiGrid Unit No. 101, First Floor, Windsor, Village KoleKalyan, off CST Road, Vidyanagari Marg, Kalina, Santacruz (East), Mumbai - 400 098	venkatraman.inumula@indigrid.com vivek.karthikeyanl@indigrid.com

Emergency Restoration System

Emergency Restoration System (ERS)

- As per **Central Electricity Authority (Grid Standards) Regulations 2010**, each transmission licensee shall have an arrangement for **restoration** of transmission lines of **400 kV and above** and **strategic 220 kV lines** through the use of **Emergency Restoration System** in order to **minimize the outage time of the transmission lines in case of tower failures**.

- **Immediate and temporary restoration** of transmission networks is possible by deploying the **Emergency Restoration System**.

Criteria for number of ERS to be arranged by Transmission Utility (as decided by MOP in 2014)

- **length of the Transmission Lines (Ckt-kms)**

  For Example:

  - **One (1) set of ERS** for Transmission Line Lengths upto **5,000 Ckt-kms**
  - **Two (2) set of ERS** for Transmission Line Lengths of about **5,000 to 10,000 Ckt-kms**
  - **Three (3) set of ERS** for Transmission Line Lengths of about **10,000 to 15,000 Ckt-kms** and so on.

  (Transmission Utility with **line length less than 500 Ckt kms** (of 400 kV) may be given option **either** to **procure ERS or have arrangement with other Transmission utilities** for providing ERS on mutually agreed terms, when need arises.)

- ***Other Criteria/Factors:***
  - **Importance** of the line considering **security** of Grid.
  - **Areas prone to tower failure** and failure pattern in different areas
  - **Command area** of the transmission utility and **transportability** across the command area.

Summary of ERS in all regions				
Region	**Voltage Level**	**ERS Required as per the Govt. norms (as per present requirement)**	**No. of ERS set (tower) available**	**No. of ERS set (tower) unavailable**
WR	66kV, 132kV, 220kV, 400kV, 765kV, HVDC-32kV, 500kV, 800kV	61	42	19
SR	220kV, 400kV & 765kV	34	23	11
NR	220kV, 400kV, 765kV, HVDC-500kV, 800kV	64	46	18
ER	66kV, 132kV, 220kV, 400kV, 765kV, HVDC-320kV, 500kV, 800kV	32		
NER	132kv, 400kV, 765kV, HVDC-320kV, 500kV, 800kV	14	6	8

Status of Availability of Emergency Restoration System (ERS)

Status of Availability of ERS in Southern Region

Sl. No.	Entity	ERS Required as per the Govt. norms (as per present requirement)	Voltage levels	Length of TL owned by the utility (ckt kms)	No. of ERS set (tower) available	No. of ERS set (tower) unavailable	Status of procurement of ERS set (tower) with location	Remarks
1	Andhra Pradesh	3	220	13291	2 Nos. (220 kV) 1. Visakhapatnam (Kalpakka-7 Towers, Srikakulam-3 towers) 2. Nellore (Nellore-6 Towers, Kurnool-4 Towers)	1	3 additional ERS sets are required for Andhra Pradesh (APTRANSCO)	APTRANSCO initiated tendering process (in 57th SRPC meeting)
		2	400	5683		2		
2	Telangana	3	220	10276	1 No. (400 kV) 1. Shapurnagar- 16 towers	3	4 additional ERS sets are required for Telangana (TGTRANSCO)	TGTRANSCO informed that 2nd ERS system is being planned. Simultaneously, exemption is being planned to be sought from CEA to reduce the requirement from 5 Nos. to 3 Nos., considering the comparatively lower seismic risk in the geographical area of Telangana. (in 57th SRPC meeting)
		2	400	7428		1		
3	Karnataka	3	220	13776	1 No. set (400 kV) 1. Bangalore(Peenya) 2. Hubballi	3	3 additional ERS sets are required for Karnataka (KPTCL)	KPTCL informed that 1 No. of 400 kV tower available at Bangalore and 1 No. of 400 kV tower at Hubli, which may be considered as 1 ERS system. Tenders would be invited for 3 additional systems within 15 days (in 57th SRPC meeting).
		1	400	3935		0		
4	Kerala	1	220	3173	Nil	2	Retendering process has started for 2 sets of ERS (at 220 kV level) (Each set comprising of 4 towers). One is proposed for northern region of Kerala and one for southern region of Kerala.	KSEBL informed that Board has given approval for new Make in India conditions. Started the re-tendering process (in 57th SRPC meeting).
		1	400	177				
		34		116028		23		

Status of Availability of ERS in Southern Region

Sl. No.	Entity	ERS Required as per the Govt. norms (as per present requirement)	Voltage levels	Length of TL owned by the utility (ckt kms)	No. of ERS set (tower) available	No. of ERS set (tower) unavailable	Status of procurement of ERS set (tower) with location	Remarks
5	Tamil Nadu	3	230	11919	2 Nos. 1. Sriperambudur 2. Trichy	3	4 additional ERS sets are required for Tamil Nadu (TANTRANSCO). TANTRANSCO informed that four additional ERS units are planned, including one at 765 kV level, considering future transmission expansion and upcoming 765 kV infrastructure.	TANTRANSCO informed they initiate action shortly (in 57th SRPC meeting).
		2	400	5075		0		
		1	765	733		1		
6	Puducherry	Mutual sharing agreement	230	53	Nil	0	Mutual sharing with another transmission licensee to be confirmed by PED.	PED informed that PGCIL had given consent to share for natural calamities only (in 57th SRPC meeting)
7	Powergrid SR 1, VTL, PSITSL	3	400	12730	**3 Nos.** 1. Visakhapatnam (400 kV) 16 Towers 2. Vijayawada (400 kV) 12 Towers 3. Nellore (765 kV) 24 Towers	2	2 additional ERS sets are required for SR-I POWERGRID	POWERGRID stated that order is placed for 5 Nos. for SR. SR-1 – 2 Nos SR-2 – 3 Nos. Order placed on 06.10.2025. Delivery is expected by April 2027 (in 57th SRPC meeting)
		2	765	6595				
8	Powergrid SR 2, PNMTL	3	400	14621	**2 Nos.** 1. Kozhikode (400 kV) 12 Towers, 2. Sriperumbudur (400 kV) 16 Towers	2	2 additional ERS sets are required for SR-II POWERGRID	
		1	765	2675				
9	Kudgi TL	1	400	220	Nil.	0	Atleast 1 ERS set is required for Kudgi TL in SR which is compatible upto 765 kV	Sterlite Invit and Kudgi TL have a binding agreement that allows Kudgi TL to deploy ERS in an emergency situation.
			765	760		1		
10	MTL, RSTCL, KNTL, Gadag TL (Indigrid)	1	400	939	Nil in SR.	1	Atleast 1 ERS set is required for Indigrid in SR which is compatible upto 765 kV.	
			765	208		0		
11	WKTL, Karur TL (Adani Energy Solutions Ltd.)	1	400	103	Nil in SR.	0	Atleast 1 ERS set is required for Adani Energy Solutions Ltd. in SR which is compatible upto 765 kV.	3 ERS are present on PAN India Basis. 1 ERS in NR (400 kV – 14 towers at Bikaner SS), 2 ERS in WR (765 kV – 18 towers in each set at Koradi SS(Nagpur) and Sami SS(Gujarat)). In case of emergency, the ERS would be moved to SR in few days from Koradi SS which is in proximity.
			765	1659		1		

Status of Availability of ERS in Western Region

Sl. No.	Entity	ERS Required as per the Govt. norms (as per present requirement)	Voltage levels	Length of TL owned by the utility (ckt kms)	No. of ERS set (tower) available	No. of ERS set (tower) unavailable	Status of procurement of ERS set (tower) with location	Remarks
1	Powergrid: WR	7	upto 400kV (HVAC), ±320kV (HVDC)	33914	4	3	-	-
		4	765kV (HVAC), ±500kV (HVDC), ±800kV (HVDC)	19941	3	1	-	-
2	CSPTCL	3	400KV	1931.98	02 Set(18 Towers)	1	-	01 Set (9 Towers)
			220KV	4267.63				
			132KV	8304.99				
3	MSETCL	1	500KV	1504	02 Sets (14 nos. of towers)	9	Tender for procurement of 03 ERS sets (10 towers each) is under finalization. Same shall be utilized at various zones in MSETCL	-
		2	400KV	8464				
		4	220KV	19882				
		4	132KV	19275				
4	Goa	1	220	283.3	Nil	1	-	Will initiate procurement process
		1	110	205.9	Nil	1		
5	TPGL	1	400	714	0	1	-	With reference to the 4th Transmission Availability Meeting of WRPC held on July 1, 2025,mail communication done with PGCIL to provide the process for availing the ERS system in case of requirement with formal agreement. (ERS Suspension Towers: 10 nos ERS Tension Towers: 06 nos)

Status of Availability of ERS in Western Region

Annexure-II

Sl. No.	Entity	ERS Required as per the Govt. norms (as per present requirement)	Voltage levels	Length of TL owned by the utility (ckt kms)	No. of ERS set (tower) available	No. of ERS set (tower) unavailable	Status of procurement of ERS set (tower) with location	Remarks
6	GETCO	2	400KV	7570.67	0	2	Procurement under process.	In any emergency condition, GETCO have used ERS system from Power grid & in future, it will be utilized as and when needed.
		5	220kv	22630.36	0	5	QR is revised. BOQ & Estimate is approved on 27.05.2025	
		2	132KV	5994.64	0	2	NIT under process. NIT will be done within 15 days	
		9	66kV	42478.12	0	9		
7	MPPTCL	7	400kV	4089	(Total 03 sets of ERS are available) Out above 03 sets ERS following no. of ERS can be formed. a) 05 no. of 400kV b) 07 no. of 220kV c) 07 no. of 132kV	4	Tender preparation for Procurement of ERS under process.	-
			220kV	16098				
			132kV	23422				
8	DD	1	220KV	6.93	NIL	1	_	-
		1	66KV	57.75	NIL	1		
9	DNH	1	220KV	71.26	NIL	1		
10	BDTCL	1	765kV	962km	1set		_	1 set of ERS is allocated for all 5 assets and shall be deployed as and when required
11	JTCL	1	765kV	992km				
12	KhTL	1	765kV	627km				
13	KTL	1	400KV	68km				
14	RTCL	1	400KV	402km				
		61				**42**		

Status of Availability of ERS in Northern Region

Sl. No.	Entity	ERS Required as per the Govt. norms (as per present requirement)	Voltage levels	Length of TL owned by the utility (ckt kms)	No. of ERS set (tower) available	No. of ERS set (tower) unavailable	Status of procurement of ERS set (tower) with location	Remarks
1	Delhi (DTL)	1	220kV	915.498	2 Nos. Set (400 kV) 32 Towers)	0	400kV Bamnauli Sub station	2 ERS set available.
		1	400kV	249.19				
2	Himachal Pradesh (HPPTCL)	1	220 kV	659	NIl	1		
		1	400 kV	75.7		1		
3	Haryana (HVPNL)		400 kV		1 No Set (400 kV) 12 Towers)		220kv Substation karnal and DD store Hisar.	ERS towers (6 nos tension and 6 nos suspension type 400kv level) in Haryana have been procured.
			220 kV					
4	Punjab (PSTCL)	2	220 kV	7921.991	2	1		
		1	400 kV	1666.43				
5	Rajasthan (RVPN)	3	220 kV	16429.022	1 No Set (220 kV)	5	01 No. ERS available at 220 kV GSS Heerapura, Jaipur	1 ERS set is available and work order has been placed for 3 more Sets.
		2	400 kV	8416.434				
		1	765 kV	425.498				
6	Uttar Pradesh (UPPTCL)	4	220 kV	17552.385	2 Nos. Set 1. Gr. Noida (400 kV) 24 Towers 2. Phulpur (220 kV) 24 Towers	5		ERS will also be used in other voltage lines.
		2	400 kV	8727.085				
		1	765 kV	839.37				
7	Uttarakhand (PTCUL)	1	220kV	1045.135	NIL	2		Tender has been scraped due to single bidder.
		1	400kV	418.394				
8	JKPTCL	1	132 kV	1040.63	1 No. Set (8 towers)	1	Z Mohr, Kanispora Pathla T141 D/C, Kalanpora Delina Railway station T 3 & T4, Bagh-i Wahpoh	1 No. LILO USHP-I Kangan Line, 2 No. In Sheeri LJHP Line, 2 No. Delina Baramulla Railway Line, 1 No. Bagh-i Wanpoh (KPTL) and 2 No. Lying at the stores
		1	220 kV	419.34				

Status of Availability of ERS in Northern Region

Sl. No.	Entity	ERS Required as per the Govt. norms (as per present requirement)	Voltage levels	Length of TL owned by the utility (ckt kms)	No. of ERS set (tower) available	No. of ERS set (tower) unavailable	Status of procurement of ERS set (tower) with location	Remarks
9	Powergrid NR-1	1	220 KV	1540.21	5 Sets	3	Ballabhgarh 4 (Make Lindsey) Meerut 4(Make SBB) Roorkee 2(Make SBB) Bhadla-I SS(11 Set, SBB make) & Bikaner-I SS (4 set, Lindsey make)	
		3	400 KV	13348.828				
		2	765 KV	8977.947				
		1	500 KV HVDC	653.88				
		1	800 KV HVDC	416.54				
10	Powergrid NR-2	1	220 KV	2157.67	3 sets	1	Kishenpur, Leh & Jalandhar	ERS tower available for 400KV rating can be used in place of lower as well as higher voltage Towers. In case used for 765KV Line, No of towers can be erected will reduce due to increase in Tower Hight.
		2	400 KV	7326.39				
		1	765 KV	1319.95				
11	Powergrid NR-3	1	220KV	1541	1 Nos. Set (400 kV) 26 Towers)	6		400KV ERS will be also be used in other voltage level lines
		3	400KV	12254			Kanpur	
		1	765KV	4396				
		1	500KV HVDC	2566				
		1	800KV HVDC	2205				
12	Adani (ATIL, BKTL, FBTL)	1	400 kV	120	1 Nos. Set (400 kV) 12 Towers)	1	Sami (Gujarat)	Make-Lindsey ERS set available for 400KV & 500KV rating can be used for lower as well as higher voltage Towers. In case used for 765KV Line, No of towers can reduce due to increase in Tower Height & nos of conductors.
		1	765 KV	764				
13	Indigrid (PKTCL, PTCL, NRSS-XXIX, GPTL)	1	400 kV	1582.4	NIL	1	It is kept in Bhopal and on need basis is moved across region	Not available, will tie up based on the requirements in future. However the parent company IndiGrid owns one set of ERS for all five regions.

Status of Availability of ERS in Northern Region

Sl. No.	Entity	ERS Required as per the Govt. norms (as per present requirement)	Voltage levels	Length of TL owned by the utility (ckt kms)	No. of ERS set (tower) available	No. of ERS set (tower) unavailable	Status of procurement of ERS set (tower) with location	Remarks
14	Tata Power (NRSS XXXVI, PTL)	1	400 kV	1786.924	NIL	1		Element I - Operational comprising of 3 kms. Element II - Work Under Progress comprising of 221.924 kms. Element II - Work Under Progress comprising of 77 kms.
15	Sekura (NRSS-XXXI(B)	1	400 kV	577.74	NIL	1		Tied up with M/s INDIGRID for providing ERS on need basis.
16	AD Hydro Power Limited (Renew)	1	400 kV	360	NIL	1		
17	ARAVALI POWER COMPANY PVT LTD	1	400 kV	132	NIL	1		
18	POWERGRID HIMACHAL TRANSMISSION LTD	1	400 kV	454	NIL	1		
19	Powergrid Ajmer Phagi Transmission Limited	1	765 KV	269	NIL	1		
20	Powergrid Fatehgarh Transmission Limited	1	765 KV	372	NIL	1		
21	POWERGRID KALA AMB TRANSMISSION LTD	1	400 kV	2.38	NIL	1		
22	Powergrid Unchahar Transmission Ltd	1	400 kV	106.744	NIL	1		
23	Powergrid Khetri Transmission Limited	1	765 KV	292	NIL	1		
		1	400 kV	156.16	NIL	1		
24	POWERGRID VARANASI TRANSMISSION SYSTEM LTD	1	765 KV	379	NIL	1		
25	POWERGRID ALIGARH SIKAR TRANSMISSION LIMITED	1	765 KV	514	NIL	1		
26	POWEGRID BHADLA TRANSMISSION LIMITED	1	765 KV	405	NIL	1		
27	POWERGRID BIKANER TRANSMISSION SYSTEM LIMITED	1	400 kV	1353	NIL	1		
28	POWERGRID RAMGARH TRANSMISSION LIMITED	1	400 kV	188	NIL	1		
29	POWERGRID SIKAR TRANSMISSION LIMITED	1	765 KV	619	NIL	1		
		1	400 kV	267	NIL	1		
		64				46		

Status of Availability of ERS in North Eastern Region

Sl. No.	Region	ERS Required as per the Govt. norms (as per present requirement)	Voltage levels	Length of TL owned by the utility (ckt kms)	No. of ERS set (tower) available	No. of ERS set (tower) unavailable	Status of procurement of ERS set (tower) with location	Remarks
1	Powergrid: NER	2	upto 400kV (HVAC), ±320kV (HVDC)	7524	3		–	–
		0	765kV (HVAC), ±500kV (HVDC), ±800kV (HVDC)	0	0	0	–	–
2	NETC	1	400	1323	1	0	Available at Silchar, Assam	1 set (16 towers)
3	KMTL	1	400	254	0	1	Procurement process yet to start	–
4	NTL (Indigrid)	1	400	489	0	1	–	Not available physically in NER, mechanism in place to arrange ERS from other region
5	Sterlite	1	400	202	0	1	–	Not available physically in NER, mechanism in place to arrange ERS from other region
6	Assam	2	400	5426	2	0	–	2 sets (8 towers)
7	Ar. Pradesh	1	132	457	0	1	Procurement process yet to start	–
8	Manipur	1	132	955	0	1	Procurement process yet to start	–
9	Meghalaya	1	132	1801	0	1	Procurement process yet to start	–
10	Mizoram	1	132	1034	0	1	Procurement process yet to start	–
11	Nagaland	1	132	517	0	1	Procurement process yet to start	–
12	Tripura	1	132	988	0	1	Procurement process yet to start	–
		14		**20970**	**6**			

Status of Availability of ERS in Eastern Region

Annexure-IV

Annexure-II

Sl. No.	Entity	ERS Required as per the Govt. norms (as per present requirement)	Voltage levels	Length of TL owned by the utility (ckt kms)	No. of ERS set (tower) available	No. of ERS set (tower) unavailable	Status of procurement of ERS set (tower) with location	Remarks
1	OPTCL	1	400 kV	1196.87	29	-	-	Available:Mancheswar-27; In use: Mendhasal-Meramundali line-2
		2	220 kV	6835.48	0	-	-	
		2	132 kV	8717.11	0	-	-	
2	Powergrid: ER	5	upto 400kV (HVAC), ±320kV (HVDC)	22520.00	4	1	-	-
		1	765kV (HVAC), ±500kV (HVDC), ±800kV (HVDC)	3173.00	2	-	-	-
3	Adani transmission limited(ATL)	1	400 kV	959.32	3	-	-	Sami(Gujarat): 1, Koradi(Maharashtra): 1 Akola(Maharashtra): 1
4	PGCIL (Odisha)	1	765 kV	1845.00	9	-	-	Rengali (Supension type: 6, Tension type: 3)
					15	-	-	Angul (Supension type: 9, Tension type: 6)
		1	400 kV	3355.00	3	-	-	Rourkela (Supension type: 2, Tension type: 1)
		1	220 kV	61.00		-	-	-
5	WBSETCL	1	220kV	4051.22	6	-	-	Durgapur-6
					2	-	-	Jeerat-2
					1	-	-	New Town-1
					3	-	-	New Jalpaiguri-3
					4	-	-	Laxmikantapur-4
		1	400 kV	2492.51	0	-	-	-
		1	132 kV	9670.58	0	-	-	-
		1	66 kV	333.00	0	-	-	-
6	Indigrid (ENICL, OGPTL & PKTCL)	1	400 kV	1556.70	1	-	-	Bhopal, IndiGrid, maintains a centrally located ERS set at Bhopal, which is deployed across all five regions on a need basis.
		1	765 kV	612.00	0	-	-	-

Status of Availability of ERS in Eastern Region

Sl. No.	Entity	ERS Required as per the Govt. norms (as per present requirement)	Voltage levels	Length of TL owned by the utility (ckt kms)	No. of ERS set (tower) available	No. of ERS set (tower) unavailable	Status of procurement of ERS set (tower) with location	Remarks
7	JUSNL	1	220 KV	2599.51	3	-	-	Hatia-3
					2	-	-	Jamshedpur-2
					3	-	-	Dumka-3
		1	400 kV	360.94	0	-	-	-
		1	132 kV	4067.80	0	-	-	-
8	DVC	1	220 kV	2975.64	7	-	-	Maithon: Suspension /Running angle 0 to 20 deg S/C ERS Tower: 4 Tension / Dead End 0 to 60 deg S/C ERS Tower: 2 Tension / Dead End 0 to 90 deg S/C ERS Tower: 1
		1	400 kV	482.69		-	-	
		1	132 kV	4005.21	0	-	-	-
9	BSPTCL	3	132kV	12194.38	42	-	-	-
		1	220 kV	5476.29	0	-	-	
		1	400 kV	600.00	0	-	-	
		32						

Note: As per information provided by utilities in the 228th OCC Meeting dated 04 June, 2025

THANK YOU

Annexure-III

भारत सरकार/ Government of India
विद्युत मंत्रालय/ Ministry of Power
केन्द्रीय विद्युत प्राधिकरण/ Central Electricity Authority
विद्युत प्रणाली अभियांत्रिकी एवं प्रौद्योगिकी विकास प्रभाग
Power System Engineering & Technology Development Division

Date: 06.09.2026

विषय: Minutes of Second Meeting of the Committee on Emergency Restoration System (ERS) Tower Requirement Standardization and Setting up ERS Training Facility at NPTI - reg.

महोदया/ महोदय,

The Second Meeting of the Technical Committee on Emergency Restoration System (ERS) Tower Requirement Standardization and Setting up ERS Training Facility at NPTI was held on 31.08.2026 at 15:00 hrs in the Manthan Conference Hall of CEA, 2nd Floor, Sewa Bhawan under the chairmanship of Chief Engineer (PSE&TD), CEA.

The Minutes of the meeting are enclosed herewith for kind reference and necessary action by all concerned please.

Encl.: As above

Regards,

Digitally signed by Kavita Jha
Date: 06-09-2026 10:53:54

(कविता झा/ Kavita Jha)
निदेशक /Director
PSE&TD Division, CEA

Copy to (for information):

1. SA to Chairperson, CEA
2. SA to Member (PS), CEA
3. PS to Chief Engineer (PSE&TD), CEA

तीसरा तल सेवा भवन, रा माकृष्ण पुरम, सेक्टर -1, नई दि ल्ली -110 066, ई-मेल: ce-psetd@gov.in, फ़ोन: 01126732392
3rd Sewa Bhawan, R. K. Puram, Sector-1, New Delhi-110 066, E-mail: ce-psetd@gov.in. Tel: 01126732392

Annexure-III

To

S. N.	Committee Member details			Email
	Name	**Designation**	**Organisation**	
1	Sh. Shishir Pradhan	Deputy Director	NPC Secretariat	sk.pradhan15@gov.in
2	Sh. Chandra Kant	Sr. DGM	PGCIL	chandra.kant@PGCIL.in
3	Sh. R. M. Patel	SE	GETCO	serandm.getco@gebmail.com
4	Sh. A. A. Joshi	EE	GETCO	eeengg2.getco@gebmail.com
5	Dr. M Selvaraj	Additional Director	CPRI	msraj@cpri.in
6	Sh. K. Vijay Kumar	Joint Director	CPRI	vijayakumar@cpri.in
7	Dr. Rokade Rajendra Pitamber	Scientist F	CSIR-SERC	rokade.serc@csir.res.in
8	Dr. R. Balagopal	Scientist F	CSIR-SERC	balagopal.serc@csir.res.in
9	Dr. K.P.S. Parmar	Deputy Director	NPTI	kpsparmar@npti.gov.in

Annexure-III

Power System Engineering and Technology Development Division
Central Electricity Authority

Minutes of the Second Meeting of the Committee on Emergency Restoration System (ERS) Tower Requirement Standardization and Setting up ERS Training Facility at NPTI

A. Introduction

The second meeting of the Committee on Emergency Restoration System (ERS) Tower Requirement Standardization and Setting up ERS Training Facility was held on 31.08.2026 under the chairmanship of Chief Engineer (PSE&TD), CEA, at Manthan Conference Hall, Sewa Bhawan, New Delhi. The list of Participants is attached as **Annexure-I**.

Chief Engineer (PSE&TD), CEA and Chairman of the Committee welcomed all the members and stated that the present meeting was intended to take the discussions of the Committee to a conclusive stage, particularly on the three principal areas for which the Committee had been constituted, namely:

a. Standardization of minimum number and configuration of ERS Towers including both suspension and tension towers, to be maintained in an ERS set
b. Feasibility of deployment of ERS through rental arrangements; and
c. Establishment of ERS training set up at institutes such as NPTI and CPRI for imparting training to power sector professionals on deployment, operation, and maintenance of ERS.

He highlighted that detailed deliberations had already taken place during the first meeting held on 15.06.2026 on all above issues, and based on the decision taken during the same meeting, the Committee members had undertaken a site visit to an existing ERS training facility of PGCIL situated at Raipur, Chhattisgarh on 03.08.2026 to get first-hand information on the technical and operational aspects involved in setting up & running an ERS Training Facility. The Committee had detailed discussions w.r.t. space requirements and the modules/ activities to be covered in class-room training and hands-on (field) training. The presentation given by PGCIL during the said meeting is given at **Annexure-II.** It was noted that the ERS training facility at Raipur is manufacturer-specific, .i.e., having set-up specific to SBB, Canada. It was also noted in general that different ERS training centers of PGCIL are all manufacturer specific.

In this connection, he emphasized that ERS training facility should not merely be a demonstration facility but should provide practical exposure covering the complete ERS deployment cycle, including survey, configuration finalization, erection, stringing, dismantling and loading/unloading.

He further emphasized that since ERS is required for temporary restoration of transmission lines, the proposed standardization by the Committee should provide sufficient flexibility for different transmission-system configurations while ensuring that the minimum requirement is clearly defined.

He also stated that where procurement of ERS by a utility is not viable, particularly for utilities having comparatively small transmission networks, the possibility of rental arrangements should be explored. However, going for such arrangements would require availability of sufficient vendors, proper geographical coverage, logistics arrangements, defined responsibilities and suitable commercial modalities.

Then Agenda Items were taken up detailed deliberations.

B. Minimum Local Content requirements for both Steel based ERS and Aluminium based on individual constituting components:

It was noted by the Committee that the domestic ERS manufacturing ecosystem has already been developed considerably in recent years. As discussed during the first meeting, the major ERS components include ERS suspension/running-angle/tension towers, mast and box sections, foundations/base plates, anchor assemblies, insulator strings and hardware, earth wire/OPGW fittings, guys and guy hardware, guy insulators, structural cables and hardware, erection tools and tackles, containers and software. It was also noted that there are two types of ERS (Aluminium based ERS and Steel based ERS) both of which had domestic and foreign Vendors. It was noted that excepting for the software related component, all other components are being sourced/ manufactured indigenously. In this regard, it was noted that there are three no. of domestic manufacturers of Aluminium based ERS (operating under license from CSIR-SERC), and have already achieved MLC levels of about 90%. It was also noted that foreign players have also achieved MLC levels of > 50%.

The Committee noted in this regard that so far MLC content has not been specified for ERS Towers/ Sets in the MoP's PPP-MII Order dated 16.11.2021. Accordingly if the same has to be specified now, in order to ensure level playing field and fair competition to start with, the MLC% levels of both kinds of manufacturers should be considered to specify the initial threshold, which can be suitably increased in phased manner. However, it was agreed that considering the good base of domestic ERS Suppliers with high levels of MLC%, the lower threshold of MLC% proposed to be stipulated to start with should be quickly brought to **90% within two years**.

In this regard, it was also noted that MLC regime may not be made applicable to ERS Services on rental basis since there is no actual procurement. In any case, it was also noted that the Vendors will to offer ERS on rental basis have also got high MLC % levels in their ERS Sets.

C. Cost and Weight Comparison of Steel based ERS and Aluminium based ERS

The Committee discussed the cost and weight comparison of Steel-based ERS with Aluminium-based ERS. It was noted that the per kg cost of Aluminium material employed in an ERS Tower is generally costlier (> 2 times) than per kg cost of Steel material employed in an ERS Tower. It was also noted that both Al-Material and Steel-Material are used in significant quanta in Aluminium based ERS; whereas Steel-Material is majorly used in Steel based ERS. Accordingly, it is observed that both types of ERS are not same footing, and a weight reduction by > 30 ~ 40 % is required in Aluminium based ERS in order to bring price parity between them.

D. Regulatory & Safety Requirements for ERS

It was noted that ERS is essentially a temporary restoration system and is intended to be deployed for a limited period during emergency restoration. Further, it is also not a proper lattice or pole structure. Therefore, the requirements applicable to permanent transmission structures need to be appropriately interpreted for temporary ERS structures, without compromising essential structural and electrical safety.

The Committee noted that the technical practices presently being followed include:

a. IS 802 for design and loading considerations relating to ERS tower structures

b. IEEE 1070 for testing of ERS structures and associated structural components such as box sections, guy plates, gimbals, bolts, nuts and washers
c. Relevant Indian/ International standards for line materials, hardware fittings, earth-wire accessories and insulators.

In particular, the following were emphasized:

1. Required electrical clearances shall be maintained as per relevant safety regulations
2. Right of Way (RoW) requirements shall not be compromised shall be calculated considering the structure as pole structure. However, lower RoW requirements than that required for conventional Lattice and Pole structures (0.8 to 0.95 times) can be employed.
3. The **design span** for ERS tower shall be considered as **400 m**. However, the ERS configuration and span shall be selected based on actual site conditions. It was also agreed that the standard restoration span of about 300 m may be adopted, while higher/ lower spans may be accommodated, justified by site conditions and structural analysis.
4. Structural stability shall be verified for the actual configuration, loading, span and site conditions
5. Periodic testing and inspection shall be undertaken to ensure that ERS components remain adequate for deployment.
6. The temporary nature of ERS should be clearly recognized while finalizing the applicable design and testing requirements.
7. Proper upkeep (operation and maintenance practices) is required.

E. Standardization of Minimum Number and Configuration of Towers to be maintained in an ERS Set

The Committee had detailed deliberations on the minimum number and configuration of ERS towers to be maintained in an ERS set, and agreed that the philosophy/ methodology for the same should be guided by the actual failure scenarios of Transmission Towers and the actual restoration methodology generally employed.

a) <u>The Guiding Philosophy:</u>

1. The mast is the primary common structural component of an ERS tower. It comprises modular sections of standardized dimensions, and the number of mast sections/ modules assembled determines the overall height of the ERS tower which can be varied in accordance with voltage level and as per actual site condition.
2. ERS towers are generally designed for a Single-Circuit (S/C) Twin Moose conductor configuration.
3. The conductors required for restoration activities are not normally part of the ERS package and shall be arranged separately by the concerned transmission utility or transmission licensee.
4. There is no fundamental distinction between suspension and tension type ERS towers with respect to the mast structure. Both configurations utilize the same modular mast components. The difference arises primarily from the ancillary components and arrangements adopted to meet specific loading and operational requirements, such as the number and configuration of guy wires, insulator cross-arms (ICA), stringing arrangements, requirements, and the number of mast modules employed to achieve the desired tower height and mechanical performance.
5. Since in Transmission lines Section Length is kept as 3 km to 5 km, with Design span of 300 m – 400 m, even though actual failure is confined to only one or two towers, the possibility adjacent Suspension Towers falling (due to pulling effect) is very real, and the total no. of

simultaneously fall of Towers could go up to 10 Towers in some cases.

6. Since ERS Towers are employed for restoration of power supply on emergency basis, the priority should be to restore at least one of Circuit, if the fallen Towers carry more than one Circuits.
7. For the Transmission lines up to Twin-configuration, each ERS Tower is used for restoring complete Circuit. For transmission lines that employ higher configurations such as Quad/ Hexa, each ERS Tower is used for restoring One Phase of a Circuit.

b) Standardization of an ERS Set:

In view of above, it is agreed that an ERS Set should at least be capable of catering to the requirement of **restoration of simultaneous of Five No. of D/C Towers (Towers carrying Two Circuits**). Accordingly, for restoring one Circuit, the minimum requirement of ERS Towers has been set as Five (5) no of Suspension Towers and Three (3) no of Tension Towers.

The minimum requirement of Suspension and Tension Towers in an ERS Set considering all possible Cases have been finalized as under:

(i). For 400 kV & below Transmission lines up to D/C Twin Configuration, 10 no. of Suspension Towers and 6 no. of Tension Towers constitute one ERS Set

(ii). For 400 kV and 765 kV Transmission lines with higher configurations such as Quad, Hexa, and Octa, 15 no. of Suspension Towers and 9 no. of Tension Towers constitute one ERS Set

(iii). For HVDC lines, due to use of Herringbone structures in restoration, 15 no. of Suspension Towers and 9 no. of Tension Towers have been considered as constituting one ERS Set.

In order to optimize the no. of ERS Sets which a Utility should possess for their transmission lines at different voltage levels, the following is recommended:

1. For 400 kV & below Transmission lines up to Quad Configuration, 15 no. of Suspension Towers and 9 no. of Tension Towers constitute one ERS Set (If the Utility has only up to Twin configuration, and does not possesses any Quad Configuration, then 10 no. of Suspension Towers and 6 no. of Tension Towers shall be taken as constituting one ERS Set)
2. For 765 kV and HVDC Transmission lines, 15 no. of Suspension Towers and 9 no. of Tension Towers constitute one ERS Set.

c) Requirement of ERS Sets:

With an ERS Set to be employed for use at different Voltage levels & Configurations as given at (b) above, the no. of **such** ERS Sets to be maintained by an Utility are guided by the MoP Guidelines dated 05.12.2014 as given under:

- One (1) set of ERS for Transmission Line Lengths up to 5,000 Ckt-kms
- Two (2) set of ERS for Transmission Line Lengths of about 5,000 to 10,000 Ckt-kms
- Three (3) set of ERS for Transmission Line Lengths of about 10,000 to 15,000 Ckt-kms and so on.

The above requirement is to be met separately for 400 kV & below transmission lines and 765 kV & HVDC transmission lines.

F. Deployment of ERS System through Rental Arrangements

The Committee considered the feasibility of deploying ERS through rental arrangements, particularly for utilities for whom procurement and maintenance of a dedicated ERS set may not be

economically or operationally viable. It was noted that the rental arrangements could be particularly useful for utilities having relatively small networks or maintaining ERS inventory at multiple locations is not economical. However, the success of such a system would depend on availability of sufficient vendors and their ability to mobilize ERS within the required response time.

In general, the committee was of the view that procuring ERS is a better option compared to having ERS on rental basis. Hence Utilities shall give preference for procuring ERS towers as per standard requirements.

In this regard, responses received from various Vendors, who are willing to offer ERS on rental basis, are tabulated below:

S.N.	Name	ERS Deployment Bases	Servicing Areas	Inventory/ Blockage Charges
1	M/s Hi-tech	Baroda, Bhubaneswar, Nagpur, West Bengal	Andhra Pradesh, Arunachal Pradesh, Assam , Bihar, Chhattisgarh Gujarat, Madhya Pradesh, Maharashtra, Meghalaya, Manipur, Mizoram, Nagaland, Odisha, Rajasthan, Sikkim, Tripura, West Bengal	a) 25 ERS towers suitable for applications up to 400 kV b) 12 ERS towers suitable for applications up to 220 kV c) 400 kV ERS system is scalable for 765 kV applications The above rental range may be considered as a blockage charge for maintaining dedicated ERS inventory for a particular utility/location.
2	M/s Advait	Mehsana, Gujarat	Able to provide the Service reliably across all States and Union Territories (UTs) of India, duly considering the logistical requirements and emergency response timelines associated with ERS.	Indicative costs may vary from client to client, depending on their technical specifications and the location where the ERS is required to be deployed.
3	M/s Ramelex	Pune, Maharashtra — HQ, establishment in Rajasthan can be done under a framework / standing contract.	Maharashtra and Rajasthan	a) 5 ERS towers suitable for applications up to 400 kV b) 5 ERS towers suitable for applications up to 220 kV c) 5 ERS towers suitable for applications up to 132 kV

The Committee also discussed various possible commercial models, including arrangements under which the vendor maintains inventory and makes it available on demand, with payment based on actual deployment, duration, services provided and transportation.

It was noted that a reservation/retainer arrangement could provide greater assured availability but would also have additional costs. Conversely, a First-Come-First-Serve basis kind of arrangement may be cheaper but could involve uncertainty regarding availability when most needed.

Accordingly, the contract agreement between the Rental ERS Vendor and the Utility should cover inter-alia the inventory, response time, transportation, manpower, erection, dismantling, liability, payment, performance requirements and other responsibilities.

G. Establishment of ERS Training Set up/ Facility at Institutes such as NPTI, CPRI and Central/ State Transmission Utilities

When an ERS Set is procured, its training covering all pertinent aspects is generally given by the ERS Vendor to the personnel of the procuring Utility. However, since this would be limited to only a few people, considering the overall requirement of manpower required for ERs activities at utility level, there may be a need for ERS Training facility (ies) at Utility level and national level. In this connection, NPTI, being a national level training Institute for power sector personnel/ professionals, could host such a training facility to develop skilled manpower in utilities for handling all ERS related activities.

It was also noted that there is an immediate requirement for having such a facility at national level due to shortage of sufficient no. of manpower trained for handling ERS related activities. (This may be roughly pegged at around 1500 considering a per-utility minimum requirement of 50 personnel for ERS activities, and 50 utilities).

In this connection, considering that PGCIL already has good experience of imparting ERS training comprising classroom as well as hands on field training, and imparts ERS training to not only to its own personnel, but also to personnel of State and Private Transmission Utilities, on specific requests, the Committee members had undertaken a site visit to an existing ERS training facility of PGCIL situated at Raipur, Chhattisgarh on 03.08.2026 to get first-hand information on the technical and operational aspects involved in setting up & running an ERS Training Facility.

It was noted that the ERS training facility at Raipur is manufacturer-specific, .i.e., having set-up specific to SBB, Canada. It was further noted in general that different ERS training centers of PGCIL are all manufacturer specific. It was however noted that training received for ERS of one specific make would come in handy for handing ERS of different makes. Accordingly, the proposed ERS Training facility at NPTI could also be of any one manufacturer specific to begin with, and ERS of other makes can be covered at a later time based on the requirement. In this connection, it was emphasized that the proposed ERS training facility should not merely be a demonstration facility but should provide practical exposure covering the complete ERS deployment cycle, including survey, configuration finalization, erection, stringing, dismantling and loading/unloading.

It may be pertinent to mention here that even though ERS Training facility is presently proposed at NPTI, its model can be replicated by other organizations such as CPRI and other Central/ State/ Private Transmission Utilities.

Based on the detailed discussions w.r.t. space requirements and the modules/ activities to be covered in class-room training and hands-on (field) training, the Committee proposes two levels of training – (i) Basic Training meant for Technicians and Executives involved in ERS Restoration Activities, and (ii) Advance Training meant for Executives esp. those involved in planning and studying and validating different configurations of ERS Towers under various scenarios through relevant software. It was also clarified that both these training programs, by their nature, can be

conducted independently (i.e., need n ot be linked with one another), and can also be imparted at different premises/ places of NPTI.

The details of these trainings and space requirements for the proposed ERS Training Facility are given under:

a) Space requirements:

The Committee discussed the space requirement for establishing the hands-on ERS training facility. It was considered that the facility should provide:

i. Building for Classroom training
ii. Open area for field training, i.e., for erection of ERS towers, stringing, destringing and dismantling
iii. Storage/yard facility for ERS Sets (Components)

The Committee deliberated that a minimum of three towers, with a span of 150 metres, would be required for field training. Further, as the guy wires extend up to 50 metres, a general clearance of 50 metres at each Tower location may be considered. Accordingly, the required land area would be approximately **400 m × 100 m**. Out of three Towers, the end two Towers would be Tension Towers and the middle one would be Suspension Tower, and all the three Towers are required to be erected in near straight line.

In this regard, NPTI/ HLTC representatives were requested to examine and identify suitable land parcels, preferably more than one alternatives, so that the most suitable location may be finalized after a joint inspection with PGCIL. As requested by NPTI, the said joint visit to HLTC, Bengaluru was scheduled no 03.09.2026, with request to furnish their findings to the Committee by 07.09.2026 for appropriate inclusion of the same in the Report of the Committee.

b) Basic Training:

After detailed deliberations, the Committee has suggested the following 5-Day schedule for imparting ERS Basic Training covering both classroom and hands-on/field sessions:

Date	Activity	Description of Activity
Day 1	Inauguration of Training program	• Inauguration of ERS Training program
Day 1 (First half)	Classroom Training	• Need of ERS system • Basic principles of ERS • ERS components and their functions • Different ERS configurations • Foundations/ base plates • Mast and module sections • Guy arrangements • Insulators and hardware • Tools and tackles
Day 1 (First half)	Classroom Training	• Survey for ERS installation • Different factors such as selection of type & no. of tower ,type of conductor, selection of anchoring

		etc
Day 1 (First half)	Classroom Training	• Methodology of erection of ERS • Step by step procedure of erection of ERS • Different methods of erection of ERS • Different configuration of towers suitable for ERS • Different Bypass methods for erection of ERS
Day 1 (second half)	Material identification and shifting from store to site	• Safety Aspects in ERS • Material identification for erection of ERS towers • Transportation of ERS material to identified site
Day 2 (First half)	Foundation plate and guying arrangement	• Installation of base plate along with gimbal arrangement and arrangement of various guy • Guying arrangements and anchoring • Stability considerations
Day 2 (Second half)	Erection of ERS tower	• Erection of ERS tower through ball point ginpole/ sliding gin pole. • Erection of 2 nos towers (1 nos tension and 1 no running/suspension tower)/ Arrangement of different fittings • Assembly of modules • Stability considerations • Erection methodology • Safety precautions during erection
Day 3	Fixing of insulators/ hard-wares/ post insulators/ top plates, etc.	• Installation of suitable insulators and hard-wares along with top plates with stringing arrangements
Day 4 (First half)	Stringing activity	• Stringing activity • Maintenance of required clearances • Conductor handling • Tensioning arrangements
Day 4 (Second half)	De-stringing activity	• De-stringing activity • Maintenance of required clearances • Conductor handling • Tensioning arrangements
Day 5 (First half)	Dismantling activity and shifting of material to store	• Removal of insulators / hardwares, etc. • Dismantling activity along with safe transportation of material back to store • Dismantling sequence • Safe removal of conductors and hardware • Dismantling of ERS structures • Inspection of components • Preparation of inventory • Loading and transportation

Day 5 (Second half)	Closing	• Case Study (finding out ERS solution for different scenarios) • Assessment • Feedback

In order to ensure sufficient attention and requisite quality, the Committee suggested to keep the Batch strength for the above program as 18 – 24.

The participants would include Engineers/ Executives as well as Technicians involved in ERS erection and restoration activities.

It was also suggested to design erecting ERS Towers considering different types of soils – sandy land, marshy land, rocky land, etc.

c) Advanced Training

This is basically a Class-room training, and is meant for Engineers & Executives esp. those involved in planning and studying and validating different configurations of ERS Towers under various scenarios through relevant software. This advanced course would primarily focus on:

- ERS planning
- Analysis of various failure scenarios
- Selection of appropriate ERS configuration
- Determination of number and height of ERS towers
- Preparation of site-specific configuration
- Structural stability checks
- Span and loading considerations
- Inventory planning
- Use of relevant software
- Verification of restoration arrangements

It was noted that since the course would involve the use of soft-wares such as PLS-CADD and PLS-Pole, a prior knowledge of the same by the participants attending the training program is necessary. It was suggested NPTI should also have at least Five no. of licenses of the said soft-ware (to cater to 3 groups in a Batch simultaneously)

The Committee suggested the following 3-Day schedule for imparting Advanced Training:

Day 1	Day 2	Day 3
• Inauguration • Familiarity with various Software Features (PLS CADD and PLS-Pole) • One failure scenario exercise	• Three to Four failure scenario exercises	• Two to Three Failure scenarios exercises • Assessment • Feedback

In order to ensure sufficient attention and requisite quality, the Committee suggested to keep the Batch strength for the above program as 10 - 25.

H. Conclusion

Chief Engineer (PSE&TD), CEA concluded the meeting by stating that as the Committee had adequately deliberately on all the ToR issues, Draft Report of the Committee would be prepared based on the deliberations of the Committee, and would be circulated for comments, appropriately incorporating which, the Final Report would be submitted to NPC for necessary action.

*****

Annexure-III

Annexure-I

List of Participants:

CEA

1. Sh. N.R.L.K Prasad, Chief Engineer (PSE&TD)
2. Smt. Kavita jha, Director (PSE&TD)
3. Smt. Jyoti Singh, Deputy Director (PSE&TD)
4. Sh. Shishir Kumar Pradhan, Deputy Director, (NPC)
5. Sh. Amrendra Pratap Singh, Assistant Director (PSE&TD)
6. Sh. Saurabh Raj, Assistant Director, (NPC)

PGCIL

1. Sh. Amit Kumar, GM
2. Sh. Ashish Kumar Singh, Chief Manager

CSIR-SERC

1. Dr. R.P. Rokade, Scientist-F

NPTI

1. Dr. KPS Parmar, Deputy Director

CPRI (Online)

1. Sh. Vijay, CPRI



सुस्वागतम्





EMERGENCY RESTORATION SYSTEM

Need of Emergency Restoration System (ERS)











Presentation by
AVINASH G GEDAM DGM(AM) WR-1

Why ERS (Emergency Restoration System) ?



Why ERS (Emergency Restoration System) ?

Failures of transmission lines can occur due to:-

- High wind loading,
- Storm damage,
- Rock slides,
- Mud slides,
- Erosion of Foundations,
- Corrosion of towers, or
- Vandalism or sabotage.

Generally, When electrical transmission is interrupted because one or several transmission towers are damaged-

- There is a high economical cost for the utility i.e. penalties for every day of non-transmission
- There are also high political and social costs to such a situation.
- Removal of damaged tower, rectification of foundation, transport of the material for the new tower to the site and installation involve time depending on the extent of damage.

LOSS in Rs. for Outage Time 24 hours

❖**Impact is considered based on Availability of WRTS system as 99.75 % and any Element outage happened for 24 hours**

SN	ELEMENT	LOSS in (Lakhs)
1	765kv Hexa Zebra line with 350 km	-23.91
2	765kv Quad Bersimis line with 270 km	-12.23
3	400kv Quad, ACSR Moose, line with 370 km	-11.81
4	400kv Twin, ACSR Moose, line with 333 km	-4.87

WHY ERS?

ERS is a reusable modular structure designed to quickly, efficiently and safely restore energy after loss of power, or during maintenance and construction work, without the assistance of heavy machinery, Tools & plants



By using ERS, the transmission towers can be replaced in just a few days/hours by creating a by-pass and power transmission can be resumed much faster than with the traditional methods.



BENEFITS & APPLICATION OF ERS

Interruption of power can cause high fines, without income, to a transmission company.

Therefore ERS towers can be used to quickly, safely and efficiently:

- **Restore power interrupted by natural disasters, sabotage or vandalism.**
- **Perform maintenance on a power line and minimizing the outage time.**
- **Perform new construction of power lines, cross roads, or new substations.**
- **Perform renovations on old lines.**
- **Perform hotline maintenance.**

The possibilities are endless…

Factors to be considered For installation of Emergency Restoration

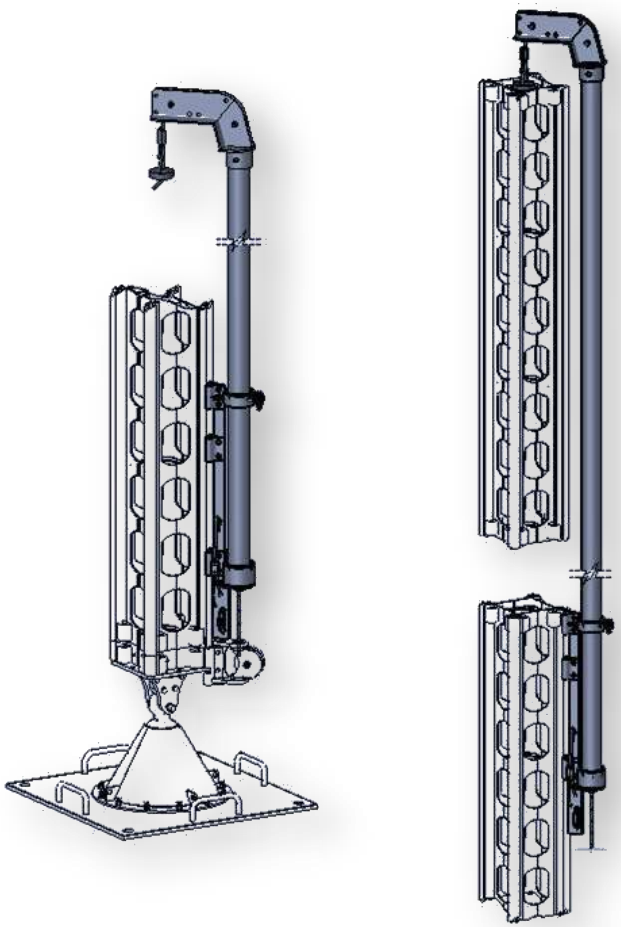


Factors to be considered For installation of Emergency Restoration

- Type & No. of tower collapse.
- Type of conductor.
- Climatic conditions like wind, temp, ice etc.
- Type of Soil type.
- Material Availability and availability of the Machinery, Tools & Plants.

ASSEMBLY METHODS

ASSEMBLY METHODS – SLIDING GIN POLE









ASSEMBLY METHODS – BALL JOINT GIN POLE





ASSEMBLY METHODS – BOOM TRUCK



ASSEMBLY METHODS – HELICOPTER





OTHER TOOLS FOR ASSEMBLY

Pionjar for crow bar installation



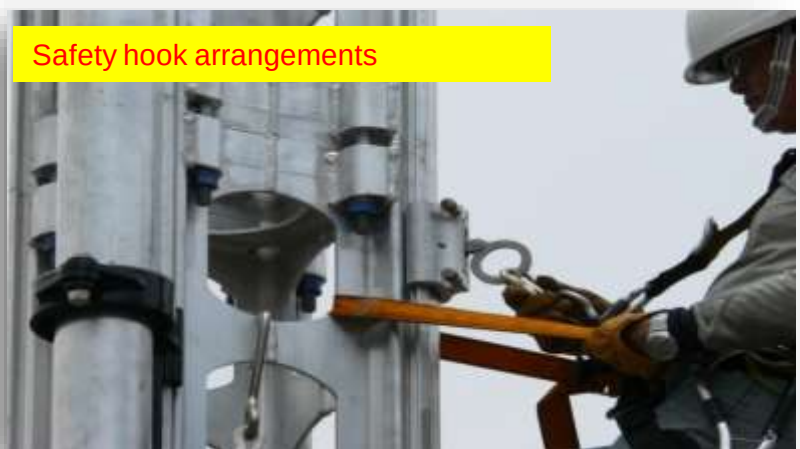
Post insulator installation



Erection of masts section



Safety hook arrangements



ERS erection with motorized capston



SOME PHOTOS DURING ERS ACTIVITIES



Material storage in ERS container (base plate)



Material storage in ERS container (Insulator)



ERS Material transportation



ERS Material mast section transportation through manual mode



Safety talk



SOME PHOTOS DURING ERS ACTIVITIES

Base plate arrangement



Gimble arrangement



Fixing of first section with gimble



Erection process



Digging for arrangement of guy



Helix installation arrangement



SOME PHOTOS DURING ERS ACTIVITIES

Erection with hydra/crane



Marshy soil anchor plate



Marshy soil anchor plate arrangment





Tightening of guy



Tension clamp arrangement



SOME PHOTOS DURING ERS ACTIVITIES













RESTORATION OF TRANSMISSION LINESON ERS IN WR-1

Name of Line	Name of TLM	Year of Restoration
400kV S/C Korba -Bhilai Ckt-1	Bilaspur TLM	2023
400kV S/C Bhatapara-Bhilai	Bhatapara TLM	2013
400kV D/C Mauda-Wardha 1&2	Wardha TLM	2012
400kV D/C Raipur-Bhadravati-2&3	Bramhapuri TLM	2012

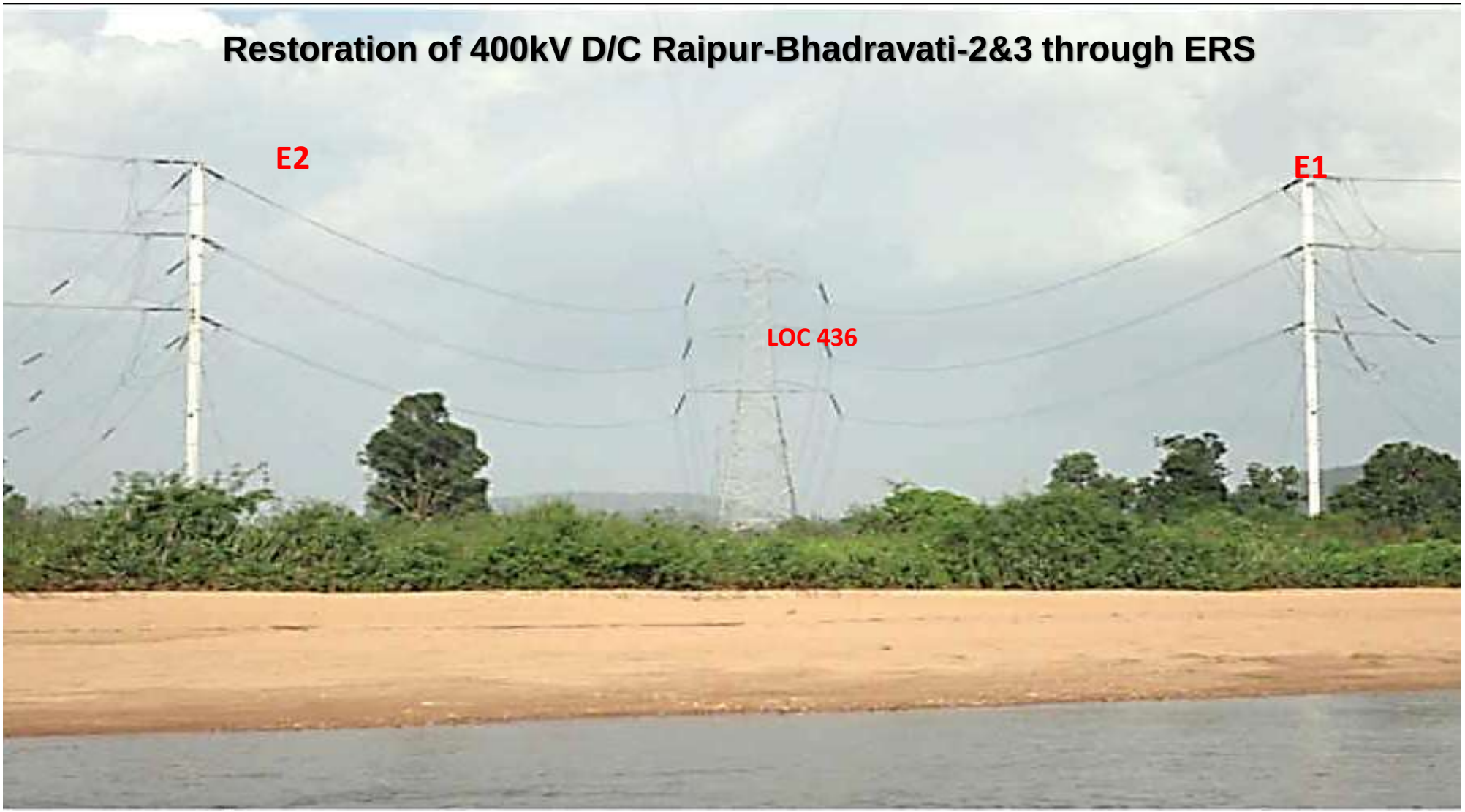
SOME PHOTOS OF RESTORATION ON ERS



SOME PHOTOS OF RESTORATION ON ERS



Diversion of 400kV Transmission LIne using ERS towers



SOME PHOTOS DURING ERS ACTIVITIES


Material Storage in ERS Container


Material Storage in ERS Container (Insulators)


Mast Loading in Substation


Hardware Fitting Verification before sending to site


ERS Material Transportation to Site


Safety PEP Talk at Site before starting of work

SOME PHOTOS DURING ERS ACTIVITIES













SOME PHOTOS DURING ERS ACTIVITIES













SOME PHOTOS DURING ERS ACTIVITIES












Barricading & Radium sticker on Guying wire arrangement


ACD & Phase Marking Provided on ERS arrangement

Barricading Tape Provided for Guying arrangement



THANK YOU



प्रदीप कुमार सिन्हा
सचिव
भारत सरकार
PRADEEP K. SINHA
Secretary
Government of India

सत्यमेव जयते

Ministry of Power
Shram Shakti Bhawan
New Delhi - 110001

विद्युत मंत्रालय
श्रम शक्ति भवन
नई दिल्ली–110001
Tele : 23710271/23711316
Fax : 23721487
E-mail : secy-power@nic.in

D.O. No.20/6/2014-OM

05.12.2014

Dear Shri Negi,

As you are aware, India has one of the largest A.C. Synchronous Transmission Grids in the world with more than 3 lakhs circuit kms of 220kV and above lines which form the backbone of the Indian Power System.

2. However, this huge network needs to be operated in a sustained and secure manner, particularly, during the time of natural disasters. Failure to do so leads to severe constraints not only in meeting the power demand but also poses serious problems in maintaining safety and security of the Grid. Difficult situations came to light in the wake of recent natural disasters, such as, floods in J&K and Phailin as well as Hud-Hud cyclone in Odisha and Andhra Pradesh. These disasters caused extensive damage to transmission networks resulting in wide spread disruption of many important transmission links and substations affecting power supply for long periods due to the time taken in restoration.

3. You would appreciate that under such adverse situations, the availability of an effective mechanism for emergent restoration of transmission lines in the shortest possible time is of utmost importance. Immediate and temporary restoration of transmission networks is possible by deploying the "Emergency Restoration Systems (ERS)." Grid Standards notified by the Central Electricity Authority(CEA) stipulate that every Transmission Licensee shall have an arrangement for restoration of transmission lines of at least 220kV and above through the use of ERS. However, presently the States do not possess such ERS infrastructure. Consequently, POWERGRID becomes the last resort whose ERS infrastructure is also limited.

4. Therefore, deployment of adequate ERS infrastructure with the States is necessary. In this connection, CEA had recently convened a meeting of the representatives from State Utilities, CTUs and RPCs to deliberate and review their preparedness to effectively restore transmission networks in times of emergency. Based on the inputs received, an indicative requirement of ERS for States has been assessed which is at Annex-I. Further, CEA has also formulated guidelines for planning, deployment and procurement of such ERS infrastructure (Annex-II).

5. I would, therefore, request you to please issue necessary directives to Transmission Utilities/ Transmission licensees operating in your State to take stock, procure appropriate number of ERS infrastructure and place them at strategic locations. Action taken by the Utilities in this regard may be informed to the CEA and the Ministry of Power, at the earliest.

With regards,

Yours sincerely,

(Pradeep K. Sinha)

Encl : as above

Shri Ramesh Negi
Chief Secretary
Govt of **Arunachal Pradesh**
Itanagar

Dist:- As per list attached.

RIGHT TO INFORMATION

स्वच्छ भारत
एक कदम स्वच्छता की ओर

ANNEX-I

Availability and Proposed Plan for deployment of ERS

Sl. No.	Region	State Utilities / PGCIL	Availability of ERS sets	Additional ERS set to be procured	Remark
I	Northern Region				
	PGCIL	NR1	3	1	
		NR2	1		
	1	Haryana	-	1	
	2	HP	-	1	Hilly terrain
	3	J&K	-	1	-do-
	4	Punjab	-	2	
	5	Rajsthan	-	3	
	6	Uttar Pradesh	-	3	
	7	Uttarakhand	-	1	
	8	Chandigarh	-	-	
	9	Delhi	-	1	DTL is procuring 2 ERS sets
	10	POWERLINKS	2		1 set each is located in NR and ER; each setting having 14 towers of 400 kV
	Total		6	14	
II	Western Region				
	PGCIL	WR1	2	1	
		WR2	2		
	10	Gujarat	-	3	

	11	MP	1	2	
	12	Chhattisgarh	-		
	13	Maharashtra	2	2	
	14	Goa	-	1	
	15	D&NH	-	-	
	16	Daman& Diu	-	-	
	Total		7	9	
III	Southern Region				
	PGCIL	SR1	1	2	
		SR2	1		
	17	AP	-	3	(To be located at Vishakahapatnam, Vijawada, Nellore)
	18	Telengana	-	1	
	19	Karnataka	-	2	
	20	Kerala	-	1	
	21	Tamil Nadu	-	2	
	22	Lakshadweep	-	-	
	23	Puducherry	-	-	
	Total		2	11	
IV	Eastern Region	PGCIL			
	PGCIL	ER1	1	-	
		ER2	2		
	24	Bihar	2	2	
	25	Jharkhand	-	1	
	26	Orissa	3	2(comprising of 12 nos. of 400kV towers which is in the process of procurement)	Existing ERS located at Bhubaneswar, Chatrapur and Budhipada (each with 14 ERS towers)
	27	West Bengal	-	2	
	28	DVC	-	1	

	29	A&N Island	-	-	
	30	Sikkim	-	-	
	Total		8	8	
V	North Eastern Region		-		
	PGCIL	NER	1		
	31	Assam	4	2	
	32	Manipur	-		
	33	Meghalaya	-		
	34	Nagaland	-		
	35	Tripura	-		
	36	Ar. Pradesh	-		
	37	Mizoram	-		
	Total		5	2	
	Total All India		28	44	

Note: POWERGRID has informed that they are procuring 6 additional sets of ERS for different regions.

Strategy adopted

1. The primary criterion for deciding number of ERS to be arranged by a transmission utility has to be the length of transmission line (ckt-kms) at different voltage levels (e.g 220 kV, 400 kV, 765 kV and +/- 500kV HVDC). Other factors to be taken into account while deciding the number of ERS are

   - Importance of the line considering security of Grid
   - Areas prone to tower failure and failure pattern in different areas
   - Command area of the transmission utility and transportability across the command area

2. For any transmission utility, one set of ERS has been planned to cater to failure of towers for transmission line lengths of up to 5000 Ckt. Kms.. Accordingly, two (2) sets of ERS have been planned for transmission line lengths of about 5000 to 10,000 Ckt. Kms. and three (3) sets for more than 10,000 Ckt. Kms and so on.

3. The transmission Utility with line length less than 500 ckt kms (of 400kV lines) may be given option either to procure ERS or have agreement with other transmission utilities for providing ERS on mutually agreed terms, when need arises.

ANNEX-II

GUIDELINES FOR PLANNING, PROCUREMENT AND DEPLOYMENT OF EMERGENCY RESTORATION SYSTEM (ERS)

1. One set of ERS should include all accessories [structures (Aluminum Alloy), polymer insulators & hardware, anchor assembly, guy wires, foundation plates, guy plate, other equipment & fittings, special Tools & Plants required for erection & stringing of ERS and trailer mounted detachable containers (without engine) for storage & transportation of ERS hardware / material etc.] and associated software.

2. One set of ERS shall be capable of restoring few numbers of suspension towers and tension towers of the transmission line corresponding to the highest transmission voltage in operation in the utility with required type of conductors. The same ERS can be used for lower voltage lines as well. The number of suspension, tension towers, insulators and associated hardware etc., to be included under one set of ERS, may be decided by the utilities at the time of procurement depending on their requirement.

3. Proper management of ERS and training of personnel for erection of towers on ERS and use of associated software is essential. A dedicated and specialized erection & commissioning gang, which is properly trained to execute such work, would be required.

4. ERS should be utilized only for emergency purposes and the line should be restored on normal towers as early as possible. It should not be a practice to run transmission line on ERS for a long time instead of shifting to normal towers. Moreover, ERS should not be used in new lines under construction. Otherwise, the very purpose of ERS will be defeated.

5. The deployment of ERS by any transmission utility / licensee should be reported to concerned RLDC and RPC.

6. The transmission utilities may approach Appropriate Commission for approval and initiate procurement process on urgent basis to comply with Grid Standards. Utilities may also approach State Disaster Management Authorities for funding.

7. The funding for procurement of ERS could be considered from PSDF for North Eastern States and a proposal be submitted by Member Secretary, NERPC.

Annex

List of Chief Secretaries of State and UTs

S. No.	State	Name and Address	Telephone/ Fax/Email
1.	Andhra Pradesh	Shri I.Y.R. Krishna Rao Chief Secretary Government of Andhra Pradesh, Secretariat, Hyderabad-500022	Tel: 040-23453620 040-23455340 Fax: 040-040-23453700, 23451133, 23451144
2.	Arunachal Pradesh	Shri Ramesh Negi Chief Secretary & Principal Secretary (Relief & Rehabilitation & Disaster Management) Arunachal Pradesh Civil Secretariat, Government of Arunachal Pradesh, Itanagar- 791 111	Tel: 0360-2212595 Fax: 0360-2212446, 2215719 M: 9436040035
3.	Assam	Shri Jitesh Khosla Chief Secretary Government of Assam, Assam Sachivalaya, Block C, 3rd Floor, Dispur, Guwahati-781006	Tel: 0361-2261120, 2261403 Fax:-0361-2260900
4.	Bihar	Shri Anjani Kumar Singh Chief Secretary Government of Bihar Old Secretariat, Patna-800015	Tel: 0612-2215804 Fax: 0612-2217085
5.	Chattisgarh	Sh. Vivek Kumar Dhand Chief Secretary Government of Chattisgarh, DKS Bhawan, Mantralaya, Raipur-492001	Tel: 0771-2221207/8 Fax: 0771-2221206
6.	Goa	Shri R.K. Srivastava Chief Secretary Govt. of Goa Secretariat Porvorim	Tel: 0832-2419402 Fax: 0832-2415201
7.	Gujarat	Shri D.J. Pandian Chief Secretary Government of Gujarat New Sachivalaya Gandhingar-382010	Tel: 079-23220372, 079-23250301-3 Fax: 079-23250305
8.	Haryana	Shri. P.K. Gupta Chief Secretary Government of Haryana, Room No.-4, 4th floor, Harayana, Civil Secretariat, Sector-1, Chandigarh-160009	Tel: 0172-2740118 Fax: 0172-2740317
9.	Himachal Pradesh	Shri P. Mitra Chief Secretary Government of Himachal Pradesh Secretariat, Shimla- 171002	Tel: 0177-2621022 Fax: 0177-2621813

10.	Jammu & Kashmir	Sh. Mohammad Iqbal Khandey Chief Secretary Government of J &K Jammu Secretariat, Jammu	Tel: 0191-2546773, 2544338 (Jammu) Fax: 0191-2546188
11.	Jharkhand	Shri Sajal Chakrabarty Chief Secretary Government of Jharkhand Secretariat, Ranchi-834004	Tel: 0651-2400240, 2400250 Fax: 0651-2400255
12.	Karnataka	Shri Kaushik Mukherjee Chief Secretary Government of Karnataka 3rd Floor, R. No. 320, Vidhan Sauda, Secretariat, Bangalore-560001	Tel: 080-22252442, 22092476 Fax: 080-22258913
13.	Kerala	Ms E K Bharat Bhushan Chief Secretary Government of Kerala Secretariat, Thiruvananthapuram-695001	Tel: 0471-2333147, 2327376 Fax: 0471-2327176
14.	Madhya Pradesh	Shri Anthony J C Desa Chief Secretary Government of Madhya Pradesh Mantralaya, Vallabh Bhawan, Bhopal-462004	Tel: 0755-2441370, 2441848 Fax: 0755-2441521
15.	Maharashtra dscsoffice @gmail.com	Shri Swadheen S Kshatriya Chief Secretary Government of Maharashtra Mantralaya, Mumbai-400032	Tel: 022-22852626 22025042,22028762 22793762 Fax: 022-22028594
16.	Manipur	Shri P.C. Lawmkunga Chief Secretary Government of Manipur Manipur Secretariat, Imphal-790001	Tel: 0385-2451144, 2450064 Fax: 0385-2452629
17.	Meghalaya	Shri P B O Warjri Chief Secretary Government of Meghalaya,Meghalaya Civil Secretariat, Shillong-793001 Email: barkos.warjri@nic.in	Tel: (O)0364-2224801, 222250, Mob:-9774033922 (R)-0364-2534629 Fax: 0364-2225978
18.	Mizoram	Shri Lalmalsawma Chief Secretary Government of Mizoram, Block C, Civil Secretariat, Aizwal- 796001	Tel: 0389-2322411 Fax: 0389-2322745
19.	Nagaland	Shri M.T. Aier Chief Secretary Government of Nagaland Nagaland Civil Secretariat, Kohima-790001	Tel: 0370-2270082, 2270076 Fax: 0370-2270057
20.	Orissa	Shri Gokul Chandra Pati Chief Secretary Government of Orissa Secretariat, Bhubaneshwar- 751001	Tel: 0674-2534300, 2536700 Fax: 0674-2536660
21.	Punjab	Shri Sarvesh Kaushal Chief Secretary Government of Punjab Punjab Secretariat, Chandigarh-160017	Tel: 0172-2740156, 2740860 Fax: 0172-2742488, 2740936

22.	Rajasthan	Shri C.S. Rajan Chief Secretary Government of Rajasthan Secretariat, Jaipur-302001	Tel: 0141-2227254 Fax: 0141-2227114
23.	Sikkim	Smt. Rinchen Ongmu Chief Secretary Government of Sikkim Secretariat, Gangtok- 737101	Tel: 03592-202315, 204323 (fax) Fax: 03592-222851 03592-204323
24.	Tamil Nadu	Shri. K. Gnanadesikan Chief Secretary Government of Tamil Nadu Secretariat, Chennai-600009	Tel: 044-25671555 Fax: 044-25672304
25.	Tripura	Shri G. Kameswara Rao Chief Secretary Government of Tripura Civil Secretariat, Agaratala-799001	Tel: 0381-2323200, 2324392 Fax: 0381-2324013
26.	Uttar Pradesh	Shri Alok Ranjan Chief Secretary Government of Uttar Pradesh Secretariat, Lucknow-226001	Tel: 0522-2621599 0522-2238212 0522-2238212 Fax: 0522-2239283
27.	Uttarankhand	Shri N. Ravi Shanker Chief Secretary Government of Uttarakhand 4, Subhash Road, Secretariat, Dehradun-248001	Tel: 0135-2712094 0135-2712100, 2712200 Fax: 0135-2712113 0135-2712500
28.	West Bengal	Shri Sanjay Mitra Government of West Bengal Secretariat, Writers Building Kolkata-700001	Tel: 033-22145858 Fax: 033-22144328
29.	Andaman & Nicobar	Sh. Anand Prakash Chief Secretary Secretariat & Administration, Government of Andaman & Nicobar Islands, Port Blair	Tel: 03192-233110, 234087 Fax: 03192-231100, 03192-232656
30.	Chandigarh	Shri K.K. Sharma Advisor to Administrator Union Territory of Chandigarh, Punjab Raj Bhawan, Sector – 6 Chandigarh-160017	Tel: 0172-2740154 Fax: 0172-2740317 0172-2740165
31.	Dadra & Nagar Havelli	Shri Ashish Kundra Administrator Government of Dadra & Nagar Havelli, Secretariat, Silvassa-396230	Tel: 0260-2230700 2642777 Fax: 0260- 2230775 0260-2642702
32.	Daman & Diu	Shri Ashish Kundra Administrator Secretariat Daman, Government of Daman & Diu, Daman & Diu	Tel: 0260-2230770, 2230700 Fax: 0260-2230775

33.	Delhi	Shri D.M. Spolia Chief Secretary Govt of NCT Delhi, Delhi Secretariat, I.P. Estate, New Delhi- 110002	Tel: 011-23392100 Fax: 011-23392102
34.	Lakshadweep	Shri H. Rajesh Prasad Administrator Union Territory of Lakshadweep, Kavaratti, Lakshadweep-682555	Tel: 04896-262255, 262279 Fax: 04896-262184
35.	Puducherry	Shri Chetan B Sanghi Chief Secretary Puducherry Administration, Chief Secretariat, 1 Beach Road, U.T. of Puducherry, Puducherry- 605001	Tel: 0413-2334145 0413-2335512 Fax: 0413-2337575
36.	Telangana	Dr. Rajiv Sharma, Chief Secretary, Govt. of Telangana, Hyderabad.	

Annexure-V

भारत सरकार/Government of India
विद्युत मंत्रालय/Ministry of Power
केन्द्रीय विद्युत प्राधिकरण/Central Electricity Authority
विद्युत प्रणाली अभियांत्रिकी एवं प्रौद्योगिकी विकास प्रभाग
Power System Engineering & Technology Development Division

Dated the 11th May, 2025

To,

As per attached list

Subject: Standard Operating Procedure (SOP) for restoration of the transmission system – reg.

Sir,

I am directed to circulate a Standard Operating Procedure (SOP) to all Transmission Companies to quickly restore damaged transmission systems, protect personnel, and strengthen power system resilience.

2. In this regard, it is mentioned that objective of the aforesaid SOP is to establish a structured plan to quickly restore damaged transmission systems, protect personnel, and strengthen power system resilience. The SOP shall apply to all substations and associated transmission infrastructure—including transmission lines, transformers, switchyards, protection & control systems, and communication systems—located in high-risk or vulnerable zones.

3. Accordingly, the aforesaid SOP is enclosed herewith for necessary compliance by all Transmission Companies/SLDCs.

4. This issues with the approval of Chairperson, CEA.

Encl: As above.

भवदीय,

(पंकज कुमार वर्मा /Pankaj Kumar Verma)
उप-निदेशक/Dy. Director

Copy to:

1. Joint Secretary (Trans), MoP
2. SA to Chairperson, CEA
3. SA to Member (PS), CEA

Annexure-V

Standard Operating Procedure for Restoration of the Transmission System

Annexure-V

Contents

1.OBJECTIVE....4
2.SCOPE....4
3. EMERGENCY PREPAREDNESS....4
4. CRISIS RESPONSE TEAM (CRT)....5
5. CRISIS MANAGEMENT STAGES....6
6. SUPPORT FUNCTIONS....8
7. MESSAGE FORMAT AND FREQUENCY....8

Annexure-V

1.OBJECTIVE

To establish a structured plan to quickly restore damaged transmission systems, protect personnel, and strengthen power system resilience.

2.SCOPE

This SOP applies to all substations and associated transmission infrastructure—including transmission lines, transformers, switchyards, protection & control systems, and communication systems—located in high-risk or vulnerable zones.

3. EMERGENCY PREPAREDNESS

1. **Manpower Availability**
    - Ensure presence of Substation In-charges, Transmission Line Engineers, Control Centre Operators, and Circle/Division Heads at their respective locations.
2. **Access Control**
    - Regulate entry at all Substations, Headquarters, Control Centres, and other critical offices.
    - Only authorized personnel with valid gate passes, government-issued IDs, and approval from respective in-charges should be permitted.
3. **Emergency Contact Display**
    - Prominently display essential contact numbers, including Police, District Administration, Hospitals, and Fire Stations at all key locations.
4. **Inventory and Spares Readiness**
    - Maintain adequate stock of critical spares including ICTs, Reactors, GIS spares, and other essential equipment.
5. **System Health and Resource Availability**
    - Ensure the following
        - Protection systems, DG sets, and firefighting systems.
        - Sufficient diesel for at least 7 days operation of DG sets and firefighting pumps.
        - Critical spares, Tools & Plants (T&P) in operational condition.
        - 24x7 availability of at least two executives in substations without residential colonies.
        - Adequate stock of food supplies, medicines, and first-aid kits.
        - Manpower, fitters, and vehicles on standby for emergency deployment.

6. **Mock Drills and Coordination**
    - Substation In-charges to coordinate with District Authorities, SDMA/NDMA etc. for conducting regular mock drills and preparedness exercises.
    - Identify critical substations (criteria at annexure) for prioritising the preparatory actions.
7. **Emergency Response Teams**
    - Identify and ensure availability of at least: 5 erection gangs, 2 stringing gangs, and 2 foundation gangs.
8. **Vendor Readiness**
    - Identify and empanel vendors/agencies for:
        - Hiring of Hydra/Crane
        - Material transportation
        - Restoration of towers, ERS, transformers, and reactors
        - OEM service support engineers

4. CRISIS RESPONSE TEAM (CRT)

Each utility shall form a CRT responsible for managing emergency situations and ensuring rapid system restoration. The CRT shall comprise the following key roles:

- **Team Head** – To be designated at the level of Chief Engineer or Director or CMD; responsible for overall command and decision-making.
- **Technical Head** – Minimum rank of Superintending Engineer; responsible for assessing damage and leading technical restoration efforts.
- **Logistics Coordinator** – Head of Procurement; responsible for timely availability and movement of critical equipment and spares.
- **Safety & Security Officer** – Head of Safety; responsible for ensuring site safety, personnel security, and risk mitigation.
- **Communications In-Charge** – Head of Communications; responsible for internal and external communication, including media coordination.
- **Liaison Officer** – Head of HR; responsible for coordination with external agencies and addressing staff welfare during emergencies.

All respective functional heads shall provide full support to the **Technical Head** to enable the fastest possible restoration of infrastructure and services.

5. CRISIS MANAGEMENT STAGES

5.1 Damage Assessment and Initial Response (Responsibility: Substation/Line Incharge)

A. Immediate Actions (within 0–1 hours of incident, depending on the site condition):

- Isolate substation and trip affected lines (if required) via remote/local SCADA.
- Initiate ground assessment using Camera or local teams (as per site condition).
- Inform Corporate Emergency Command Centre (At Head Quarters) and Head of CRT.
- Deploy Assessment Teams with PPE (Personnel Protective Equipment) and GPS after obtaining necessary clearances.
- Declare Level of Emergency:
    - *Level I*: Localized damage (e.g., one bay, single transformer, single location)
    - *Level II*: Partial damaged (e.g., switchyard + comms; without element outage)
    - *Level III*: Major substation/area-wide damage (multiple tower locations/ multiple equipment)

B. Damage Reporting:

- Photograph and geotagged reports
- Categorization of damage:
    - *Structural* – foundation, gantries
    - *Electrical* – transformers, CT/PT, breakers, isolators
    - *Communication* – PLCC, OPGW, routers
    - *Transmission lines* – towers, conductors, insulators

5.2 Resource Mobilization (6–12 hours) (Responsibility: Technical Head)

A. Spares Availability Check (within 3 hours):

- Regional stores: Transformer banks, CT/PT, Breakers
- Fetch real-time spares availability
- Contact Vendor for balance items

B. T&P and Machinery (through already identified sources)

- Mobile Cranes, Jacking Systems
- High-Capacity Oil Filtration Units
- Hydraulic Tools, Welding Units
- Manlift etc

C. Transportation and Logistics:

- Coordinate with state authorities for clear corridor.
- Liaison with authorities for movement permissions
- Arrange Transportation through identified sources, accompany with escorts

D. Manpower Mobilization:

- Identification, retention and mobilisation planning for Hired Fitters/Labors
- Safety briefing and emergency response training to be given
- Emergency shift roster (3x8 hrs) (as applicable)

5.3 Restoration and Commissioning Plan (Station Incharge) (24 hrs–15 days)

A. Transformers:

- Visual check for tank rupture, bushings, OLTC and extent of damage
- Replace from Hot Spare(If Available)
- In case of partial damage (bushing etc), replace from available spares (bushing etc)
- In case of non availability of Hot spare, arrange for Diversion of the nearest available spare.

B. Switchyard Equipment:

- Replace damaged CT/PT/CB/LA from available spares
- Relay coordination and settings validation

C. Communication Systems:

- Re-terminate OPGW if cut
- Replace damaged routers, switches, PLCC equipment from spares stock
- If Remote Control Centre communication is out, start 24x7 shift operations
- If RLDC/SLDC data is affected, communicate the exceptions on regular basis.

D. Transmission Lines:

- Identify ERS requirement

- Divert nearest ERS and ERS specialist Gang
- Deploy Emergency Restoration Systems (ERS)
- In case of partial damage, replace damaged insulators and conductors

5.4 Testing, Energization and Monitoring (Station Incharge) (24 Hrs-15 days)

- Minimum required pre-energization checks as per requirement
- Test charging of transformers and bays in isolation
- Monitor loading, temperatures, harmonics
- Reinforce security at site
- Setup CCTV/remote surveillance if damaged

6. SUPPORT FUNCTIONS

6.1 Documentation and Reporting (Technical Head)

- Reporting of damage to Head Quarter and Control Centre for onwards reporting to Government/RLDC.
- Daily restoration bulletin to Head Quarter
- Incident log to be maintained

6.2 Coordination with Stakeholders (Liaison Officer)

- Defence and Civil Authorities for access/security
- State Discoms for load shedding support
- OEMs and Vendors for fast-track supply and remote guidance

7. MESSAGE FORMAT AND FREQUENCY

Update Type	Responsibility	Frequency	Recipients
Initial Incident Alert	Substation/Line Incharge	Within 15 mins	CRT, applicable board level executives and Chairman
Damage Assessment Report	Substation /Line Incharge	Within (1-6 hrs)	CRT, Control Centre
Restoration Progress	Head of Region/Division	Twice Daily	CRT, applicable board level executives and Chairman
Security and	Head of	Daily (till	All senior stakeholders

Annexure-V

Update Type	Responsibility	Frequency	Recipients
Safety Summary	Regional HR	restoration)	

Note: The above document shall be read in conjunction with the Disaster Management Plan.

Annexures:

1. **Criteria for Critical Substations**
2. **List of Spare Transformers**
3. **List of Spare Reactors**
4. **List of ERS towers available.**
5. **List of GIS Spares**
6. **List of CRT members with Contact details.**

Annexure-V

Criteria for specifying a station as critical station

A power station shall be specified as " Critical Power Station" if it falls under one of the below mentioned classification:

1. 400 kV and above Substations falling within 100 km of the border.

2. Important for Grid security:
   i. The converter stations of all HVDC links along with their associated HVAC station.
   ii. All 765 kV Stations.
   iii. All stations at voltage level 400 kV and above where inter-regional lines terminate or are important for import of power by any specific state
   iv. All stations which handle more than 3000 MW of power capacity.

3. Falling in disaster prone areas/border areas and probable to be affected by floods, cyclones, landslides, movement of air force, war etc.

4. All or selected stations at 400 kV and above voltage level which are essential to ensure continuity of supply to following category of loads as per information furnished by State Load Despatch Centre and DISCOMs:
   i. State capitals
   ii. Railways, metro rail, airports, refineries, underground mines, defence establishments. VIP areas, Space, ports and important industries.
   iii. Important for islanding scheme of nuclear power plants or major metropolitan areas or defence establishments

Annexure-V

Availability of Spare Transformers

Sl No.	Voltage	Capacity	Phase	Total	Location

Availability of Spare Reactors

Annexure-V

Sl No.	Voltage	Capacity	Phase	Total	Location

Annexure-V

Availability of ERS

Total ERS TOWERS					
State	**Voltage Level**	**Total ERS towers**	**ERS Towers available location wise**	**ERS set**	**Location**

Annexure-V

Availability of GIS Spares

GIS Spares					
State	**Voltage Level**	**Make**	**Section Type(Isolator/Bus/etc)**	**Nos**	**Location**

****

Annexure-V

Address List:

Sl. No.	Address	Tele/Fax No./Email
1.	Spl. Chief Secretary (Energy) Government of Andhra Pradesh AP Secretariat Velagapudi : 522003 Andhra Pradesh Ph.0863-2442309	secvenergyap@gmail. com
2.	Commissioner-cum-Secretary (Power), Government of Arunachal Pradesh, Civil Secretariat Itanagar 791111	secvpower.arn@gmail.com commissionerpower.arn@gmail.com
3.	Pr. Secretary (Power) Government of Bihar Urja Vibhag,	energv@bihar.gov.in energvbihar@gmail.com

Annexure-V

	Daroga Prasad Rai Path Patna - 800001	
4.	Secretary (Power) Government of Assam Assam Sachivalaya Dispur - 781006	nv.principalsecretaryassam@gmail.com prsecv-cm@assam.gov.in power.assam@gov.in
5.	Secretary (Power) Government of Chhattisgarh Mantralaya, Atal Nagar Naya Raipur-492002	chairman@cspc.co.in secy-cmo.cg@gov.in
6.	Secretary (Power) Government of Goa Secretariat Porvorim-403521	sect-cmo.goa@nic.in, cs-goa@nic.in
7.	Principal Secretary (Energy) Government of Gujarat Block No.5/5, New Sachivalaya Gandhinagar-382010	secepd@guiarat.gov.in
8.	Addl. Chief Secretary (Energy) Government of Haryana New Secretariat, Sector-17 Chandigarh - 160017	pscmofficehry@gmail.com acspowerhrv@gmail.com
9.	Chief Secretary Government of Himachal Pradesh H.P. Secretariat Shimla - 171002	powersecv-hp@nic.in
10.	Secretary (Do WR,RD&GR) Shram Shakti Bhawan, Rafi Marg, New Delhi - 110001	Secy-mowr@nic.in

Annexure-V

11.	Addl. Chief Secretary (Energy) Government of Jharkhand MDI Building, Dhurwa Ranchi - 834004	psec.energy@gmail.com
12.	Addl. Chief Secretary (Energy) Government of Karnataka Vikas Soudha, Dr. Ambedkar Road, Bangalore - 560001	prs-energy@karnataka.gov.in prs.energy@gmail.com
13.	Principal Secretary (Power Government of Kerala Secretariat, Thiruvananthapuram - 695 001	Secy.pwr@kerala.gov.in
14.	Addl. Chief Secretary (Energy) Government of Madhya Pradesh Mantralaya, VallabhBhawan Bhopal - 462001	secvenergy@mp.gov.in urjavibhag@yahoo.co.in
15.	Addl Chief Secretary (Energy) Government of Maharashtra Mantralaya Mumbai 400032	secenergy@maharashtra.gov.in psec.energy@maharashtra.gov.in
16.	Secretary (Power) Government of Manipur New Secretariat Imphal 795001	kh.raghumani@nic.in secy.powermnp@gmail.com
17.	Commissioner & Secretary (Power) Government of Meghalaya Meghalaya Civil Secretariat, Shillong - 793001	eddiekharbhih@gmail.com sanjaygoyal.ias@gmail.com
18.	Secretary (Power) Government of Mizoram Mizoram Secretariat Aizwal 796001	spower.mizo@gmail. com

Annexure-V

19.	Principal secretary (Energy) Room no 16 2nd Floor Dr B.R Ambedkar Telengana Secretariat Hyderabaad-500022	Prlsecv_enery@telangana.gov.in Prlsecy.energy@gmail.com
20.	Secretary Power Development & Non- Renewal Energy Department. The Administration of UT of Ladakh-494101	Secy.pddnre@gmail.com, cepdladakh@gmail.com
21.	Commissioner & Secretary (Power) Government of Nagaland New Secretariat Complex Kohima 797004	secrevpower-ngl@nic.in Nagaland.dopn@gmail.com
22.	Principal Secretary (Energy) Government of Odisha Secretariat Bhubaneshwar 751001	energy@nic.in secy.energy@odisha.gov.in
23.	Principal Secretary (Energy) Government of Punjab Punjab Civil Secretariat Sector-9, Chandigarh 160009	secy.power@puniab.gov.in
24.	Addl. Chief Secretary (Energy) Government of Rajasthan Secretariat Jaipur - 302005	prsecretary@gmail.com ps.energy@rajasthan.gov.in
25.	PCE-cum-Secretary (Power) Government of Sikkim Secretariat, Kazi Road	secypower.sikkim@gmail.com acepowersikkim@gmail.com

Annexure-V

	Gangtok 737101	
26.	Pr. Secretary (Energy) Government of Tamil Nadu Secretariat Chennai - 600009	enersec@tn.gov.in
27.	Spl. Chief Secretary (Energy) Government of Telangana Dr. B.R. Ambedkar Telangana Secretariat Hyderabad - 500033	Prlsecy_enegy@telangana.gov.in
28.	Secretary (Power) Government of Tripura New Secretariat Complex Agartala - 799010	secv.power-tr@gov.in secvpower.tr2023@gmail.com
29.	Addl. Chief Secretary (Energy) Government of Uttar Pradesh U.P. Secretariat, Bapu Bhawan Lucknow - 226001	psecup.energy@nic.in acsenergyup@gmail.com
30.	Secretary (Energy) Government of Uttarakhand Secretariat, Subhash Road Dehradun 24800	energy.secy.uk@gmail.com pssecretary76@gmail.com
31.	Secretary (Power) Govt, of West Bengal Vidyut Unnayan Bhawan Salt Lake City, Kolkata 700098	powersecv@wb.gov.in

Annexure-V

Annexure-V

32.	Secretary (Power) Andaman & Nicobar Administration Secretariat Port Blair 744101	secretary201ani@gmail.com
33.	Secretary (Power) Chandigarh UT Administration UT Secretariat, Sector-9D Chandigarh 160009	fs-chd@nic.in fsutchd@gmail.com
34.	Secretary (power) UT Admn. of Dadra & Nagar Haveli and Daman & Diu Secretariat Moti Daman - 396220	secretarypower2020@gmail.com elec-dmn-dd@nic.in
35.	Secretary (Power) Government of NCT of Delhi Delhi Secretariat, I.P. Estate New Delhi - 110002	pspowen@nic.in
36.	Pr. Secretary (Power) Government of Jammu & Kashmir Civil Secretariat Jammu - 180001	jkpdd9@gmail.com, pdd-jk@nic.in
37.	Secretary (Power) Union Territory of Lakshadweep Secretariat Kavarati 682555	vikranth.raja@nic.in mdldcl2278@gmail.com lk-ktelect@nic.in

Annexure-V

38.	Member Secretary, Northern Regional Power Committee, Shaheed Jeet Singh Marg, Katwaria Sarai, New Delhi-110 016	ms-nrpc@nic.in
39.	Member Secretary, Western Regional Power Committee, Plot No. F-3 MIDC, Area, Marol, Opp. SEEPZ, Central Road, Andheri(East), Mumbai- 400093	ms-wrpc@nic.in
40.	Member Secretary, Southern Regional Power Committee, 29, Race Course Cross, Road, Bangaluru- 560009.	mssrpc-ka@nic.in
41.	Member Secretary, Eastern Regional Power Committee 4, Golf Course Road, ERPC Building, Tollygunj, Kolkata- 33.	mserpc-power@nic.in
42.	Member Secretary, North Eastern Regional Power Committee NERPC Complex, Dong Parmaw, Lapalang, Shillong - 793006 (Meghalaya)	ms-nerpc@gov.in
43.	Member Projects, National Highway Authority of India, Ministry of Road, Transport & Highways , Govt, of India, G 5&6, Sec-10, Dwarka, New Delhi-110075	Email: chairman@nhai.org; mk.proiects@nhai.org

44.	Chairman & Managing Director, Powergrid Corporation of India Ltd., SAUDAMINI, Plot No.2, Sector-29, Gurgaon, Haryana- 122001.	Email: cmd@powergrid.in
45.	Chief Operating Officer, CTU India Ltd., Saudamini, Plot No. 2, Sector-29, Gurgaon-122001 (Haryana)	Email: coo-ctu@ctuil.in, ashok@powergrid.in
46.	Chairman BBMB, sector-19 B Madhya Marg, Chandigarh- 160019	Email: cman@bbmb.nic.in, cets@bbmb.nic.in, power@bbmb-nic.in, spsecy@bbmb.nic.in, secy@bbmb.nic. in
47.	Chairman & Managing Director, Damodar Valley Corp. Head Quarter, DVC Towers, VIP Road Kolkata - 700054	Email: chairman@dvc.gov.in
48.	Chairman & Managing Director	cmd@nlcindia.in

Annexure-V

	Neyveli Lignite Corporation Limited Corporate Office, Block - 1, Neyveli-607801	
48.	Chairman & Managing Director, Delhi Transco. Ltd., Shakti Sadan, Kotla Marg, New Delhi- 110002	md@dtl.gov.in gmoml.dtl@gmail.com
49.	Chief Engineer (Elect.) Goa Electricity Department Vidyut Bhawan, Panaji, Goa	cee-elec.goa@nic.in, eel-elec.goa@nic.in
50.	Chairman Haryana Vidyut Prasaran Nigam Ltd. Shakti Bhawan,Sector No. 6 Panchkula - 134 109, Haryana	chairman@hvpn.org. in
51.	Managing Director, Jammu & Kashmir Power Transmission Corporation Ltd. Exhibition Ground, Srinagar(J&K)-190 009	md@ikspdcl.com, mdikptcll@gmail.com
52.	Chairman Karnataka Power Corporation Ltd. Shakti Bhawan, 82 Race Course Road Bangalore-560 001..	mdkpcl@gmail.com, md@kptcl.com
52.	Chairman Kerala State Electricity Board Board, Secretariat, Vidyuthi Bhavanam, Pattom Thiruvananthapura m- 695 004	cmdkseb@kseb.in
53.	Chairman & Managing Director Maharashtra State Electricity Transmission Company Ltd.,	md@mahatransco.in, dirop@mahatransco.in

Annexure-V

	C-19, E-Block, Prakashganga, Bandra-Kurla Complex Bandra(E), Mumbai 400 051	
54.	Chief Engineer (P) Manipur Electricity Department Govt, of Manipur, Manipur Sectt. South Block, Imphal, Manipur- 795 001.	snandei@gmail.com, md.mspcl@gmail.com ed.tech.mspcl@gmail.com
55.	Chairman & Managing Director, Meghalaya Energy Corporation Ltd.. Lumjingshai Short Round Road Shillong- 793 001	meecl.webportal@gmail.com, directormeptcl@gmail.com, cetranzemeptcl@gmail.com, apborkharpan@gmail.com
56.	The Engineer-in- Chief, Power and Electricity Deptt., Govt, of Mizoram, Power House, Bara Bazar, Aizwal- 796 001, Mizoram	eincpower@gmail.com, eincplanning@gmail.com, mizoplan@gmail.com
57.	Chief Engineer, Nagaland Deptt. of Power, Kohima 797 001. Nagaland	secvit-ngl@nic.in, vizol23@gmail.com, cetransgen@gmail.com, asang.dcare@gmail.com
58.	Chairman & Managing Director Punjab State Transmission Corporation Ltd., The Mall, Mall Road, Patiala- 147 001, Punjab	cmd@pstcl.org
59.	Chairman & Managing Director Rajasthan RajyaVidyutPrasara n Nigam Ltd. VidyutBhawan, Janpath . . Jaipur (Rajasthan)- 302 005	cmd.rvpn@gmail.com, dir.oper@rvpn.co.in
60.	Managing Director	sikkim.serc@gmail.com

Annexure-V

	Sikkim Power Development Corporation Ltd. 31-A, N.H. Way, Gangtok- -737 101	
61.	Chairman & Managing Director Uttar Pradesh Power Transmission Corporation Ltd. Shakti Bhawan, 14- A, Ashok Marg, Lucknow- 226001	cmd@upptcl.org
62.	Commissioner- cum-Secretary (P) Andaman and Nicobar Electricity Department, Secretariat, Andaman and Nicobar Islands, Port Blair- 744 101	secvship14@gmail.com secretary201ani@gmail.com
63.	Secretary Dadra & Nagar Haveli Electricity Department, Dadar Nagar Secretariat, Silvassa- 396230	tapasvaraghav@gmail.com
64.	Secretary, Daman & Diu Electricity Department, Dadar Nagar Secretariat, Moti Daman- 396220	secretarvpower2020@gmail.com
65.	Secretary Lakshyadeep Elecy Department, U.T. of Lakshyadeep Kavaratti- 682555	lk-ktelect@nic.in
66.	Secretary ' Puducherry Elecy. Department Secretariat, Puducherry- 605001	secycs.pon@nic.in ' secytran.pon@nic.in

Annexure-V

67.	Chairman & Managing Director Orissa Power TransmissionCorpo ration Ltd. Janpath, Bhubaneswar- 751 022.	cmd@optcLco.in, dir.operation@optcl.co.in
68.	Chairman Jharkhand, Urja Sancharan Nigam Ltd. Engineering Building, HEC, Dhurwa, Ranchi- 834 004	mddjusnl@gmail.com,
69.	Chairman West Bengal State Electricity Transmission Company Ltd (WBSETCL) Vidyut Bhawan, Block-DJ, Sector-II, Bidhan Nagar, Kolkata- 700 091.	md@wbsetcl.in
70.	Managing Director Bihar State Power Transmission Company Limited, 4th Floor, Vidyut Bhawan, Baily Road, Patna- 800 021	mdcellbsptcl@gmail.com
71.	Chairman and Managing Director Gujarat Energy Transmission Corporation Ltd. Sardar Patel Vidyut Bhawan, Race Course , Vadodara- 390 007	md.getco@gebmail.com
72.	Managing Director Madhya Pradesh, Power Transmission Company Ltd. Block No. 2, Shakti Bhawan,	md@mptransco.nic.in

Annexure-V

	Rampur, P.O. Vidyut Nagar Jabalpur-482 008(MP)	
73.	Managing Director Himachal Pradesh Power Transmission Corporation Ltd. Near, Shimla Bypass (below Old MLA Quarters, Tutikandi, Panjari, Himachal Pradesh 171005.	md@hpptcl.in
74.	Chief Engineer (Power) Department of Power Govt, of Arunachal Pradesh Itanagar (Arunachal Pradesh) - 791 111.	vidvutarunachal@rediffmail.com, vidyutarunachal@gmail.com
75.	Chief Engineer(Transmission) Transmission Corporation of Andhra Pradesh Ltd. VidyutSoudha, Gunadala Eluru Road, Vijaywada Andhra Pradesh - 520 004	surendrababu.karreddula@aptransco.co.in, ce.trans@aptransco.gov.in
76.	Chairman & Managing Director Transmission Corporation of Telangana Ltd. Vidyut Soudha, Khairatabad, Hyderabad - 500082	cmd@tstransco.in
77.	Managing Director Assam Electricity Grid Corporation Ltd., Bijulee Bhawan, Paltan Bazar Guwahati- 781 001	managing.director@aegcl.co.in, md_aegcl@yahoo.co.in.
78.	Chairman & Managing Director Tripura State Elecy. Corporation Ltd.	cmd.tsecl@rediffmail.com

Annexure-V

	Govt, of Tripura, Bidyut Bhawan Agartala-799 001.	
78.	Managing Director Power Transmission Corporation of Uttarakhand Ltd. Vidyut Bhawan, Saharnpur Road, Near I.S.B.T. Crossing, Dehra Dun, Uttarakhand - 248002	md.ptcul@rediffmail.com, md@ptcul.org
79.	Managing Director TANTRANSCO, 10th Floor/NPKRR Malikai, No. 144 Anna Salai, Chennai- 600002	mdtantransco@tnebnet.org
80.	Managing Director Chhattisgarh State Power Transmission Company Ltd., Dangania, Post Sunder Nagar Raipur - 492013.	chairman@cpsc.co.in mdtransco@cspc.co.in
81.	Shri E.V. Rao, KEC International Limited, RPG House, 463, Dr. Annie Besant Road, Worli, Mumbai-4000 030	kecindia@kecrpg.com
82.	Shri Kaushal Thakkar, Manager, Kalpataru Power Transmission Ltd., Plot No. 101, Part III,GIDC Estate, Sector 28, Gandhinagar-382028, Gujarat	kaushal.thakkar@kalpatarupower.com thakkarkaushal86@yahoo.com
83.	Shri Chanchai Kumar, Managing Director,	md@nhidcl.com, edl@nhidcl.com

Annexure-V

	National Highways & Infrastructure Development Corporation Ltd(NHIDCL), 3rd Floor, PTI Building, 4-Parliament Street, New Delhi - 110001	
84.	Head- Corporate Affairs & Business Devpt. Sterlite Grid Limited, The Mira Corporate Suite, Plot No. 1 & 2, C Block, 2nd Floor,Ishwar Nagar, Mathura Road, New Delhi 110 065	tan.reddy@sterlite.com kamlesh.garg@sterlite.com arun.sharma1@sterlite.com
85.	Sekura Energy Ltd CEO, Windsor, 504 & 505, Off, CST Road, Kalina, Santacruz (E, Mumbai, Maharashtra 400098	Neeraj.Verma@energy-sel.com Nimish.Sheth@energy-sel.com
86.	Essar Power Sh. Partha Bhattacharya, 27th KM, Surat Hazira Road, District Surat, Hazira, Gujarat 394270	Tamendra.Kumar@essarpower.co.in, Rajive.Tiwari@essarpower.co.in, Raiat.Bajpai@essarpower.co.in, khilendra.pant@essarpower.co.in,
87.	CEO, Suzlon Energy Ltd Suzlon House, 5 Shrimali Society, Navrangpura, Ahmedabad 380009, India.	Email: mca@suzlon.com; info-india@suzlon.com;
88.	Mr. Vijay Chhibber, Director General, Electric Power Transmission association, Core 6- A, Ground Floor India, Habitat Centre, Lodi Road, New Delhi - 110 003.	epta.dg@gmail.com, dg.epta@epta.in,
89.	CMD,	isrmivaskumar@meilgroup.in

	M/s Megha Engineering & Infrastructures Ltd., S-2, Technocrat Industrial Estate, Balanagar, Hyderabad - 500 037	
90.	Chairman & Managing Director Reliance Power, Reliance Centre, Ground Floor, 19, Walchand Hirachand Marg, Ballard Estate, Mumbai 400001	reliancepower.ipo@relianceada.com
91.	Kalpataru Power Transmission Ltd., 101, Kalpataru Synergy, Opp. Grand Hyatt, Vakola , Santacruz (E), Mumbai 400055. India.	milind.nene@kalptarupower.com kaushal.thakkar@kalpatarupower.com thakkarkaushal86@yahoo.com ajay.tripathi@kalpatarupower.com
92.	Director, Torrent Power Ltd., Electricity House, Lal Darwaja, Ahmedabad - 380 001.	NAMANSHAH@torrentpower.com kaushal.thakkar@kalpatarupower.com kashyapdesai@torrentpower.com MAYANKGUPTA@torrentpower.com VATSALPATEL@torrentpower.com BIPINBSEIAH@torrentpower.com
93.	Chairman & Managing Director, KEC International Limited,. RPG House, 463, Dr. Annie Besant Road,Worli, Mumbai - 400030	kecindia@kecrpg.com

Annexure-V

94.	Chairman and Managing Director, M/s Juniper Green Transmission Private Limited F-9 First Floor, Manish Plaza-1, Plot No. 7, MLU, Sector 10, Dwarka, New Delhi South West Delhi DL 110075	rohit.gera@junipergreenenergy.com rohit.gera91@gmail.com
95.	Chairman & Managing Director, M/s ReNew Transmission Ventures Private Limited ReNew , Commercial Block-1, Zone 6, Golf Course Road DLF City Phase-V, Gurugram-122009, Haryana	mohit.jain@renewpower.in, anuj.iain@renewpower.in amit.kumar1@renewpower.in
96.	Chairman & Managing Director, M/s Apraava Energy Private Limited 7th Floor, FULCRUM, Sahar Road, Andheri (East), Mumbai - 400 099. India.	sumit.sinha@apraava.com naveen.munjal@apraava.com roshni.shah@apraava.com
97.	L&T Infrastructure Development Projects Limited (L&T ID PL), L&T campus TCTC building , First Floor, Mount Poonamalle Road, Manapakkam, Chennai-600089, Tamil Nadu, India.	contactus@lntidpl.com csr@lntecc.com
98.	Chairman & Managing Director, Tata Power, NDPL House, Hudson Lines, Kingswa	vrshrikhande@tatapower.com BD@tatapower.com nitin.kumar@tatapower.com neeraj.srivastava@tatapower.com

Annexure-V

Annexure-V

		piyushkumar@tatapower.com
99.	Director, M/sGR Infraproject Limited G R INFRAPROJECTS LIMITED2nd Floor, Novus Tower, Plot No. 18, Sector 18,Gurugram, Haiyana - 122015, India	modassar.a@grinfra.com ashwin@grinfra.com akul.s@grinfra.com
100.	MD & CEO Adani Transmission Ltd 3rd Floor, South Wing, Adani Corporate House,ADANI Shantigram, S. G. Highway, Ahmedabad - 382 421.	MolavKumar.Maitra@adani.com sameer.ganiu@adani.com, Narendran.Qiha@adani.com sunnykumar.singh@adani.com
101.	Head & VP - Regulatory & Contracts) Regulatory & Contracts) IndiGrid Unit No. 101, First Floor, Windsor, Village KoleKalyan, off CST Road, Vidyanagari Marg, Kalina, Santacruz (East), Mumbai - 400 098	venkatraman.inumula@indigrid.com vivek.karthikeyanl@indigrid.com

Checklist for Survey for Installation of ERS (Emergency Restoration System)

1. Pre-Survey Preparation

- Collect route profile and tower schedule of existing line (damaged line)
- Identify the damaged tower location and nearest approach roads
- Obtain necessary permits and RoW clearance before entering any area (Field / Forest etc.)
- Identify voltage level, conductor configuration (type and nos.) and average of power flow in last 3 months
- Arrange survey team locally / company, survey equipment (DGPS / Total station), and safety PPE

2. Survey of Installation Area

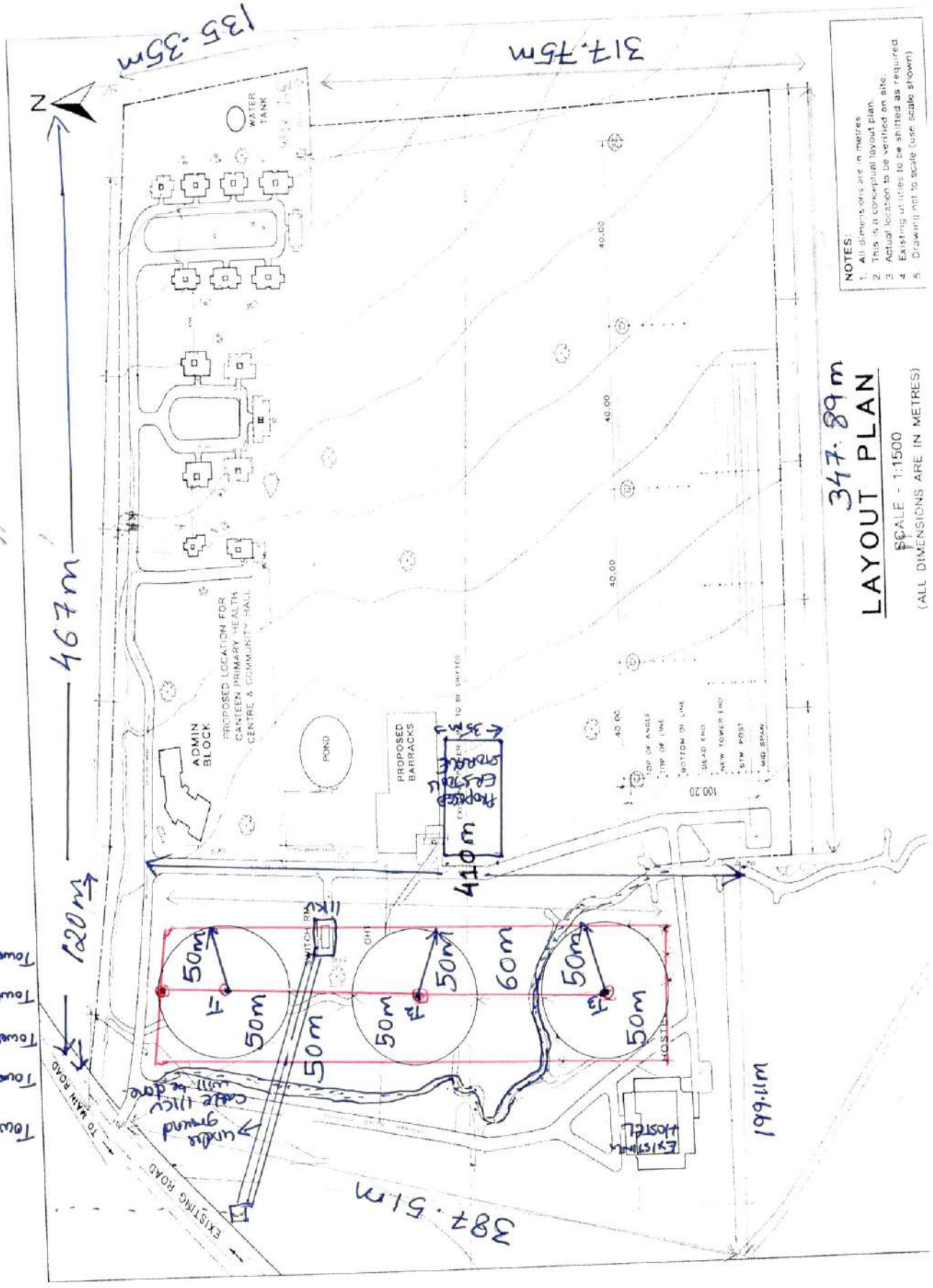
- Confirm exact location of damaged tower(s), nos. of towers and its type. And assess extent of damaged section
- Determine span length to be restored
- Check terrain condition (plain, hilly, marshy, rocky)
- Check for underground utilities or pipelines
- Assess soil condition at tower
- Check for forest area, any structure (house/factory), village, roads, any religious place and waterbody near to damaged tower area and marked it all on google earth along with existing line route
- Verify safe working clearance from existing line / structures and roads
- Assess accessibility for transportation of ERS materials and storage area in working site
- Check availability of crane/equipment in working area and identify any environmental or safety constraints

3. Finalization of Number of ERS Towers

- Considering all above (2.), final plotting of ERS route will be done primary on google earth afterwards filed survey will be done with help of DGPS/total station.
- Finalization of conductor configuration (Single/Twin/Quad etc.) based on power flow online and phase arrangement for shifting of required conductor
- Calculate the required number of ERS towers (Tension, Delta / running angel) based on span and loading
- Proper plotting ERS section should be done in PLS-CADD Software.
- Verify tower height requirements for statutory clearances. (tower height should be mentioned for each ERS tower)

4. Spotting of ERS Towers

- Mark proposed ERS tower locations using GPS coordinates
- Verify span lengths between ERS towers and ensure adequate ground clearance at all spans
- Spotting of ERS tower & its anchoring direction/position should be done with help of PLS-Pole software. And anchor spotting shall be done in such way that it will not overlap with restoration area of conventional line.



Tower(T1) - (T2) = 150mts

Tower(T2) - (T3) = 160 mts

Tower(T1) radius = 50mts

Tower(T2) radius = 50 mts

Tower(T3) radius = 50 mts

Hill ERS PROPOSAL

Revised Standard Operating Procedure for Islanding Schemes

1. Design Protocol:

i. As per Clause 10 of the Central Electricity Authority (Grid Standards), Regulations, 2010:

"Islanding Schemes: (1) The Regional Power Committees shall prepare Islanding schemes for separation of systems with a view to save healthy system from total collapse in case of grid disturbance. (2) The Entities shall ensure proper implementation of the Schemes referred to in sub regulation *(1).*"

ii. As per Indian Electricity Grid code (IEGC), 2023 Sub-Clause 10 of Clause 29:

"RPCs shall prepare the islanding schemes in accordance with the CEA Grid Standards for identified generating stations, cities and locations and ensure their implementation. The islanding schemes shall be reviewed and augmented depending on the assessment of critical loads at least once a year or earlier, if required."

iii. As per Indian Electricity Grid code amended from time to time, all regional constituents shall ensure that the islanding schemes are always functional.

iv. Islanding Schemes may be designed:

a. For survival of some predefined generations and loads at the time of grid disturbance to avoid total blackout and quicker restoration of failed grid.
b. for major cities having Essential Loads such as Super Critical and Critical Loads.

v. **Predefined Generation of Islanding Schemes:** Islanding schemes shall be designed to ensure survival and stable operation of predefined generation resources, including renewable energy sources (solar and wind) with adequate storage systems, in order to:

a. Maintain grid stability.
b. Ensure supply to Super Critical and Critical Loads.
c. Enable black-start capability and faster grid restoration.

vi. **Consideration of Essential Loads in Design of Islanding Schemes:** The Essential loads falling under an Islanding schemes may be taken under consideration while designing Islanding schemes. Generally, the essential loads are classified into two categories (i) Super Critical Loads and (ii) Critical Loads. The detailed categorisation of Super Critical Loads and Critical Loads are tabulated below:

(i) Super Critical Loads			
Sl. No.	**Priority Level**	**Category Description**	**Illustrative Loads**
1.	Priority–1	National Security	Loads of Defence area
		Constitutional & Strategic Governance Infrastructure	Rashtrapati Bhawan, Parliament House/State Legislative Assemblies, Raj Bhawan, High-Level Constitutional Offices (such as Supreme Court, High Court).

		Grid Control Functions	NLDC, RLDCs, SLDCs
2.	Priority–2	Life-Saving & Emergency Services	Hospitals (Government & Private)
		Strategic Urban Lifeline Infrastructure	Metro Rails, Water Supply Pumping Stations, Water Treatment Plants, Major Oil & Gas Pipeline Control Systems, Disaster Management Control Centre, etc.
(ii) Critical Loads			
Sl. No.	**Priority Level**	**Category Description**	**Illustrative Loads**
1.		Strategic Public Infrastructure	Airport, Railways, Ports
		Designated High-Priority VIP Residences	VIP Residences
2.	Priority-2	Economic Continuity Infrastructure	Important Industries
		Governance & Digital Infrastructure	Critical Data Centres of Central and State Government Bodies.

<u>Note:</u> The Super Critical and Critical Load of the major city may be considered in consultation with the DISCOMs/SLDC, Concerned Authorities and Ministry of Defence (MoD).

vii. Ministry of Defence (MoD) may be consulted to include their defense loads in such Islanding schemes. In case MoD requests any of their locations for which Islanding schemes is to be designed, the same would be considered. Only those defence establishments may be included in the Islanding Schemes for which MoD is agreed. The Ministry of Defence/Dept. of Military Affairs shall furnish information regarding their requirements as per format given at **<u>Annexure-I.</u>** All the existing islanding scheme may be reviewed to include the Defence load in the scheme. Defence load of small capacity (upto 2 MW) not falling under any major cities may be continued with their arrangement of backup supply.

viii. If there is need to establish a power plant in/around such a city for the purpose, the proposal may be submitted for consideration of the concerned State /Utility under intimation to MoP. Possibility of installation of storage system at such location may also be explored. This provision may be suitably qualified for Essential Loads only.

ix. Islanding Schemes are to be formed with anticipated load-generation balance and with tripping of predetermined feeders/ ICTs/ generators. In every islanding scheme, adequate

automated mechanism should be implemented for achieving load generation balance in the islanded sub-system.

x. Islanding schemes shall be treated only as schemes to enable survival of pre-identified portion(s) of the grid and shall not replace separate emergency supply arrangements for Super Critical and Critical loads.

xi. Studies are to be carried out for verifying the operation of the Islanded system by the respective control area LDC (SLDC in case of state).

xii. The cyber security in the power system for Islanding schemes must be in accordance with the Regulations/Guidelines issued by Government of India.

2. <u>Monitoring of Vital Parameters :</u>

i. Since formation of Island can take place at any time, monitoring of the following vital parameters, which have a significant role in on successful Island formation, is of paramount interest:

   a. Anticipated/ Actual Generation within the electrical boundary of the Island. RE generation within the Island to be monitored separately
   b. Anticipated/ Actual Load within the electrical boundary of the Island
   c. Voltage, Frequency & Power Flows along the peripheral lines which are required to be tripped to form the Island

ii. Above parameters are to be monitored in real-time basis in the Control Room/ Despatch Centre (i.e. Sub SLDCs/SLDC/RLDC/NLDC) of the area by creating a dedicated page specific to the Islanding Scheme in the SCADA display. For this purpose, suitable provisions may be made, wherever required, for the installation of adequate measuring instruments (such PMUs/RTUs) at appropriate locations within the islanded subsystem, and the application for islanding detection may be based on measured (such as PMU/RTUs) data. The monitoring framework may be supported by redundant telemetry systems, time-stamped data acquisition, defined alarm thresholds, and backup communication channels to ensure reliability and continuity of monitoring at all critical islanding points.

3. <u>Certification of Healthiness of Islanding Scheme:</u>

i. Since healthiness of an integrated system depends on the healthiness of its constituting components, healthiness of Islanding Scheme has to be ascertained/ ensured by seeking monthly certificate for healthiness of batteries, installed at all Substations located within the electrical boundary of the Islanding Scheme. The idea is since these battery banks provide power supply to Relays, RTUs and PLCC equipment, healthiness of the former is critical to operation of the latter when called for.

ii. It is to confirm the healthiness of islanding schemes by participating Generators as well as concerned transmission utilities/DISCOMs for their respective portion in the monthly OCC / Protection Committee meeting/Communication Committee meeting.

iii. The data in the formats at **<u>Annexures-II</u> (Format I to IV)** may be submitted by RLDCs/SLDCs/Generators/Transmission utilities/DISCOMs etc to RPCs on monthly basis to certify the healthiness of Islanding Schemes.

4. Role and Responsibility and Coordination Activities:

i. The Role and Responsibility of the Organizations / Officers/Officials in designing and operating the Islanding Schemes is defined at **Annexure-III.**

ii. This is proposed to be achieved by having a Nodal Officer for each participating Utility in the Island [i.e., those who own assets (Generating stations, substations, transmission lines, distribution lines, etc.) within the Island], and a Chief Nodal Officer from the concerned Despatch/ Control Centre. The Chief Nodal Officer from LDC and Utility- specific Nodal Officers ensure free flow of information among them w.r.t. Islanding Scheme Operational status, and ensure correct & prompt communication between the SCADA Control Centre and various stations (Generating Stations/ Substations). There will be a coordination officer in each region from each RLDCs.

iii. An updated list of contact details of all Nodal Officers as mentioned above shall be maintained with LDC & all Utilities involved. The Details of officials as mentioned above may be obtained in the in the **Format V** of **Annexures-II.**

5. Sensitization and Training of Officers involved:

i. Even though chances of Island formation in a strongly integrated grid are remote, since the Islanding schemes are designed to protect major essential loads/ sensitive generation in the unfortunate event of failing of all other defence mechanisms. The Nodal Officers & concerned field staff associated with O& M of various stations (generating stations as well as substations) within the electrical boundary of the Island should be sufficiently sensitized about the colossal loss of those critical assets on account of Island failure, and consequent disruption to various sectors & businesses

ii. To ensure this, apart from conducting periodic orientation training programmes, the concerned Officers/ Staff should also be involved in the activities concerning management of grid under stressed conditions, SCADA, communication upkeep, and in the activities relating to audit/ inspection of critical loads & sensitive stations within the Island.

iii. The Officials and Officers in the Generating Station/Substation/Utilities / LDC/ RLDC / RPCs would be sensitized about the (concerned) Islanding Scheme. They also to be trained to handle the Critical and Emergency Load Management in the system.

iv. Training shall be focused on individual Islanding Schemes and integration of Islanding schemes with rest of the grid until restoration of normalcy to the national and regional grid.

v. All the concerned utilities shall organise periodic training program for the nodal officers and concerned field officers. The training programs shall be in consultation and coordination with the RPCs. The training and sensitization program may be conducted once in six months and additionally, as and when required in emergency.

6. Periodic Inspection/ Audit of Essential Components:

i. Periodic Inspection/ Audit includes Internal audit as well as Third-party audit of all essential components as given below and shall be carried out regularly as per the periodicity mentioned below and Inspection/ audit report may be submitted to respective RPCs:

a. Under Frequency Relays (UFR) on Island forming elements (Lines & ICTs).
b. Associated communication equipment at all stations within Island.
c. Associated DC supply for Control panel & communication system.
d. Verification of relay settings, trip logic, communication paths, SCADA visibility.

ii. **Periodicity of Internal Audit and Third-Party Audit:** Internal audit by concerned utilities shall be carried out annually and Third-party audit shall be carried out once in five (5) years, aligned with the periodic third-party protection audits for 220 kV and above voltage levels, and separately for 132/110 kV systems.

iii. Apart from the internal audit and third-party audit, the data in the formats at **Annexures-II (Format I to IV)** may be submitted by RLDCs/SLDCs/Generators/Transmission utilities/DISCOMs etc to RPCs on monthly basis to certify the healthiness of Islanding Schemes.

7. Mock drill: As per IEGC 2023, Sub-Clause 11 of Clause 29:

"Mock drill of the islanding schemes shall be carried out annually by the respective RLDCs in coordination with the concerned SLDCs and other users involved in the islanding scheme. In case mock drill with field testing is not possible to be carried out for a particular scheme, simulation testing shall be carried out by the respective RLDC."

8. Review Plan of Islanding Schemes:

i. Considering the fact that Network Changes (additions/ deletions/ reconfigurations of transmission elements & generators) in an evolving grid such as Indian electrical grid are unavoidable/ inevitable, it is but necessary to review the Islanding scheme operation w.r.t. prevailing grid conditions at regular intervals, and incorporate requisite changes so as to make them reliable & dependable.

ii. RLDC /SLDC to periodically update and inform RPC regarding any changes or additions of elements in the Islanding scheme. RLDC to submit monthly report of element additions in all Islanding schemes in respective region to RPC.

iii. In such review, all details as used in the existing scheme have to be re-collected including the new changes for studying the modifications to be carried out in the In- service Island. These details, among others, include participating generators, anticipated generation, participating loads, anticipated load, elements (lines and/ or ICT's) to be tripped to form the modified Island, geographical map & SLD of the modified Island, AUF load relief, df/dt load relief, pumped loads details, etc. Using these details, system studies may also be carried out to verify stability (including voltage profile & line loadings profile) of the modified Island.

iv. It is recommended to carry out above review of the In-Service Islanding scheme at least once a year, or earlier upon any material network change, by all concerned utilities. However, the review may also be carried out as soon as any network change, which may affect the operation of the Islanding Scheme, comes to notice.

9. Identification of Short-comings & Remedial action:

i Based on the shortcomings identified by the RLDC/SLDC during monitoring of vital islanding parameters, assessment of island healthiness, periodic inspection/audit of essential islanding

components, and other related activities, the observed deficiencies/shortcomings shall be taken up with the respective entities for timely corrective action on a monthly basis.

ii The period of redressal from the instant of noticing shortcomings shall be at most one week/ fortnight. The compliance report may be submitted to RPCs in this regard.

10. Post Islanding survival:

i. In every islanding scheme, adequate automated mechanism should be implemented for achieving load generation balance in the islanded sub-system. Also, for frequency control of islanded subsystem there should be generating units in the island on free governor mode of operation. Also, load connection/ disconnection should preferably be automatic based on the Load generation balance from the Control Centre/ the dispatch centre of the islanded sub-system. Health of all facilities in the islanding scheme should be closely monitored so as keep necessary electrical, mechanical, electronics and communication systems in good health all the time.

ii. For Islanding Systems involving more than one control area, the RLDC/SLDC may have the necessary provision for load connection and disconnection of the Islanding Scheme for the islanded subsystem. Further, periodic end-to-end testing of the same may be ensured, as applicable.

11. Pre Islanding Survival:

In addition to Post Island Survival, necessary Pre Islanding load Disconnection in Islanding schemes shall be ensured to avoid load generation mismatch.

12. Review Plan for SOP of Islanding Scheme:

i. Standard Operating Procedure (SOP) for the Islanding Scheme shall be subject to periodic review and revision to ensure its continued relevance, effectiveness, and compliance with prevailing regulatory and operational requirements. The review shall be undertaken at regular intervals, or as and when necessitated by changes in the guidelines, regulations, or directives issued by Ministry of Power (MoP), Central Electricity Authority (CEA), Central Electricity Regulatory Commission (CERC), or any other statutory authority.

ii. All revisions to the SOP may be approved by the competent authority, and communicated to all concerned stakeholders for implementation. The updated SOP may supersede the previous version from the date of approval.

13. SOP Template for designing of Islanding Schemes is at Annexure-IV.

*****

Annexure-I

MINISTRY OF POWER
CENTRAL ELECTRICITY AUTHORITY

Details of information to be furnished by Defence Establishments for the purpose of designing the Electrical Islanding schemes:

Item No.	Description	Details
1.	**Basic Details:**	
1.1	Service: Army/Navy/Airforce/MES etc.	
1.2	Name of the Establishment	
1.3	Location (State, District, Taluk & Village)	
1.4	Name of the nearest City & Distance from it	
2.	**Power Supply Details:**	
2.1	Name of the DISCOM (Power Supply Distribution Company) from which supply is being availed:	
2.2	Name of the DISCOM Substation from which supply is being availed:	
2.3	Number of incoming lines/feeders of supply and Voltage level	
3.	**Load Details:**	
3.1	Contracted Capacity in kVA/MVA	
3.2	Maximum Demand in kVA/ MVA	
3.3	Connected Load in kW/MW	
3.4	Critical Load(kW/MW)/ Non-Critical Load(kw/MW)	
3.5	Any other information on Load details	
4.	**Backup Power Supply:**	
4.1	Details of DG sets: (Number of DG sets & their Rating in kVA/MVA & No. of hours they can run/sustain)	
4.2	Battery Banks/ UPS Rating (with/without BESS)	
4.3	In-house Renewable (Solar/Wind (with/without BESS)) Generation in kW/MW	

4.4	Captive Generation, if any, in kW/ MW	
5.	**Specific Requirement from Ministry of Power, CEA/RPCs, NLDC, RLDC, STU, SLDC and Discoms w.r.t uninterrupted power supply to Defence installation**	
6.	**Other Relevant Information, if any**	

****

Annexure-II

Formats for collection of information regarding Islanding Schemes:

a. **Format - I** for RLDC/SLDCs

S. No.	Name of Islanding Scheme	Healthiness of Communication Channel	End-to-End Trip Signal Testing Status	SCADA Visibility Status	Communication Latency (ms)	SCADA Discrepancy Observed*	Details of Discrepancy (if any)	Outage Details (if any)	Rectification Status	Date of Testing	Remarks

*Detailed Analysis of SCADA discrepancy to be furnished by RLDC to RPC.

b. **Format - II** for Generating Station

S.No	Name of Islanding Scheme	Healthiness of Islanding Relay	Healthiness of Communication channel

c. **Format - III** for Transmission Utility/ DISCOMs

S.No.	Name of Islanding Scheme	Elements considered for tripping to from Island	For communication based tripping logic of feeders	For UFR based tripping logic of feeders	
			Healthiness of Communication channel	Healthiness of PT Fuse and status of DC supply to UFR relay*	Healthiness of Relay#

* Where dedicated UFR relay have been installed for tripping of the feeders under islanding scheme

Where UFR function have been enabled within backup protection relay of the line.

d. **Format - IV** for collecting Relay details of the Islanding scheme.

The following format may be used to get Relay details of the Islanding scheme:

S.No.	Description	UFRs-for load relief (A)	df/dt -for load relief (B)	Relay for Island creation(C)
1.	Relay location (S/s name)			
2.	Relay make & model			
3.	Frequency setting of the relay (at which load shedding is envisaged)			
4.	Feeder name (voltage level and source-destination name) signalled by the Islanding Relay for separation /load shedding/separation from outside grid			
5.	Quantum of load relief due to tripping of feeder (as per state's peak of previous year)			
6.	Quantum of load (Min, Avg, Max in MW) on the feeder (as per state's peak of previous year)			

e. **Format - V** for Contact details of all Nodal Officers

Utility Name &Location	Name	Designation	Organization	Email ID	Mobile No.

****

Annexure –III

Roles and Responsibilities of Officers involved in Islanding Schemes:

S.No.	Entity	Roles and Responsibilities of Officers
1.	**RPCs**	i. In compliance with CEA (Grid Standards) 2010 and its amendments, MS, RPCs shall be responsible for preparation of Islanding Schemes. The designing/ implementation and Review of Islanding Scheme may be discussed in appropriate Committee/Sub-Committee of RPCs or a separate Sub-group may be formed. ii. MS, RPC may Nominate Officer at the level of Superintending Engineer for Coordinating the Islanding Schemes in the Region. iii. MS, RPC shall be responsible to review and augment Islanding Schemes depending on the assessment of critical loads at least once a year or earlier, if required.
2.	**RLDCs**	i. There shall be a Nodal Officer at the level of General Manager & above appointed by the appropriate Authority of the RLDC. Nodal officer of RLDCs may act as Coordinating Nodal officer. ii. The Nodal Officer of RLDCs shall coordinate the Chief Nodal officers of SLDCs, Gencos & STU's in their respective regions. iii. Coordinating Nodal Officer shall ensure real-time monitoring of vital parameters of all operational Islanding Schemes and shall immediately take up any SCADA discrepancies with SLDC/Utility concerned and ensure time-bound rectification. iv. To ensure proper monitoring, measuring instruments (like PMUs etc.) and communication systems may be recommended by Co coordinating nodal officer to the concerned utility. v. Coordinating Nodal Officer shall monitor and ensure the healthiness of the components involved in the Islanding Scheme like SCADA system, communication channel etc. at their end. vi. Coordinating Nodal Officer shall certify overall readiness of Islanding Schemes on monthly basis, covering communication system and SCADA visibility. vii. Coordinating Nodal Officer shall ensure follow-up of the recommendation of the Internal / third party Audit conducted by entity concerned in a time bound manner. viii. Coordinating Nodal Officer shall plan and coordinate periodic mock drills for islanding schemes in consultation with SLDCs and utilities concerned. ix. Coordinating Nodal Officer shall facilitate availability of redundant communication paths for all critical islanding signals and monitor their performance.

S.No.	Entity	Roles and Responsibilities of Officers
3.	**Nodal officer of LDCs**	i. There shall be a Nodal Officer at the level of Chief Engineer & above for all Islanding Schemes in the respective state appointed by the appropriate Authority of the LDCs. ii. Nodal Officer of LDCs shall act as Chief Nodal officers for nodal officers of DISCOMs, TRANSCOs & GENCOs of the state and shall ensure proper communication among all the nodal officers. iii. Chief Nodal Officer shall coordinate and responsible for implementation of newly designed Islanding Schemes in coordinated manner with all utilities involved. iv. Chief Nodal Officer is responsible for collection of data from the concerned utilities and submission the same to committee for study purpose in respect of existing/new IS for review/design purpose. v. Chief Nodal Officer shall ensure monitoring of the vital parameters of operational/implemented Islanding Schemes in the state, which have a significant role in successful Island formation. vi. To ensure proper monitoring, measuring instruments (like PMUs etc.) and communication system etc. may be recommended by nodal officer to the concerned utility. vii. Chief Nodal Officer shall ensure the healthiness of the components involved in the Islanding Scheme like SCADA system, communication channel etc. at their end. viii. Chief Nodal Officer shall conduct monthly self-certification of healthiness of the components at their end involved in the Islanding scheme and communicate it to the concerned RPC in the format prescribed in the SOP. ix. Chief Nodal Officer shall be responsible for Internal & third-party audit of the components of an Islanding Scheme. x. Chief Nodal Officer shall ensure follow-up of the recommendation of the internal & third-party Audit conducted by Entity in a time bound manner.

S.No.	Entity	Roles and Responsibilities of Officers
4.	**Nodal officer of Participating GENCOs**	i. There shall be a Nodal Officer at the level of General Manager / Chief Engineer & above for Islanding Schemes appointed by the appropriate Authority of the Generation Company. ii. Nodal Officer shall be responsible for the implementation of newly designed Islanding Schemes for GENCOs part. iii. Nodal Officer is responsible for submission of data for GENCOs part to committee for study in respect of existing/new IS for review/design purpose. iv. Nodal Officer shall ensure the healthiness of the components involved in the operational Islanding Scheme like Generating Units, Substations /Switch yards, Relays, communication channel etc. at their end. v. Nodal Officer shall conduct monthly self-certification of healthiness the components at their end involved in the Islanding scheme and communicate it to the concerned RPCs in the format prescribed in the SOP. vi. Nodal Officer shall be responsible for Internal & third-party audit of the components of an Islanding Scheme. vii. Nodal Officer shall ensure follow-up of the recommendation of the Internal & third-party Audit conducted by Entity in a time bound manner.
5.	**Nodal officer of STUs/ ISTS Licensee.**	i. There shall be a Nodal Officer at the level of General Manager / Chief Engineer & above for all the Islanding Schemes appointed by the appropriate Authority of the Transmission Company. ii. Nodal Officer shall be responsible for the implementation of newly designed Islanding Schemes at transmission part. iii. Nodal Officer is responsible for submission of data to committee for study in respect of existing/new IS for review/design purpose for Transmission part. iv. Nodal Officer shall ensure the healthiness of their components involved in the operational Islanding Scheme like Substations, Transmission Lines, Relays, communication channel etc. at their end. v. Nodal Officer shall conduct monthly self-certification of healthiness of the components at their end involved in the Islanding scheme and communicate it to the concerned RPC in the format prescribed in the SOP. vi. Nodal Officer shall be responsible for Internal & third-party audit of the components of an Islanding Scheme. vii. Nodal Officer shall ensure follow-up of the recommendation of the Internal & third-party Audit conducted by Entity in a time bound manner.

S.No.	Entity	Roles and Responsibilities of Officers
6.	**Nodal officer of DISCOMs**	i. There shall be a Nodal Officer at the level of General Manager /Chief Engineer & above for each Islanding Schemes appointed by the appropriate Authority of the Distribution Company. ii. Nodal Officer shall be responsible for identification of essential loads and defence load for the Islanding Scheme. iii. Nodal Officer shall be responsible for the implementation of newly designed Islanding Schemes at their end. iv. Nodal Officer is responsible for submission of data for their part to committee for study in respect of existing/new IS for review/design purpose. v. Nodal Officer shall ensure the healthiness of the components involved in the Islanding Scheme like Feeders, Relays, communication channel etc. at their end. vi. Nodal Officer shall conduct monthly self-certification of healthiness of the components involved in the Islanding scheme at their end and communicate it to the concerned RPC in the format prescribed in the SOP. vii. Nodal Officer shall be responsible for Internal & third-party audit of the components of an Islanding Scheme. viii. Nodal Officer shall ensure follow-up of the recommendation of the Internal & third-party Audit conducted by Entity in a time bound manner.

****

Annexure-IV

SOP Template for Designing of Islanding Schemes:

1. **Purpose**
2. **Design**
   i. **Generation**
      a. Coal
      b. Gas
      c. Nuclear
      d. Hydro
      e. Solar
      f. Wind
      g. Total generation
      h. PLF or availability /scheduling
      i. Generation considered
      j. Generators on prolonged outage
      k. Probability of the anticipated generation
      l. Pumped storage
      m. ISGS
      n. SGS
      o. IPP/MPP
   ii. **Load**

      a. Loads of Defence area
      b. Rashtrapati Bhawan/ Raj Bhawan
      c. Parliament House/ State Legislative Assemblies
      d. High-Level Constitutional Offices (such as Supreme Court, High Court).
      e. NLDC, RLDCs, SLDCs
      f. Metro Rails
      g. Water Supply Pumping Stations
      h. Water Treatment Plants
      i. Major Oil & Gas Pipeline Control Systems
      j. Disaster Management Control Centre.
      k. Hospitals (Government & Private)
      l. Airport, Railways, Ports
      m. VIP Residences
      n. Important Industries
      o. Critical Data Centres of Central and State Government Bodies.
      p. Drinking water
      q. Irrigation
      r. Agriculture
      s. Commercial

t. Domestic
u. Lift Irrigation System/Scheme

iii. **Load relief**
a. df/dt-I
b. df/dt-II
c. AUFR-I
d. AUFR-II
e. AUFR-III
f. AUFR-IV

iv. **Transmission lines in the islanded area**
a. 765 kV
b. 400 kV
c. 220/230 kV
d. 132/110 kV
e. 66 kV
f. 33/22/11 kV
g. Inter-regional lines
h. Inter-state lines
i. Intra-state lines/Substations in the area
j. CTU
k. STU
l. ISTS

v. **Transmission lines that get disconnected on operation of df/dt and AUF relays**
a. 220/230 kV
b. 132/110 kV
c. 66 kV
d. 33/22/11 kV

vi. **Transmission lines to be tripped for forming Island**
a. 765 kV
b. 400 kV
c. 220/230 kV
d. 132/110 kV
e. 66 kV
f. 33/22/11 kV

vii. **Name of the cities covered having population >=**
a. 10 million
b. 1 million
c. Defence locations

viii. **Diagrams**
a. SLD map of the island
b. Geographical map of the island with boundary
c. Major cities/Super Critical Loads & Critical Loads /defence loads marked

d. Substations marked

3. SCADA mapping

Island generation and island loads on the SCADA display

4. Constraints

i. Generation limits
ii. Line loading limits
iii. ICT loading limits o Frequency set points
iv. df/dt-I
v. df/dt-II
vi. AUFR-I
vii. AUFR-II
viii. AUFR-III
ix. AUFR-IV
x. Load Islanding Scheme (LIS) relief frequency
xi. RE generation disconnection frequency
xii. Islanding frequency

5. Controlling generation in islanded area

i. AGC
ii. RGMO/FGMO

6. Controlling load in islanded area

i. Automatic
ii. Flow based
iii. Voltage based
iv. Frequency based
v. Manual

7. Validation check list

i. Generation > Load?
ii. Non-Hydro only islanding?
iii. Less number of disconnecting lines? All disconnecting lines with AUFR?
iv. RE-solar/wind included?
v. LIS loads excluded?
vi. LF studies for islanded area, converging?
vii. In the converged LF studies, line loadings profile & voltage profile are within permissible limits?
viii. All critical load/defence loads included?
ix. Critical/defence loads are not part of SPS, df/dt or AUFR schemes?
x. Islanding frequency - (47.9 Hz)?
xi. Adequate margin between lower frequency of IEGC band and first stage AUFR?
xii. Adequate margin between islanding frequency and AUFR last stage?
xiii. Scheme was discussed & approved in OCC/ PCC?
xiv. Scheme approved in RPC?

50.20		
50.10		
50.05		**IEGC band**
50.00		
49.90		
49.80		**Urgent load Mgt.**
49.70		
49.60		**Emergency Load Mgt.**
49.50		
49.40		**UFR load shedding**
49.30		
49.20		
49.10		
49.00		
48.90		
48.80		
48.70		
48.60		
48.50		
48.40		

48.30		
48.20		
48.10		
48.00		
47.90		**Islanding Frequency**
47.80		

Note:

i. Above values are subject to change as per newly adopted frequency settings in NPC.

ii. The pre-Islanding load shedding through UFR or df/dt shall start at 48.4Hz so that the desired load generation balance is achieved before Island formation at 47.9Hz.

8. Operation

i. **Successful**

a. Generation in the island area
b. Load in the islanded area
c. Date & time island formation
d. Date & time of island closed/shutdown
e. Frequency of the islanded area
f. Voltage profile of the buses
g. Flows/ Loadings on critical lines
h. Duration of island survival
i. Whether anticipated generation was there?
j. Whether anticipated load was there?
k. All the lines were disconnected as per the plan?
l. Reason for islanding success
m. Any measures to further improve

ii. **Failure**

a. Generation in the islanded area
b. Load in the islanded area
c. Date & time island formation
d. Date & time of island closed/shutdown
e. Duration of island survival
f. Whether anticipated generation was there?
g. Whether anticipated load was there?
h. All the lines were disconnected as per the plan?
i. Reason for islanding failure

j. Remedial measures

9.Review plan

i. Island formed and approved date

ii. Change in generation

a. Addition

b. Deletion

c. Alteration

iii. Change in load

a. Addition

b. Deletion

c. Alteration

iv.Change of the lines to be disconnected

v. Any new lines to be included for disconnecting

vi.Requirement of additional df/dt & AUFR relays

10. Nodal officers of Islanding Scheme

i. RLDC

ii. SLDC

iii. STU

iv. SGS

v. ISGS

vi. ISTS

11. Sensitization Training of nodal officers

i.Training by RLDC

ii. Training by NPTI/PSTI

iii. Training by SLDC

iv. RPCs special meetings

12. Periodic Inspection of Essential components of Islanding Scheme

i. Inspection of UF relays of disconnecting lines

ii. Ensuring adequate relief under df/dt and AUFR stages

iii. Ensuring relays for disconnecting RE sources

iv. Ensuring relays for disconnecting LIS

v. Ensuring critical/defence loads are not under df/dt & AUFR stages

vi. Monitoring the anticipated generation and load in the islanded area

13. Mock drill (Earlier, there was no provision in the IEGC; however, as per the IEGC 2023, the provision has now been incorporated in the SOP as mentioned above.**)**

14. Certifications of healthiness of IS

i. Batteries

ii. Relays

iii. Lines within the islanded area

15. Identifications of short comings

16. Further updations.

****