Workshop Proceedings
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Disclaimer:

This outcome document serves as a comprehensive knowledge resource dedicated to strengthening the power sector resilience. It synthesizes the technical expertise and operational insights shared by participating organizations, subject matter experts, and energy authorities. The strategies and perspectives documented herein are attributed to the respective contributing entities and do not necessarily reflect the official policy, position, or endorsement of the Coalition for Disaster Resilient Infrastructure (CDRI).

Executive Summary:

The national workshop was -jointly organized by the Coalition for Disaster Resilient Infrastructure (CDRI), National Institute of Disaster Management (NIDM). Central Electricity Authority (CEA) and Ministry of Power to strengthen disaster resilience in India's power sector. With climate and weather extremes intensifying such as cyclones, floods, and heat stress the workshop brought together policymakers, utilities, regulators, disaster management authorities, financial institutions and technical experts to deliberate on strengthening the resilience of India's power infrastructure in the context of increasing climate and disaster risks. The workshop deliberations were informed by the findings from the Disaster Resilient Power Systems for Odisha study, a comprehensive multi-year engagement that developed a replicable methodology for assessing vulnerability in transmission and distribution infrastructure using multi-hazard zonation and asset-level risk indicators. The study demonstrated that coastal power infrastructure is increasingly vulnerable to cyclones, flooding, storm surges, and emerging climate stressors such as extreme heat. These hazards have significant cascading impacts on essential services, economic activity, and public safety, highlighting the urgent need to embed disaster risk considerations into infrastructure planning, design, and operational decision-making.

The workshop discussions emphasized that power infrastructure remains highly exposed to multi-hazard risks, with disruptions creating cascading impacts on essential services and economic stability. Participants highlighted the urgent need to shift from reactive recovery to proactive, risk-informed planning embedded within infrastructure design and operational decision-making. The sessions emphasized transitioning from reactive post-disaster recovery approaches to proactive and risk-informed resilience planning. Stakeholders underscored the need to revise engineering standards and wind zonation maps to reflect evolving climate patterns and hazard intensities. The discussions highlighted the vulnerability of aging distribution infrastructure, particularly in coastal regions, and stressed the importance of strengthening structural design standards, promoting underground cabling in high-risk zones, and adopting advanced monitoring and forecasting technologies to improve system reliability and recovery capacity. The workshop also highlighted operational preparedness measures, including strengthening disaster management protocols, improving resource inventory systems, enhancing workforce safety mechanisms, and integrating early warning information into grid operations. Case studies from utilities demonstrated that pre-positioning resources, decentralised response planning, standardized equipment specifications, and technology-enabled coordination significantly reduce restoration time and improve service continuity during disasters.

Institutional and governance reforms emerged as key priorities. Participants emphasized the importance of cross-sectoral coordination among power sector agencies, disaster management authorities, regulatory bodies, and technical institutions to bridge science–policy–implementation gaps. There was broad consensus on the need to institutionalize resilience considerations across national and state-level planning frameworks, strengthen regulatory mechanisms, and enhance technical capacity through targeted training programmes.

Financial sustainability was identified as a critical enabler for resilience implementation. The workshop highlighted the necessity of adopting blended financing mechanisms, including government capital support, concessional financing, and innovative risk transfer instruments, to address the incremental costs associated with resilient infrastructure while maintaining tariff stability. Participants also recommended expanding the scope of disaster response funding frameworks to support higher-voltage infrastructure restoration and incorporating "Build Back Better" principles within post-disaster reconstruction policies.

The workshop underscored that sustained collaboration and knowledge sharing between central and state agencies, utilities, technical institutions, and disaster management authorities is critical to bridging science–policy–implementation gaps. Moving forward, institutionalizing resilience within sector planning, scaling lessons beyond Odisha, strengthening capacities and prioritizing investments in resilient infrastructure were identified as essential steps ensuring reliable, climate and disaster resilient power systems.

1. Introduction

1.1 Context:

Climate change has significantly intensified the frequency and severity of catastrophic events such as cyclones, storm surges, extreme heat, and flooding. These events pose a significant threat to the socio-economic stability of coastal regions, disrupting critical infrastructure ranging from transportation and healthcare to water supply systems. The power sector is particularly vulnerable. Extreme weather causes extensive damage to power plants, substations, and transmission and distribution (T&D) lines. The resulting prolonged power outages cripple the delivery of electricity to homes and businesses and severe lifelines to essential emergency services and hospitals during crises.

Over a three-year engagement, CDRI and the Government of Odisha conducted a comprehensive study titled "Disaster Resilient Power Systems for Odisha." The study explored replicable resilience strategies for Transmission and Distribution (T&D) infrastructure against cyclones and floods. The study examined the state's T&D infrastructure based on 16 asset-level indicators (Please see the link- Policy Brief – Lessons from Odisha) and an easy-to-adopt methodology comprising cyclone zonation, flood zonation, exposure analysis and vulnerability analysis. The study was carried out in two phases, the study addressed preparedness, grid stability, risk-based governance, and financial adaptation. Using 16 asset-level indicators and multi-hazard zonation, it mapped vulnerability for T&D assets within 60 km of the coast. This collaborative effort resulted in a prioritization matrix to guide future resilience investments and policy reforms for coastal regions.

CDRI organized a two-day, in-person national workshop in New Delhi in association with National Institute of Disaster Management (NIDM), and the Central Electricity Authority, Ministry of Power (MoP) to bring together the power sector professionals, representatives from SDMAs and other relevant stakeholders from coastal states and union territories of India (Please see Annex 2 for list of Participants). The participants deliberated on how to implement the methodology and the key policy recommendations that emerged from a two-phase approach focusing on preparedness mechanisms, risk-based governance, financial adaptation, and the implementation of updated codes and standards to facilitate resilient recovery in coastal regions.

1.2 Workshop Objectives:

The objective of the workshop was to deliberate on building resilient power infrastructure in the face of multi-hazard risks, and to explore strategies, share good practices, and foster collaboration.

2. Workshop Participants and Methods

2.1 Agenda

The two-day workshop was divided into multiple sessions. Day 01 included presentation on the recommendations of the Disaster Resilient Power System study and insights from coastal states including Odisha, context setting presentation on 'Wind Zonation' and 'Codes & Standards' and a group exercise and presentations on Disaster preparedness by CEA and a Fireside chat in between Chairman, Odisha Electricity Regulatory Commission (OERC) and DG, All India Discom Association (Former Secretary, Ministry of Power). Day 02 included a presentation on Extreme Heat Impacts on Power System by Prayas Energy Group, Regulation and Financing followed by a group exercise.

2.2 Participants

The workshop brought together a high-level and diverse stakeholders representing the full spectrum of India's power and disaster management sectors. Strategic leadership is provided by key central agencies, including the Ministry of Power (MoP), the Central Electricity Authority (CEA), and the National Disaster Management

Authority (NDMA), alongside the National Institute of Disaster Management (NIDM). This policy-level group is supported by critical regulatory and standard-setting bodies such as the Odisha Electricity Regulatory Commission (OERC), the Bureau of Indian Standards (BIS), and the India Meteorological Department (IMD), ensuring that discussions bridge the gap between scientific data, policy, and regulation.

On the operational and implementation front, the participants representation was ensured from major central utilities like NTPC, POWERGRID, and DVC, as well as various state-level power utilities and State Disaster Management Authorities (SDMAs) including private sectors. The ecosystem is further reinforced with the presence of financial and development institutions, including the Asian Development Bank (ADB), Power Finance Corporation (PFC), who emphasized on the funding mechanisms. Technical expertise is provided by research and training institutes like the Central Power Research Institute (CPRI) and the National Power Training Institute (NPTI), alongside think tanks and industry forums such as the India Smart Grid Forum (ISGF), Council of Energy, Environment and Water (CEEW), and the Shakti Foundation.

2.3 Facilitation Team

a) Ranjini Mukherjee, Amit Tripathi, Nony Gupta and Wasi Alam from CDRI
b) Dr Amir Ali Khan, Shreyash Dwivedi and Avipsha Mohanty from NIDM

2.4 Methods

The two-day workshop included interactive and participatory methods such as overarching presentations for technical sessions followed by groups exercises and fire-side chat between ex-senior government officials from Power and Disaster Management. CDRI also presented its technical study and its overall programme and initiatives within India and other countries across the world.

3. Summary of Workshop Sessions

The National Workshop on Building Resilience of the Power Sector in Coastal Regions convened policymakers, technical experts, utilities, and development partners to deliberate on strengthening disaster and climate resilience of electricity systems. Organized over two days, the workshop opened with perspectives from CDRI, CEA, NDMA, and NIDM emphasizing the growing vulnerability of coastal power infrastructure to cyclones, floods, and emerging climate stressors, and the need for coordinated, multi-stakeholder approaches. Technical discussions highlighted the findings of the Disaster Resilient Power Systems study, with states and utilities reflecting on localized impacts, preparedness practices, and adaptation of methodologies across diverse coastal contexts. Participants through group exercise examined the relevance of India's wind zonation maps, the relevance of existing codes and standards, and the need for revisions that better account for evolving hazard profiles and climate variability. Later sessions focused on strengthening preparedness and operational resilience. Experts discussed approaches to enhancing transmission and distribution robustness, disaster resource inventory frameworks, and institutional preparedness mechanisms such as task forces and planning protocols. Discussions also addressed the impacts of extreme heat on power infrastructure, expanding the resilience discourse beyond cyclonic hazards to include long-term climate stresses. Technology-driven solutions from grid modernization and forecasting tools to smart systems and innovative operational practices were presented as enablers for adaptive and reliable power delivery.

Reflections from utilities and state representatives underscored the value of integrating early warning information, adopting good practices, and contextualizing technical recommendations to regional conditions. The workshop concluded with forward-looking dialogue on regulatory and financing dimensions necessary to mainstream resilience across the power sector. Participants discussed embedding resilience criteria into policy frameworks, improving cross-sector coordination, expanding training and capacity-building initiatives,

and exploring financial instruments such as dedicated preparedness funds, insurance mechanisms, and grants to support technological advancement. These discussions generated draft recommendations intended (presented in subsequent section below) for submission to relevant ministries, reinforcing the importance of aligning technical, regulatory, and financial pathways to strengthen power system resilience in coastal regions.

Overall, the workshop provided a collaborative platform for consolidating knowledge, identifying policy priorities, and mapping actionable pathways to safeguard critical power infrastructure against current and future climate risks.

4. Key takeaways and way forward:

a. Set up a cross sectoral coordination committee- together with Ministry of Power, CDRI should lead formation of an expert panel (Industry, Academia, BIS, CEA) to transition from static maps to dynamic, granular zonation maps. CDRI, to facilitate the first meeting on revising Wind Zone maps.

b. Advocate for co-blended financing mechanism to finance the infrastructure resilience measures including Ministry of Power, Ministry of Home Affairs (NDMA) and Multilateral Development Banks. This framework should be like earlier concessional line of credit for Renewable Energy Projects (Green Energy Finances). Learning from the successful model of green energy financing can be adopted to create similar financings mechanism which incentivises concessional lending/viability gap funding for building disaster resilient infrastructure in the priority geographies i., e. coastal and mountain regions.

c. Creation of dedicated window of grant-based financing mechanism under the Central Government scheme for power sector including for the privatised discoms in India. This “Resilience Window" will utilizes Blended Finance. This would combine government capital grants (to cover the incremental cost of resilience) with soft loans, preventing tariff shock for consumers.

d. Advocate for policy shifts with the Ministry of Power and MHA to expand SDRF/NDRF norms to cover 33kV infrastructure.

e. Develop model concessionaire agreements and standard bidding documents that explicitly defines resilience performance metrics for power sector projects.

f. Expand the scope of State and National Disaster Response Funds should be expanded to cover restoration of 33kV infrastructure and increase the per-kilometre funding limits to reflect current costs.

g. Standardize critical equipment specifications (e.g., Distribution Transformers, Poles) by coastal hazards. Initiate Community of Practice using DRI connect to advocate for Odisha Model to promote good practice for power sector across coastal states.

h. Accelerate the standardization of critical distribution equipment (like transformers) across all states to enable seamless mutual aid and cost-effective procurement. Further, initiate specific studies to revise standards for thermal loading on transformers and cables.

i. Launch a pilot study in one high-heat affected state to measure transformer failure rates against ambient temperature data.

5. Workshop Proceedings

5.1 Inaugural

a) Opening remarks: Mr. Ramraj Narasimhan, Deputy Director General, CDRI

Mr. Ramraj Narasimhan, on his opening remarks, shared that country is witnessing more severe disaster with greater frequency. He underscored the aim to reduce the impact of the disasters and to be able to provide the continuity of the services. He highlighted power sector/infrastructure as one of the critical services and damages around the power sector has huge cascading effects on the other critical infrastructure i.e. hospital, schools, telecom and water supply impacting the resilience of local people along with huge economic impact to the country. He also shared about the power sector study is a three-year joint effort with the Odisha state government which provides a roadmap and replicable methodology for other states in coastal regions. He further stressed that the workshop would provide huge opportunity to co-learn from study findings, knowledge exchange among state utilities regulators for delivering a robust, and adaptable methodology relevant in other coastal areas for fortifying power infrastructure in cyclone and flood prone areas through roadmap development. Lastly, the remarks concluded with a call for active participation to reach a consensus on priority actions, ensuring that India's power infrastructure is prepared for imminent threat of disaster and are resilient.

b) Shri Ghanshyam Prasad, Chairperson, Central Electricity Authority (CEA)

The chairperson of CEA stated that coastal regions in India faces an undeniable reality of high exposure to cyclones and floods, and these hazards (cyclones, floods) are annual occurrences. He observed a recurring cycle where stakeholders rush to act during a disaster, apply "patchwork" solutions, and then return to routine life without implementing preventive measures for the future. He urged the sector to break this cycle to prevent larger devastation in subsequent events.

Drawing the lesson from cyclone Phani he shared that due to lack of preparedness restoration of power took 30 days and significant number of state transmission towers collapsed due to inadequate safety factors, whereas lines with higher design specifications resisted the damage.

He also highlighted that there is currently a lack of adequacy in our emergency restoration of the systems further recognizing the sensitivity to long-term impacts. He stressed that disaster management should not be treated in silos rather it should integrate pre, during, and post-disaster strategies. He underscored the importance of resilient design system to withstand from impact of natural hazards. To mitigate future risks, he emphasized that CEA is re-evaluating wind zones and designing towers with higher safety parameters in coastal areas and implementing specific infrastructure, such as underground cabling, in distribution segments 20–60 km from the coast to minimize losses. The address emphasized that state machinery alone is often insufficient during major disasters hence protocols were established for neighbouring states to provide immediate aid. He also shared the example of pre-positioning trucks and manpower in Andhra Pradesh helping reduce restoration time to just 48 hours. He also underlined that CEA has launched a portal to track inventory (poles, conductors, transformers) across states. This ensures that during a disaster, utilities can locate materials immediately rather than waiting for manufacturers to produce them.

He referred to the Odisha power sector study to inform future infrastructure. He further proposed the creation of Task Forces for resilience in key coastal states including West Bengal, Tamil Nadu, Odisha, Kerala, Gujarat, Goa, and Daman & Diu. He also shared to launch a portal to generate a comprehensive inventory of assets to be able to track and protect understanding their exposure and vulnerabilities. He also highlighted on the delegation of responsibilities to specific people before the disaster strikes, not during the chaos. He also encouraged for partnership for resilience to think if systems can be designed to not disrupt during disasters. Lastly, he shared that through this workshop and existing interventions, to promote knowledge sharing and

collaboration and use such platform to institutionalize resilience in power sector. Shri Ghansyam Prasad concluded by reaffirming the commitment of the CEA to partner with CDRI, NIDM, and NDMA. He stressed that the goal is to protect consumers and the economy by ensuring that power infrastructure are disaster ready and restoration processes are planned, transparent, and swift.

c) Dr. Krishna S. Vatsa, Member, NDMA

Shri Krishna S. Vatsa began by acknowledging the collaboration between CDRI, NIDM, and the Central Electricity Authority (CEA). He commended the CEA Chairperson, Shri Ghanshyam Prasad, for his practical insights, noting that having a seasoned practitioner in such a strategic position benefits the entire power ecosystem. Shri. Vatsa widened the context to include recent disasters in India's hilly states, emphasizing that the power sector suffering huge loss across diverse geographies. He cited recent damages where the rockslide/landslide severely impacted the NHPC plant, causing significant financial loss and the tragic loss of 200 lives in the tunnel. Furthermore, he also shared the Glacial Lake Outburst Flood (GLOF) washed away the Chungthang dam and power plant, resulting in thousands of crores in losses that have yet to be recovered through insurance. His address also was linked to disaster resilience to India's broader strategic goals i.e. net zero by 2070, developed Nation by 2047. He stressed that to achieve the above-mentioned status; India's per capita power production must increase by at least 5 times. He shared that "Stable Power" is key for modernizing the economy and integrating with global markets. Shri Vatsa outlined three major systemic interventions required for the sector; Referring to a directive from the Prime Minister, he urged the CEA to develop detailed National Guidelines for Resilience in the Power Sector. He highlighted that the PM Gati Shakti platform and GIS mapping to integrate network design with disaster risk data. He strongly advocated for captive insurance (self-insurance) arrangements for the power sector. Noting that traditional market insurance can be prohibitively expensive, he suggested that a captive model is a more cost-effective way for the sector to manage long-term financial risks. He proposed that the findings of the Odisha study be converted into a formal 2–3 days training program to be offered regularly to power sector professionals, covering not just pre-disaster planning, but continuous mitigation strategies. Shri Vasta's address concluded with a call for systemic intervention. Shri Vatsa encouraged active participation in the workshop, hoping that the lessons from the Odisha study would be disseminated and adopted by all other states to ensure the stability of India's energy future.

6. Workshop Technical Sessions:

6.1 Technical Session 1: Cyclone and Flood Impacts on Power Sector & recommendations for Disaster Resilience

a) Presentation on the recommendations of the Disaster Resilient Power System study
Presenter: Mr Amit Tripathi, Advisor-Power Sector, CDRI

Mr. Amit Tripathi, Advisor Power Sector, presented context of the comprehensive study conducted in Odisha, which was triggered by the devastation of Cyclone Fani in 2019. He shared that the cyclone caused financial losses exceeding $1 billion to the power transmission and distribution systems, serving as a wake-up call to shift the focus from post-disaster relief to long-term mitigation and resilience planning. He shared that the study, conducted in partnership with the Government of Odisha, aimed to create a replicable methodology for risk identification and infrastructure improvement that could be adopted by other coastal states.

He underscored the findings of the risk mapping, which revealed that over 30% of the infrastructure along the Odisha coast is exposed to 100-year return period scenarios. The presentation emphasized the vulnerability of the existing network, noting that nearly 75% of distribution lines were commissioned over three decades ago, and 80% of the poles were identified as susceptible Joist poles. Furthermore, he highlighted operational gaps, such as span lengths exceeding 70 meters in the 33kV network, which compromised structural integrity during high-wind events. Addressing the solutions, Mr. Tripathi shared a prioritized investment matrix derived

from the assessment. He underlined the need for specific technical interventions, such as underground cabling in urban areas and the use of robust Spun or H-poles in rural regions. He also emphasized the urgency of updating codes and standards, noting that current Indian Standards (like wind zone maps) are static and often fail to reflect the climate reality of intensifying cyclones, as seen when wind speeds in Odisha exceeded the "Zone 5" classifications.

Reiterating the statement from Mr. Krishna Vatsa he also stated that there should be policy focus on coastal and high mountain regions. Mr Tripathi stressing the recommendation from the study shared the opportunity of specific "resilience windows" within central government sectoral schemes. He noted that while some support exists, there is currently significant ambiguity regarding how states can access funds specifically for resilience, requiring urgent clarification. Mr. Tripathi underscored the financial realities of the power sector as a regulated asset class, where investments must eventually be reflected in tariffs. He emphasized the risk of "moral hazard" if states rely solely on government grants for post-disaster restoration. To counter this, he highlighted the recommendation for utilities to allocate at least 1.5% of their annual revenue to a dedicated "Power Utility Focused Disaster Fund" or captive insurance model to ensures a sustainable financial buffer for adaptation and mitigation.

Mr. Tripathi's presentation also emphasized the necessity of a "Cross-Sectoral Climate Resilience Data Access Platform." Mr. Tripathi shared that CDRI is developing tools like GIRI and called for stronger collaboration with the IMD to develop impact-based forecasting moving beyond simple weather alerts to actionable infrastructure insights. He concluded by urging all stakeholders including the Ministry of Power, CEA, Department of Economic Affairs, and private investors to incorporate resilience risk assessments into every aspect of new and brownfield investments to build a disaster ready power sector.

b) Reflections from the coastal states & UTs in India

- Upon the sharing of Odisha Power sector assessment from Mr. Amit Tripathi, the second part of 1st technical session focused on reflections from the coastal states and experiences. The brief of various reflection from Mr. Pradeep K. Jena and representatives for coastal states from India are provided below.

i) Reflections from Shri. Pradeep Kumar Jena: Chairman, Odisha Electricity Regulatory Commission (OERC)

Shri Pradeep Kumar Jena, Chairperson of the Odisha Electricity Regulatory Commission (OERC), shared his journey from a young collector during the 1999 Super Cyclone to becoming the Power Secretary who revolutionized Odisha's grid resilience. The Catalyst for Change Shri Jena began by highlighting the devastating impact of the 1999 Super Cyclone, recalling how wind speeds exceeded the measuring capacity of instruments at 269 km/h. He underscored the vulnerability of the power sector, noting that during the subsequent 2013 Cyclone Phailin, the state lost over 6 lakh electric poles and 34,000 kilometres of lines. He stressed the severe constraints faced at the time: private DISCOMs were financially insolvent, and the state had to manually mobilize materials from steel plants and assemble a workforce of 7,000–8,000 people under immense political pressure to restore power in weeks rather than months. He also provided an insight on a pivotal moment in his narrative occurred during a drive from Bhubaneswar to Brahampur after a cyclone. Shri Jena emphasized while the utility's single-pole power lines had collapsed, the railway traction lines running parallel remained intact. He highlighted the structural difference railways used two poles with cross-bracing, whereas the power sector relied on single poles.

Shri Jena shared that he had to take a bold administrative risk. He recounted cancelling existing tenders to redraw project specifications, increasing the cost from ₹2,600 crore to ₹4,200 crore to incorporate resilient designs. He shared the intense scrutiny he faced from the State Cabinet regarding the cost escalation. He underlined his conviction by requesting the Cabinet to record that if they reverted to the old, cheaper

specifications, he should not be held accountable for future infrastructure failures. The Chief Minister approved the resilient design, a decision Shri Jena noted has paid off, as the new infrastructure has withstood seven subsequent cyclones.

Shri PK Jena underscored the urgent need to rework strategies to align with the vision of Viksit Bharat, acknowledging that building resilient infrastructure is highly capital-intensive. They highlighted a critical gap in current funding mechanisms, noting that while the State Disaster Response Fund (SDRF) provides some relief, its support is typically limited to infrastructure up to 11kV leaving 33kV infrastructure unsupported creating a significant financial burden on states and utilities for higher-voltage infrastructure, which is not covered under standard disaster response frameworks. He emphasized that because electricity is a regulated sector, any government grant ultimately benefits the consumer by neutralizing tariffs and stressing that there should be government support private DISCOMs with capital grants for resilience to avoid burdening consumers.

Shri Jena commended the proactive steps taken by private players like Tata Power in Odisha, who are adopting better specifications despite the costs. He suggested that states should utilize the CDRI study to assess their vulnerabilities and prepare investment plans. A specific recommendation was added for the government to support private DISCOMs through capital grants or specific budgetary provisions for resilience, ensuring that the benefits of robust infrastructure are passed on to consumers without spiking tariffs. The session concluded with a call for resilience to be embedded as a core government policy, moving beyond retrofitting to ensuring all future assets are disaster-proof by design.

ii) Reflections from Workshop Participant – Experience sharing

a) National Thermal Power Corporation (NTPC), Mr Chandan Shahi

Mr. Chandan Shahi shared specific operational vulnerabilities faced by NTPC's coastal stations, such as Vallur (Tamil Nadu) and Simhadri (Andhra Pradesh). He highlighted that the immediate impact often occurs at the port level, where "Grab Unloaders" are damaged by high winds, severing the coal fuel supply chain before generation even begins. Furthermore, he underscored the unpredictability introduced by climate change, citing the 2023 deluge at the Khargone station in Madhya Pradesh. He emphasized that despite being in central India, the plant faced unprecedented flooding that marooned cooling towers, blocked access to switchgear rooms, and caused overflows in the Flue Gas Desulfurization (FGD) system drains. Regarding preparedness, Mr. Shahi stressed the critical importance of human safety and headcount accountability. He shared that NTPC employs a digital tracking system called "CLIMPS" to monitor the punching and presence of all workers and contractors, ensuring that in the event of a cyclone, the safety of every individual can be verified immediately. He underlined his philosophy with the military adage, "If you sweat more in peace, you bleed less in war," emphasizing that rigorous planning during non-disaster periods is the only way to minimize losses. Mr. Shahi highlighted the traditional "Hierarchy of Controls" used in industrial safety (Elimination, Substitution, Engineering Controls, Administrative Controls, and PPE). However, he underscored a distinct gap in this model regarding large-scale events. He proposed and emphasized a "Sixth Dimension" to this hierarchy specifically for disaster scenarios: a dedicated mitigation mechanism to handle the aftermath when preventive controls fail.

b) Ms. Madhuri Saha, Calcutta Electric Supply Corporation Limited (CESC Limited)

Ms. Madhuri Saha shared the unique challenges faced by CESC, one of the country's oldest organizations operating in a highly dense 567 sq. km area around Kolkata. She highlighted the unprecedented devastation caused by Cyclone Amphan in 2020, describing it as a "multi-hazard" event combining heavy rainfall, high wind speeds, and storm surges. She underscored the complexity of managing this disaster against the

backdrop of the COVID-19 pandemic and restrictions. Furthermore, she emphasized the vulnerability of the region to sudden events, citing a recent flash flood in September 2023 during Durga Puja, where a lack of warning coupled with temporary festival power supplies created hazardous and fatal conditions. Reflecting on the lessons from Cyclone Amphan, Ms. Saha stressed that the organization took immediate steps to revamp its preparedness strategy. She shared that CESC has completely revised its Disaster Management Plan (DMP) and Standard Operating Procedures (SOPs). She underlined the importance of integrating offline functions with support functions to ensure a cohesive response mechanism for future events. Despite the massive scale of damage where lakhs of supplies were worn out, Ms. Saha emphasized the utility's record achievement in restoration. She highlighted that through coordinated efforts, CESC managed to restore 99% of the power supply within a record time of 7 to 8 days post-Amphan. She concluded by underscoring her intent to use the workshop to further identify and adopt best practices to handle the region's high vulnerability.

c) Mr. Karunakar Jha, Tata Power Northern Odisha Distribution Ltd (TPNODL) –

Mr. Karunakar Jha shared the distinct vulnerability of the Northern Odisha region, which has a long coastline. He emphasized the dual nature of threats faced by the utility. Apart from major cyclones like Dana and Yaas that severely impact districts like Balasore and Jajpur, he highlighted the recurring challenge of No'rwester/kaalboisakhi. He stressed that these intense, short-duration storms (often lasting just 15 minutes) occurring between March and the monsoon season cause significant damage, frequently bringing down lines and conductors over a prolonged period.

Reflecting on the learnings from Cyclone *Yaas* (2021), Mr. Jha underscored the massive logistical improvements made in anticipation of Cyclone *Dana*. He shared that the utility strategically pre-positioned materials at 159 locations specifically for poles and established five stores in each circle. He highlighted the robust mobilization of approximately 10,000 manpower, supported by clear Standard Operating Procedures (SOPs). Furthermore, he emphasized the decentralization of command, noting that control rooms were created at every division level with senior mentors allocated to specific locations to oversee operations.

Mr. Jha underlined "Safety Management" as a critical success story. He stressed that by assigning a dedicated Safety Officer to every section and aligning local teams with safety protocols, the utility achieved zero fatal accidents during the restoration period. On the technical front, he emphasized the adoption of resilient infrastructure, such as the use of Spun Poles in rural planning. For urban centres like Balasore and Jaipur, he highlighted the strategy of "Ring-Fencing" through the deployment of underground cables and Ring Main Units (RMUs) to ensure stability.

d) Reflections by Tamil Nadu & Puducherry Power Utility

The representative from the Tamil Nadu & Puducherry Power Utility shared their experience with the recent Cyclone *Fengal*. They highlighted that the cyclone unexpectedly changed its path from Odisha to Tamil Nadu, making landfall in the Villupuram district. They emphasized the scale of the impact, noting that rainfall exceeded 100 cm, leading to severe flooding where most villages were submerged. The representative underscored that manpower, and materials were arranged within 1-2 hours of the alert. They stressed the strategic deployment of senior engineers (Superintendent level) from non-affected districts to lead restoration teams in the impact zone, ensuring experienced leadership on the ground. The participants highlighted a proactive shift in infrastructure under the central RDSS scheme. They shared that work is underway to convert Low Tension (LT) lines into Aerial Bunched Cables (ABC) and High Tension (HT) lines into Covered Conductors. These technical upgrades are designed to prevent short-circuiting during storms and future-proof the grid against similar cyclonic events. As a result of these coordinated efforts, the utility managed to restore power to villages within 2-3 days and achieved full restoration in agriculture within 10 days, earning appreciation from the local assembly.

e) Mr. Amit Prothi (Director General, CDRI)

Mr. Amit Prothi, DG CDRI commended the openness displayed by the Odisha state representatives in discussing their challenges and failures. He underscored that while it is often difficult for officials to speak about failure, understanding "what is not working" is as critical as sharing success stories for genuine progress in resilience. He emphasized that the primary objective of the workshop was to promote peer-to-peer learning, encouraging states on the frontlines to exchange diverse strategies. To illustrate that infrastructure vulnerability is a global challenge and not unique to India, he cited a personal anecdote from his time in Washington D.C., where a storm caused a massive power outage lasting four days, leaving residents including his own family with a newborn unprepared and without electricity. Furthermore, DG, CDRI added a crucial economic perspective to the discussion. Referring to a forthcoming report and recent discussions with economic planners, he underscored the direct correlation between restoration speed and economic stability. He concluded by stating that the faster the power sector can restore services, the significantly lower the impact on the broader economy, reinforcing the urgency of the workshop's agenda.

6.2 Technical Session 2: Wind Zone Map, Codes & Standards

Mr. Amit Tripathi, Advisor-Power Sector (CDRI), set the context for the upcoming group discussions. He reiterated that the core objective of the workshop is to gather direct feedback from participants on what practical measures work on the ground versus what don't.

For context setting for Standards and Codes Mr. Tripathi presented key findings from the CDRI report regarding failures in Odisha, highlighting specific gaps in current standards. He shared about the distribution sector vulnerability 80–90% of cyclone damage occurs in 33kV, 11kV, and Low Tension (LT) lines. These lines, often built in the 70s–90s using older REC standards, are designed for wind speeds of only 130–150 km/h, which is insufficient for modern cyclones. Mr. Tripathi also shared about the transmission infrastructure built to IS 802 standards (Wind Zone 4) struggled when wind speeds exceeded 170–180 km/h (Wind Zone 5 conditions), pointing to ambiguities in code interpretation. He also noted that while standards like IS 802:1995/2015 exist, agencies like Power Grid Corporation of India Limited (PGCIL) have proactively adopted higher safety factors (K4 factor) rather than waiting for formal standard revisions. Following the context setting, the session transitioned to interactive group exercises moderated by Mr. Wasi Alam. The participants were divided into groups to deliberate on specific technical interventions and policy recommendations based on the identified gaps.

A. Group Exercise Findings: Codes, Standards, and Wind Zonation

During the workshop, participants engaged in a structured group exercise to evaluate the current state of wind zonation maps and infrastructure codes in India. The following is a summary of the participant responses, consensus points, and recommendations.

Group Exercise 1a: Wind Zonation

1. **Assessment of India's Current Wind Zone Map:** Participants unanimously agreed that the current wind zone map requires significant review due to the rapid pace of climate change.
2. **Revision of Current Zonation's:** There was a strong consensus (indicated by most respondents) that the map needs immediate revision. The current map often fails to predict actual wind speeds observed during recent extreme weather events. A specific example cited was Odisha (Zone 5), where wind speeds frequently exceed the design parameters of the current classification. Because technical specifications and infrastructure development rely heavily on these maps, inaccurate zonation leads to

under-designed assets that are prone to failure. There is a pressing need to move beyond static maps to incorporate data from accurate weather applications and increased density of weather stations to reflect changing climatic scenarios**.**

3. **Cyclonic Factors:** Participants noted that the current application of cyclonic factors is inadequate. It was suggested that revisions must account for complex phenomena such as wind shearing, swirling, and soil erosion, which are currently overlooked.
4. **Proposal for Mandatory Automatic** Weather Stations (AWS) Participants supported mandating the inclusion of AWS for capital-intensive projects to ensure data-driven decision-making. The rationale and requirements included:
    - **Financial Justification**: A robust dataset is essential to validate projected Returns on Investment (RoI) and ensure proper fund allocation for large Capex infusions.
    - **Technological Integration:** Utilization of IoT, backend data processing, and AI tools for predictive analysis**.**
    - **Collaborative Modelling:** Integrating data from ISRO and IMD (satellite data, Earth Observation) to simulate climate change scenarios and create future-proof predictive models.
5. **Actionable Steps to Revise Wind Zone Maps: To effectively revise the maps, the group proposed the following actions:**
    - **Data Aggregation:** Analyse data from the last 10–20 years, incorporating "safety factors" for cyclones.
    - **Multi-Sectoral Data Sources:** Beyond IMD, data should be sourced from the private sector, Coast Guard, offshore oil mining entities, and aviation departments.
    - **Technology Utilization:** Deploy Radar and Remote Sensing to assess wind gust speeds and increase the density of data collection points.
    - **Dynamic Updates:** Move towards a system where wind zone maps are updated dynamically and frequently rather than remaining static for long periods.
    - **Granularity:** Develop precise, detailed zonation maps specifically for urban areas.
    - **Institutional Review:** Form expert committees to review the maps and ensure findings are broadcast effectively to coastal utilities.

B. Group Exercise 1b: Codes and Standards

- **Assessment of Current Codes (Transmission & Distribution):** While current codes address general requirements, participants felt they lag the realities of climate change.
- **Structural Gaps:** Tower design and loading factors specifically regarding wind and ice loading need review as current considerations are insufficient for recent extreme events.
- **Emerging Hazards:** There is a lack of standards addressing Urban Heat Island effects, cloud burst warnings, and specific environmental hazards (e.g., carcinogenic vapours).
- **Modernization:** Existing standards need to integrate new technologies, such as AI-based disaster risk forecasting and smart sensor data.
- **Prioritization of Revisions:** Participants categorized necessary revisions into immediate and medium/long-term priorities

a) Immediate Priorities:

- Revision of Tower Design Loading and Wind Load Standards.
- Lightning Protection Standards and design specifications for poles in coastal zones (specifically regarding wind speed).
- Mandating the use of GI (Galvanized Iron) structure materials for corrosion resistance.
- Developing standards for evaluating the performance of resilient power infrastructure.
- Studies on the effects of high temperature on solar panels and other power infrastructure.
- Revising limits for Particulate Matter (PM-1) and hazardous exposures.

b) Medium to Long-Term Priorities:

- Comprehensive Urban T&D Infrastructure standards.
- Thermal Design considerations.
- Clarification of National Electricity Safety Regulations.
- Integration of local lightning data and thunderstorm warning systems.

6.3 Technical Session 3: Disaster Preparedness

a) Disaster preparedness in power sector

Presenter: Mr. Irfan Ahmad, Chief Engineer, Power Data Management & Load Forecasting Division, CEA

Mr. Irfan Ahmad outlined the comprehensive disaster management framework for the power sector, anchored in Section 37 of the Disaster Management Act (2005). He shared that the Central Electricity Authority (CEA), on behalf of the Ministry of Power, prepares and annually revises the Disaster Management Plan (DMP) in alignment with the Sendai Framework, COP21 targets, and the PM's 10-point agenda. He highlighted the established four-tier institutional structure comprising National, Regional, State, and Plant-level Disaster Management Groups and their corresponding control rooms (NLDC, RLDCs, SLDCs), which ensure coordinated response and recovery. Focusing on infrastructure, Mr. Ahmad presentation underscored the vulnerability of coastal regions to frequent cyclones like Phailin, Hudhud, and Fani. Mr. Ahmad highlighted key recommendations from the Task Force on Cyclone Resilience, such as retrofitting existing transmission towers with stronger bracing and deploying narrow-base steel towers for new infrastructure. For distribution, he emphasized the use of spun/rail poles, shortening span lengths, and the critical need for underground cabling in the first 20–60 km from the coast. He also outlined substation resilience measures, including raising transformer plinths and transitioning to Gas Insulated Substations (GIS) in flood-prone areas.

Mr. Ahmad shared proactive steps taken to enhance preparedness, noting that power utilities conducted over 1,870 mock drills in 2024-25 alone, covering scenarios from cyber-attacks to gas leakages. He highlighted a specific case study of a chemical leak mock drill at NTPC Kaniha, which revealed the necessity of establishing command centers outside plant boundaries for better crowd management. Furthermore, he underscored the financial aspect, reiterating the provision for utilities to set aside 1.5% of their annual revenue for a dedicated disaster fund. The presentation concluded by stressing the importance of "building back better" and the ongoing efforts to integrate early warning systems for hydro stations and preparedness measures for critical assets.

b) Presentation: Disaster Resource Inventory for Power System (DRIPS)

Presenter: Mr. Karan Sareen

Mr. Karan Sareen introduced the DRIPS portal, launched in August 2024 under the guidance of the Honourable Power Minister. He explained that the portal serves as a specialized online inventory system designed for DISCOMs, Transmission Utilities, and GENCOs to facilitate resource sharing during emergencies. He underscored the portal's core function as a facilitator: for instance, if a utility in Andhra Pradesh exhausts its spares during a cyclone, it can use the portal to locate compatible inventory in neighboring states like Odisha and arrange for mutual aid at the state level, bypassing time-consuming tendering processes. The presentation outlined the operational workflow, which involves the registration of designated nodal officers via the National Power Portal. Mr. Sarin shared that specific inventory lists have been finalized through stakeholder discussions, covering 74 items for DISCOMs, 118 for Transmission, and 45 for Generation (thermal and hydro). He highlighted key features such as the "Master List Inventory" for searching specifications (e.g., circuit breakers, transformers) and the flexibility for utilities to request the addition of new inventory items through the portal. Addressing the critical challenge of keeping data current, Mr. Sareen stressed that manual entry often leads to outdated records. He highlighted a major initiative driven by the Power Secretary to automate this process. The CEA is currently piloting a solution with NTPC, PowerGrid, and Delhi DISCOMs (BRPL, Tata) to fetch inventory data directly from utility ERP systems using JSON formats or APIs. He emphasized that once the pilot is successful, this automated approach will be rolled out Pan-India to ensure real-time data accuracy without burdening utility staff.

Q&A Session:

i) Concern on Manual Data Entry (NTPC)

- **Question:** An NTPC representative raised a concern regarding the "humongous effort" required to manually populate inventory fields for 47 different stations with varied fleet sizes, questioning the feasibility of such an exercise for operational teams.
- **Response:** Mr. Sareen clarified that utilities are not required to list every single item, but only critical major equipment (e.g., circuit breakers, centrifugal pumps) identified by stakeholders. He reiterated that the shift to automation (JSON format) is specifically aimed at resolving this issue by automatically fetching data fortnightly, thereby minimizing manual intervention.

ii) Alignment with IDRN (NIDM)

- **Comment:** A representative from the National Institute of Disaster Management (NIDM) noted that the India Disaster Resource Network (IDRN) has been running a similar portal for disaster resources at the district level for over 20 years.
- **Response:** Mr. Sareen acknowledged the comment, confirming that the DRIPS portal is conceptually in line with the IDRN framework but specialized for the power sector's technical needs.

iii) Clarification on AWS and Standards: Addressing queries from the previous session, Mr. Sareen shared that CEA has released guidelines mandating Automatic Weather Stations (AWS) for any Renewable Energy pooling station greater than 50 MW. He also confirmed that IS 5613 Part 3 (regarding transmission lines above 66kV) has been revised, while updates for Parts 1 and 2 are pending.

6.4 Fire Side chat

What are the actions required to strengthen power sector preparedness?

Mr. Pradeep Kumar Jena: Chairman, Odisha Electricity Regulatory Commission (OERC) and Mr. Alok Kumar, DG, All India Discom Association (Former Secretary, Ministry of Power) The fire side chat featured a high-level dialogue between Mr. Pradeep Kumar Jena (Chairman, OERC) and Mr. Alok Kumar (DG, AIDA & Former

Power Secretary). The discussion focused on actionable strategies to enhance resilience of power sector in the face of climate risks and financial constraints.

Mr. Alok Kumar set the context by highlighting two critical trends on recent data and cost of resilience. He emphasized that India witnessed extreme weather events on 88% of days in 2024, impacting not just coastal areas but also hilly regions like Uttarakhand and Himachal Pradesh. The economic, social, and political costs of power outages have surged because modern livelihoods, healthcare, and education are now entirely dependent on electricity and digital connectivity.

In addition to that, a significant portion of the chat focused on the financial aspect of building resilience. Mr. Jena explained that while DISCOMs (especially private ones like Tata Power in Odisha) are willing to invest in resilient infrastructure, regulators often cannot approve these costs because they would lead to steep tariff hikes, burdening consumers. Both speakers agreed that the incremental cost of resilience which is capital-intensive cannot be borne solely by DISCOMs or consumers. Mr. Kumar argued strongly for Government Capital Grants or budgetary support to bridge this gap, especially in low-revenue rural and coastal areas where DISCOMs are reluctant to invest. Mr. Jena pointed out a critical gap in central funding (SDRF/NDRF), which currently supports restoration only up to 11kV, leaving the vital 33kV network unsupported. He urged the Ministry of Power and CEA to work with the MHA to amend these norms.

Given limited resources, Mr. Alok Kumar suggested prioritizing critical assets like Distribution Transformers (DTs) and Substations over overhead lines, which are easier to restore. He further shared that AIDA is working to standardize equipment specifications (like DTs) across states. Additionally, he shared that this will not only lower costs through competitive procurement but also facilitate easier resource sharing between states during emergencies. A low-cost, high-impact solution identified was regular tree pruning. Tata Power's proactive vegetation management in Odisha has significantly reduced line snapping during storms.

Both the speakers also highlighted on the emergency challenges like the vulnerability of rooftop solar installations in cyclone-prone areas. Mr. Jena noted that standard structures often fail in high winds. Innovations like maintaining a low 8-degree slope (within parapet height) and using concrete ballast blocks have shown promise in withstanding winds up to 180 km/h. There is a lack of insurance products for rooftop solar, which hampers adoption. Both the speakers called for policy support from the Ministry of Finance to de-risk these assets.

Lastly, both the speakers fire side chat proposed some key recommendations listed below. The government should provide specific budgetary support or capital grants to cover the incremental cost of disaster-resilient infrastructure (e.g., underground cabling, spun poles) to prevent tariff shocks for consumers.

The scope of State and National Disaster Response Funds should be expanded to cover restoration of 33kV infrastructure and increase the per-kilometer funding limits to reflect current costs. Accelerate the standardization of critical distribution equipment (like transformers) across all states to enable seamless mutual aid and cost-effective procurement.

MNRE should mandate specific wind-resilient structural standards (e.g., aerodynamic designs, concrete ballasting) for rooftop solar installations in coastal zones. Institutionalize coordination between DISCOMs, Forest Departments, and PWDs to ensure pre-monsoon tree pruning and rapid road clearance post-disaster, which are prerequisites for power restoration.

Day 2: National Workshop on "Building Resilience of Power Sector in Coastal Regions"

7. Recap of day 1

The day began with a comprehensive recap of the previous day's proceedings, where the inaugural address by the CDRI Director General was highlighted for its focus on the increasing frequency of disasters and the replicability of the Odisha resilience model. The session underscored the CEA Chairperson's call for improved infrastructure design across wind zones. Further, Dr. Krishna Vatsa's emphasis on aligning disaster management with net-zero goals was also shared by the participants. During the recap, participants shared insights from the technical sessions, particularly Mr. P.K. Jena's experiences with cyclones, which emphasized that resilience relies on the integration of policy reforms, retrofitting, and rigorous training. During the recap participants also explained the outcomes of the group exercises, which pointed to the urgent need for updating wind zone maps and engineering standards, concluding with the fireside chat's message that resilient power sector is fundamental to resilient economic development.

7.1 Technical Session 4: Extreme Heat Impacts on Power Sector

a. Presentation on Extreme Heat Impacts on Power System

Presenter: Ms. Shweta Kulkarni, Prayas Energy Group, Extreme Heat Impacts on Power System

Ms. Shweta Kulkarni from Prayas Energy Group delivered an insightful presentation that highlighted the increasingly critical impact of extreme heat on India's power sector. She noted that rising temperatures, particularly the phenomenon of Urban Heat Islands, are creating significant operational challenges for power distribution companies. The presentation emphasized that the inability of equipment to cool down during hotter nights is leading to a higher rate of failures in transformers and cables. Ms. Kulkarni shared data illustrating how demand patterns are shifting, with sharp spikes in cooling loads that are difficult to manage, especially given the current renewable energy generation profiles.

Ms. Kulkarni additionally stressed the urgent need for updating equipment standards to reflect these new thermal realities. She underscored the importance of forming a collaborative committee involving DISCOMs, Original Equipment Manufacturers (OEMs), and the Bureau of Indian Standards (BIS) to revise these codes effectively. Furthermore, she reiterated that robust Demand Side Management (DSM) strategies are essential for balancing the grid during peak heat events. The presentation pointed out that accurate load forecasting is currently hampered by a lack of granular weather data, urging for better data-sharing mechanisms between meteorological agencies and power utilities.

The session concluded with a focus on risk proofing the sector. Ms. Kulkarni explained that integrating resilience planning into everyday operations is no longer optional but necessary. She advocated for a multi-sectoral approach, suggesting that urban development policies, such as the Energy Conservation Building Code (ECBC), must be aligned with power sector planning to mitigate future demand surges. Finally, she noted that financial health and regulatory support are crucial for enabling utilities to invest in resilient infrastructure, thereby ensuring a reliable power supply even in the face of escalating climate risks.

b. Panel discussion- Operational Experiences and Technology Solutions:

The session, moderated by Ms. Shweta Kulkarni, brought together industry leaders to discuss practical challenges and solutions for managing extreme heat and other disasters in the power sector. Ms. Madhuri Saha from CESC provided a detailed account of the operational hurdles faced during heatwaves, which are now considered more dangerous than cyclones by her team due to their prolonged and intense nature. She highlighted that while heatwaves were not officially classified as disasters, they necessitated extensive infrastructure upgrades and meticulous planning. Ms. Saha shared that CESC has implemented innovative solutions such as deploying "Transformers on Wheels" to quickly restore power in affected areas and using Diesel Generator (DG) sets as a temporary measure during outages. She also noted a significant challenge

with consumer behaviour, where declared loads often do not match actual usage due to undeclared air conditioning units, complicating demand management.

Mr. R.M. Patel from GETCO focused on the transmission sector, explaining how rising ambient temperatures derate the capacity of critical substation equipment like circuit breakers and current transformers. He emphasized the necessity of N-1 contingency planning to ensure grid stability even if one component fails. Mr. Patel also pointed out the difficulty in predicting localized demand surges, which can overload specific transmission lines, and stressed the importance of incorporating these realities into future network planning. Mr. P.K. Jena shared insights from Odisha, underscoring the human element of disaster management. He explained that worker safety is paramount, leading to strict regulations that restrict field work during peak heat hours (11 AM - 3 PM) to prevent heat strokes. He shared simple yet effective practices like ensuring hydration for field staff and conducting regular thermal scanning of substations to identify hotspots before they lead to failure. The panel collectively agreed that while long-term technological upgrades like storage are essential, immediate resilience relies on optimizing existing infrastructure, enhancing real-time monitoring with tools like thermal cameras, and rigorous preventative maintenance during cooler months.

c) **Reflection from National Thermal Power Corporation (NTPC) and Calcutta Electric Supply Corporation- Cyclone preparedness for National Thermal Power Corporation (NTPC)**

Presenter: Chandan Shahi, National Thermal Power Corporation (NTPC)

Mr. Chandan Shahi from NTPC delivered a comprehensive presentation on the organization's robust cyclone preparedness and disaster risk reduction strategies. He began by highlighting the necessity of thorough Hazard Identification and Risk Assessment, noting that proper assessment accounts for 50% of the preparedness effort. Mr. Shahi explained the specific vulnerabilities of NTPC's coastal assets, such as the critical need to lock grab unloaders and stacker reclaimers at ports when wind speeds exceed 60 km/h, utilizing built-in anemometers for automated safety. He shared anecdotal evidence from past cyclones, like the incident in Gujarat where an unlocked gantry crane caused significant damage, to underscore the importance of these protocols.

Mr. Chandan detailed the extensive measures taken to protect plant infrastructure, including the deployment of trailer pumps to prevent flooding in critical areas like cooling towers and switchgears. He emphasized the vulnerability of loose roof sheets at heights, citing them as a top risk that requires proactive securing. The presentation noted the importance of communication redundancy, revealing that key personnel and coastal stations are equipped with satellite phones to maintain connectivity when conventional networks fail. Furthermore, he stressed the role of the "Contract Labor Information Management System" (CLIMS) for rapid headcounts during emergencies, ensuring the safety of the workforce.

The session also covered the logistical and human aspects of preparedness. Mr. Shahi explained that NTPC maintains food supplies for 1,000 people for four days and keeps liquid cash available to manage immediate expenses when ATMs are non-functional. He highlighted the specific medical protocols, including triage systems and hospital tie-ups, to handle potential mass casualty events. The presentation concluded with a focus on post-disaster recovery, reiterating the need for a clear chain of command where media briefings are centralized through HR to prevent misinformation. The comprehensive checklist approach, covering everything from securing temporary structures to ensuring the availability of dewatering pumps, was presented as a model for operational resilience.

d) Presentation on CESC's Disaster Resilience and Best Practices

Presenter: Ms. Madhuri Saha, Senior Manager at CESC Limited

Ms. Madhuri Saha, Senior Manager at CESC Limited, presented an overview of the organization's robust disaster management framework and operational best practices. She began by highlighting CESC's legacy as India's oldest power utility, operating in a highly disaster-prone region susceptible to cyclones, floods, and Kal Boisakhi. Ms. Saha explained that CESC adopts a proactive approach, emphasizing disaster risk reduction (DRR) through structural interventions such as converting overhead bare conductors to Aerial Bunched (AB) cables, raising pillar boxes in low-lying areas, and installing sensors to detect waterlogging in real-time. She also shared that all new transformers in congested areas are dry-type units installed at elevated heights to prevent water ingress.

A significant portion of the presentation focused on preparedness and response mechanisms. Ms. Saha noted the critical role of communication redundancy, detailing the use of satellite phones, multiple SIM cards, and a dedicated optical fiber network to maintain connectivity during crises. She underscored the collaboration with the India Meteorological Department (IMD) through a specific WhatsApp channel for real-time weather updates, which are then disseminated internally. Furthermore, she emphasized innovative community engagement strategies, such as the deployment of "safety tableaus" and social media campaigns to raise public awareness about electrical safety during storms.

The session concluded with insights into CESC's rapid recovery protocols. Ms. Saha described the deployment of "Transformers on Wheels" and standby Diesel Generator (DG) sets to ensure continuity of supply to vital installations like hospitals and pumping stations. She acknowledged that while immediate restoration is often achieved within days, permanent recovery can take months, necessitating a dedicated stock of disaster management materials. The presentation reiterated that continuous learning from past events, like Cyclones Amphan and Yaas, drives the regular revision of their Standard Operating Procedures (SOPs), ensuring that CESC remains resilient in the face of evolving climate risks.

7.2 Technical Session 5: Technology Solutions for building power sector resilience

Moderator: Mr. Reji Pillai, President, India Smart Grid Forum (ISGF)

Panellists:

- **Mr. Safi Ahsan Rizvi:** Advisor, National Disaster Management Authority (NDMA)
- **Mr. Pradeep Kumar Jena:** Chairman, Odisha Electricity Regulatory Commission (OERC)
- **Mr. Samrat Ray:** Senior Project Officer, Asian Development Bank (ADB)

Panel Discussion Summary: Regulation and Financing for Resilience

The post-lunch session focused on the critical aspects of regulation and financing required to build a resilient power sector. Moderated by Mr. Reji Pillai, President of ISGF, the session began with an acknowledgment of the sector's shift towards disaster resilience, particularly following major events like the 2013 cyclone in Odisha. Mr. Pillai highlighted the need for a dedicated "Disaster Resilience Fund," suggesting a nominal cess of 2-5 paise per unit of electricity to build a corpus for immediate response. He underscored that digital modernization is futile without robust physical infrastructure, advocating for the undergrounding of distribution networks in disaster-prone areas.

Mr. Pradeep Jena provided a candid view from the regulator's chair. He underscored the paradox regulators face ensuring high-quality, resilient power supply versus maintaining affordable tariffs. Further, he shared, in states like Odisha, coastal areas (50%) are highly vulnerable, while inland areas are not. Convincing consumers in safe zones to pay higher tariffs to subsidize resilient infrastructure in coastal zones is politically and socially difficult. He stated that while private DISCOMs (like Tata Power in Odisha) are willing to bring in equity for resilience, this attracts a 15-16% Return on Equity (RoE), which spikes tariffs. Therefore, Mr. Jena argued that resilience funding must come from government grants or soft loans rather than commercial equity, to keep tariffs neutral, without overburdening consumers

Mr. Safi Ahsan Rizvi from NDMA added that while government grants are available, they are insufficient for the scale required, urging the sector to explore innovative financial instruments like Catastrophe (CAT) bonds and risk pooling. Mr. Safi Rizvi brought a financial perspective, noting that government funds (NDMF/SDMF) are finite ($6 billion for mitigation over 5 years for the whole country). He highlighted the potential for Indian power utilities to raise Cat Bonds in international markets. These instruments allow global investors to diversify their portfolios by taking on disaster risk, a model successfully used in the US and New Zealand.

Mr. Samrat Ray shared ADB's experience in financing resilient infrastructure in India (e.g., Tripura, Sikkim) and globally (Philippines, Indonesia). He emphasized that transmission lines financed by ADB in Sikkim withstood recent catastrophes due to superior design standards insisted upon during the project phase. He suggested tapping into global pools like the Green Climate Fund (GCF) and Climate Investment Funds (CIF). Although accessing them can be complex, even a small component (10-15%) of grant funding in a blended package can significantly lower the overall cost of capital, making resilient projects viable without burdening consumers.

Mr. Pillai concluded by discussing the role of the newly formed All India Discoms Association (AIDA). AIDA is working to standardize specifications for critical equipment (transformers, poles) across all states. He underlined that uniform standards would lower costs through economies of scale and enable seamless inventory sharing between states during disasters (e.g., Kerala borrowing transformers from Karnataka), eliminating compatibility issues. Lastly, the panel reached a consensus that resilience requires a multi-pronged financing strategy. Relying solely on tariffs is unfeasible; the path forward lies in blended financing (grants + soft loans), innovative instruments (Catastrophic Bonds), and standardization to reduce costs and improve mutual aid capabilities.

A. Group Exercise Summary: Regulation

The group underscored the necessity of integrating resilience into regulatory frameworks, suggesting that regulation should directly inform tariff structures. A key proposal was a hybrid financing model combining Tariffs and Government Grants.

The group proposed a tiered tariff structure based on geographic vulnerability: Higher tariffs for coastal regions (which require costlier, resilient infrastructure) and lower tariffs for the rest of the state. The group during the presentation also highlighted that a dedicated funding window for resilience must be established within government funds to support this transition. Participants shared that current frameworks are inadequate and emphasized that risk assessment mechanisms should be directly linked to tariffs. The group stressed that the component of "Building Back Better" must be formally built into the National Disaster Response Fund (NDRF) norms. They recommended that Post-Disaster Needs Assessment (PDNA) guidelines be revised to allow funding for improvement (better standards) rather than just restoration to the old state. The creation of co-financing facilities was suggested, using capital as "catalyst money" to drive cross-sectoral projects. To ensure effective preparedness, the group recommended for a focal for disaster management at every Circle level. They also suggested creating a compendium of best cases and documenting learnings to institutionalize knowledge and introducing competition among stakeholders and recognizing best practices at the district and state levels.

B. Group Exercise Summary: Financing

The group on financial supported the establishment of power-utility-focused funds to mitigate disaster risks. However, the participant during the exercise highlighted a challenge i.e such funds are expensive unless populated by a massive group of entities over a long period. Therefore, they concluded that the government

must initiate/seed these funds to make them viable the current insurance landscape was deemed "Insufficient" and "Inadequate" for power infrastructure, particularly regarding coverage for prolonged disruptions and shared that mega-risk funds (like those used by NTPC) are effective, but expensive. The group pointed out that large corporations should explore Catastrophe Bonds (Cat Bonds) to raise protection from international financial markets, viewing them as a reliable mechanism for funding reconstruction.

On the force majeure the group stressed that the current clause is not adequate in the changing climate scenario, as it often fails to account for disaster risk reduction efforts. A significant gap was underscored regarding Contingent Liabilities. Participants highlighted that while Technical Standards (T.S.) specify resilience levels, contracts often mention the T.S. without explicitly defining the resilience outcome. Consequently, in the event of a disaster, contractors often face no liability. It is required that the specific level of resilience be explicitly defined in contracts, holding contractors liable if infrastructure fails below that threshold. The group agreed that creating a grant component would enhance technological advancement by fostering shared accountability, noting that the current Technical Standards component alone is not practical enough to achieve these objectives.

8. Closing Remarks

Ms. Ranjini Mukherjee, Director, Capacity Development, CDRI, delivered the concluding address for the two-day workshop. She expressed her deep appreciation to the participants for their active engagement and physical presence, noting that the insights gathered from practitioners on the ground would significantly enrich CDRI's work. Ms. Mukherjee explained the broader context of CDRI's current initiatives, noting that the organization is working towards the second edition of its Global Report on Disaster and Climate Resilient Infrastructure, scheduled for release at COP30 in Belém. She highlighted that the report focuses on infrastructure capacity to absorb, respond, and recover from disasters. She acknowledged that the practical challenges and solutions shared by the workshop participants served as a vital validation of the recommendations being proposed in the upcoming global report. She reiterated the need to integrate resilience into power sector policies, designs, standards, and investment frameworks. She discussed the necessity of a coherent, collective "national movement" towards climate-resilient and sustainable power systems, calling for strategic plans with short, medium, and long-term actions. She highlighted the shift from theoretical concepts to on-ground action, noting the importance of building governance and institutional capacity to manage resilient infrastructure.

She shared a specific recommendation regarding Public-Private Partnerships (PPP) and contracts, suggesting that resilience standards must be clearly defined within contractual agreements to ensure systematic implementation. Regarding financial mechanisms, Ms. Mukherjee summarized the discussions on funding, advocating for blended finance models. She explained that relying solely on government grants or transferring the burden to communities via increased tariffs is not sustainable; instead, provisions for financing resilience must be created through incremental approaches. In her concluding remarks, Ms. Mukherjee acknowledged the pivotal role of mentors and partners. She thanked Shri Jenna for his long-standing guidance and commitment to disaster management. She also recognized the unwavering support from partner agencies, specifically the National Disaster Management Authority (NDMA) and the National Institute of Disaster Management (NIDM), for their collaborative role in training and advocacy. Finally, she commended the CDRI capacity building, research, event management, and administrative teams for orchestrating a successful workshop.

9. Annexes:

1. Workshop Agenda

Day 1	
Programme	**Schedule**
0930-1030	**Registration of Participants**
Inaugural Session	
1030 – 1040	**Welcome Address by Shri Ramraj Narasimhan**, Deputy Director General (DDG), CDRI
1040– 1050	**Special Address by Shri Ghanshyam Prasad**, Chairperson, Central Electricity Authority (CEA)
1050 – 1100	**Keynote Address by Shri Krishna Vatsa**, Member, National Disaster Management Authority (NDMA)
1100 - 1105	**Vote of Thanks** **Dr Amir Ali Khan,** Head-RID, NIDM
1105-1115	**Group Photograph**
1115 - 1130	**Tea**
Technical Session 1 1130-1230	**Cyclone and Flood Impacts on Power Sector and recommendations for Disaster Resilience** • **Presentation on the recommendations of the Disaster Resilient Power System study** by **Mr Amit Tripathi,** Advisor-Power Sector, CDRI (30 mins) • Reflections from the coastal states & UTs in India (30 mins) **Moderator:** Mr Pradeep Kumar Jena: Chairman, Odisha Electricity Regulatory Commission (OERC) **Key Questions (Discussion):** • What are the impacts of cyclones and floods on power infrastructure in your region? • What preparedness measures have you taken in anticipation of these events based on warnings? • What are some good practices and solutions you have implemented in your region? • How applicable is the methodology followed in the Odisha study to your region? • What modifications do you think would be necessary to tailor it to your region?
1230 – 1330	**Lunch**
Technical Session 2 1330 – 1530	**Wind Zone Map, Codes & Standards** **Context Setting Presentation** **Mr Ramraj Narasimhan, DDG**, CDRI **Moderator: Mr Amit Tripathi,** Advisor-Power Sector, CDRI • Participants will be divided into two groups based on their expertise and interests: Wind Zonation Map and Codes & Standards for the current discussion.

	• Each group will discuss key questions and develop a set of draft policy recommendations to be submitted to the relevant ministry	
	Wind Zonation **(Facilitator: CDRI)**	**Codes & Standards** **(Facilitator: NIDM)**
	Participants: • IMD • CEA • Bureau of Indian Standards (BIS) • Centre Power Research Institute (CPRI) • Power Grid Corporation of India Limited (POWERGRID) • Private Sector/ Think Tank - CEEW, Shakti Foundation • State Utilities • SDMAs	Participants: • Bureau of Indian Standards (BIS) • CEA • IMD • NTPC • PRDC • Centre Power Research Institute (CPRI) • India Smart Grid Forum (ISGF) • REC • State Utilities • NPTI • DVC
	Key Questions: • How do you assess the suitability of India's current wind zone map? • Do you think the current map needs revision? • Is the current application of the cyclonic factor adequate? • What are your thoughts on the proposal to mandate the inclusion of an AWS for capital-intensive projects? • What are the actions required to revise the wind zone maps?	**Key Questions:** • How do you assess the current codes and standards in relation to climate change and disasters, particularly for Transmission & Distribution (T&D)? • Which codes and standards do you think require immediate revision? Please categorize them into immediate, medium, and long-term priorities. • Do you support the creation of a new panel to evaluate the applicability of codes concerning climate change and disasters?
1530 - 1545	**Tea**	
Technical Session 3 1545-1715	**Disaster Preparedness**	
	Presentation on Disaster Preparedness (30 Mins) • Mr. Distribution Planning & Technology Division, CEA • Mr. Irfan Ahmad, Chief Engineer, Power Data Management & Load Forecasting Division, CEA Broad Topics to be covered:	

	• Robust electricity transmission and distribution infrastructure in the coastal areas o Disaster resource inventory for power sector (DRIPS) o Disaster management plan, task force on cyclone resilient infrastructure Q&A **(15 minutes)** **Fire Side chat (30 minutes)-** What are the actions required to strengthen power sector preparedness? Mr. Pradeep Kumar Jena: Chairman, Odisha Electricity Regulatory Commission (OERC) and Mr. Alok Kumar, DG, All India Discom Association (Former Secretary, Ministry of Power)
Day 2	
	Extreme Heat Impacts on Power Sector
Technical Session 4 1000-1130	• Presentation on **Extreme Heat Impacts on Power System** **By Ms. Shweta Kulkarni, Prayas Energy Group** • Reflections by the states on the key recommendations coming out of the study • Q & A • Way forward **Key Questions:** • What are the impacts of power infrastructure from extreme heat in your regions? • How are the preparedness measures that you have taken in anticipation of these event warning? • What are some of the good practices and solutions that you have implemented in your region? • What are the modifications that you think would cater to your region?
1130 - 1200	**Tea**
	Technology Solutions for building power sector resilience
Technical Session 5 **1200-1300**	• **Moderator: NIDM / Ministry of Power** • Brief Presentation on **Technology Solutions** CESC, Kolkata, NTPC • Discussion on the presentation • Q & A
1300 – 1400	**Lunch**
	Regulation & Financing

<table>
<tr><td rowspan="3">Technical Session 6

1400 – 1530</td><td colspan="2">Moderator: Mr. Reji Pillai, - President, India Smart Grid Forum (ISGF)

Context Setting Presentation
Mr. Pradeep Kumar Jena: Chairman, Odisha Electricity Regulatory Commission (OERC)
Mr. Srikant Nagulapalli, Additional Secretary, Ministry of Power, DG, Power Foundation of India
Mr. Safi Ahsan Rizvi, Advisor, National Disaster Management Authority (NDMA)
Note:
Participants will be divided into two groups based on their expertise and interests: Regulation and Financing for the current discussion.
Each group will discuss key questions and develop a set of draft policy recommendations to be submitted to the relevant ministry</td></tr>
<tr><td>Regulation</td><td>Financing</td></tr>
<tr><td>Participants:
India Smart Grid Forum (ISGF)
State Utilities
CEA/MoP
NPTI
NTPC
POWER Grid
DVC
PRDC
SDMAs
BIS
Key Questions:
To what extent do you support incorporating a "Resilience" component across policy frameworks? How should it be financed—by the people or the operator?
Is there an adequate cross-sectoral framework for stakeholder collaboration? How can such collaboration drive the development agenda?
Are there sufficient training programs for effective disaster preparedness? How frequently should they be conducted?</td><td>Participants:
ADB
Power Finance Corporation
REC
CEEW
Shakti Foundation
State Utilities
SDMAs
Key Questions:
Do you support the establishment of power-utility-focused funds dedicated to disaster preparedness?
What is your opinion on the various insurance mechanisms available for funding disaster reconstruction?
Is the current state of the Force Majeure clause adequate, or does it need revision?
Do Contingent Liabilities and other contractual obligations favor any particular party?
Would the creation of a grant component for power utilities enhance technological advancement?</td></tr>
<tr><td>1530 - 1545</td><td colspan="2">Tea</td></tr>
<tr><td colspan="3">Closing Remarks & Vote of Thanks</td></tr>
<tr><td>1545 - 1600</td><td colspan="2">Ms. Ranjini Mukherjee, Director, Research, Knowledge Management & Capacity Development, CDRI
Dr Amir Ali Khan, Head-RID, NIDM</td></tr>
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