

**SOUTHERN REGION**

**MANUAL FOR RECOVERY OF  
ELECTRICAL INFRASTRUCTURE  
DURING NATURAL DISASTER**

# MANUAL FOR RECOVERY OF ELECTRICAL INFRASTRUCTURE DURING NATURAL DISASTER

## 1. Introduction

In the 35<sup>th</sup> SRPC meeting held on 2<sup>nd</sup> February 2019 it was noted that the Southern Regional states are facing wrath of natural disasters every year. SRPC had endorsed the need to have Manual for recovery of Electrical Infrastructure during Natural Disaster. Among critical infrastructure, electric power is a cornerstone of modern economies.

Though natural disasters are inevitable, the risk diminution, plan, warning signals, preparedness, response & recovery can be synergised to be disaster resilient.

Natural hazards can affect the electricity supply and result in power outages which can trigger accidents, bring economic activity to a halt and hinder emergency response until electricity supply is restored to critical services.

The four priorities for action under the *Sendai Framework* (approaches promoted globally by the United Nations - a non-binding agreement- on a voluntary basis.) which holds goods for electrical infrastructure are:

- a. Understanding disaster risk
- b. Strengthening disaster risk governance to manage disaster risk
- c. Investing in disaster risk reduction for resilience
- d. Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction

## 2. Natural Hazards in Southern Region

A brief description of categories of the disasters arising from natural factors is given below:

| Hazard family | Event  | Effect on Electrical infrastructure  | Remarks  |
|---------------|--|--|--|
| Geophysical   | Earthquake/Mass movement of earth materials, Tsunami etc | Earthquakes can cause inertial damage to heavy equipment (such as generators and transformers) and brittle items and ground failure and soil liquefaction can be devastating to electric infrastructure assets. Structural damages can also occur.<br>The equipment contained in | <b>No early warning –</b><br>Periodical update and preparedness.<br>Anchored equipment performs better than unanchored equipment, and withstands relatively strong ground motion without serious damage. |

|              |                   |   |  |
|--------------|-------------------|---|--|
|              |                   | <p>buildings is often more vulnerable to dynamic horizontal loading than building structures. Control buildings include computers, network racks, electrical panels, file cabinets, HVAC equipment and battery racks. These and other equipment items that are heavy, have tall and slim shapes, and rest on small surfaces, which makes them particularly vulnerable to strong ground motion. Unanchored equipment frequently topples and/or falls from racks and tables. The risk of toppling or falling increases with the height and decreases with the base diameter.</p> <p>Large Power Transformers, Emergency Diesel Generators and turbines may break off from their foundations and tilt, topple or move horizontally. Widespread damage to the switchyard is a common occurrence.</p> <p>Earthquake damage to the sub transmission and distribution subsystems is similar to that of the transmission network.</p> | <p>Anchored batteries generally remain undamaged -they are relatively important because they provide backup power to protective equipment and control room information and communication systems.</p> <p>Anchoring and base-isolation are successful hazard mitigation options.</p> <p>Supporting columns is found to be a relatively effective hazard mitigation technique.</p> |
| Hydrological | Flood, Landslides | <p>Erosion due to the floodwaters and landslides triggered by floods undermine the foundations of transmission towers. Serious, and often explosive, damage may occur when</p>  | <p><b>Generally season based – preparedness at beginning of season.</b></p> <p>Floods are commonly associated with power outages.</p>  |

|                |   |   |   |
|----------------|---|---|---|
|                |   | electrified equipment comes in contact with water. Flooding of Control Centres, Sub Stations, switchyard, plant areas may also occur. | Restoration of a flooded substation takes much longer than the repair of a downed and damaged power line. |
| Meteorological | Hazard caused by short-lived, micro- to meso-scale extreme weather and atmospheric conditions that may last for minutes to days<br>Ex Cyclone, Storm, Wind, Lightning, Heavy Rain etc                                       | Transmission lines, distribution system, substations, switchyards, generating stations can be affected.                               | <b>Early warning possible</b>   |
| Climatological | Unusual, extreme weather conditions related to long-lived, meso- to macro-scale atmospheric processes ranging from intra-seasonal to multi-decadal (long-term) climate variability<br>Ex Drought, Forest/Wildfire Fires etc | Transmission lines and distribution systems & substations can be affected.  | <b>Warning possible.<br/>For forest/wildfire it may be sudden.</b>  |

### Cyclone and Wind

India has a long coastline of nearly 7,500 km, consists of 5,400 km along the mainland, 132 km in Lakshadweep and 1,900 km in the Andaman and Nicobar Islands. About 10 per cent of the World's tropical cyclones affect the Indian coast. Of these, the majority have their initial

genesis over the Bay of Bengal and strike the east coast of India. On an average, five to six tropical cyclones form every year, out of which two or three could be severe. Cyclones occur frequently on both the west coast in the Arabian Sea and on the east coast in the Bay of Bengal. More cyclones occur in the Bay of Bengal than in the Arabian Sea and the ratio is approximately 4:1.

In India, tropical cyclones occur in the months of May-June and October-November. The cyclones of severe intensity and frequency in the northern part of the Indian Ocean are bimodal in character, with their primary peak in November and secondary peak in May. The disaster potential is particularly high at the time of landfall in the northern part of Indian Ocean (Bay of Bengal and the Arabian Sea) due to the accompanying destructive wind, storm surges and torrential rainfall.

### **Flood**

Riverine flooding is perhaps the most critical climate-related hazard in India. Flood control is a key element of national policies for water resource management. Floods occur in almost all river basins of the country. Heavy rainfall, inadequate capacity of rivers to carry the high flood discharge, inadequate drainage to carry away the rainwater quickly to streams/rivers are the main causes of floods.

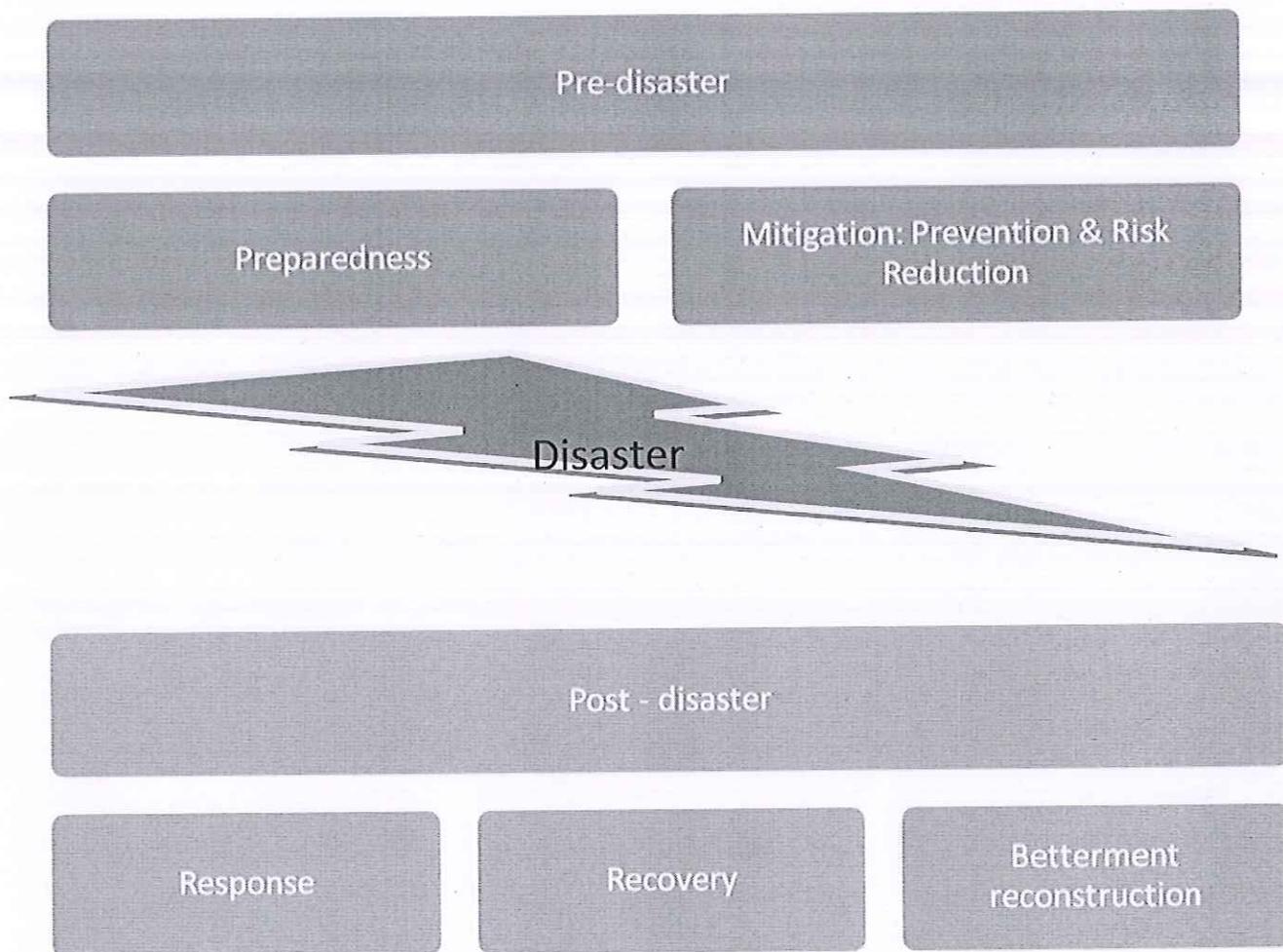
### **Urban Floods**

The problem of urban flooding is a result of both natural factors and land-use changes brought about by urban development. Urban flooding is significantly different from rural flooding as urbanisation leads to developed catchments which increases the flood peaks from 1.8 to 8 times and flood volumes by up to 6 times. Consequently, flooding occurs very quickly due to faster flow times, sometimes in a matter of minutes. Urban flooding is caused by the combination of meteorological, hydrological and human factors. Due to land-use changes, flooding in urban areas can happen very rapidly with large flow.

### **Earthquake**

Nearly 59 percent of India's territory is vulnerable to earthquakes. Collapse of infrastructure and services may be the major consequences of the earthquake.

## **3. Disaster Management Cycle**



#### 4. Risk mitigation – enhancing resilience

The following measures would be required for risk mitigation and therefore enhance resilience towards overcoming the natural disasters on electrical infrastructure:

##### 4.1 Understanding Risk

Electric power is the utility on which most other critical infrastructure sectors rely for daily operations. Therefore, a prolonged power outage is likely to adversely affect many critical infrastructure sectors which lack of redundant systems, such as backup generators. However, some of these sectors may be supporting emergency repairs and the power grid restoration effort. This produces a vicious circle, in which the disruption of the power grid caused by a natural hazard adversely affects other critical infrastructure sectors, the disruption of which undermines the recovery of the power grid.

This would require preparing a **database** of impending natural disasters based on past experience, National disaster Management Plan (NDMP) etc. **Zoning, mapping & classification** of areas on natural disasters. **GIS mapping** of electrical infrastructure w.r.t

type of hazard may be very useful in understanding the risk and also during recovery post disaster.

#### **4.2 Inter agency coordination**

Coordination with other central, state & local agencies during contingencies and in peace time is required. Co-ordination with other power utilities in Southern Region would be required to understand the needs and the requirement to ensure mobilisation of manpower & material in shortest possible time. Transport and communication are generally badly affected during the natural disasters and coordination with these agencies is also required. With the transition from the traditional to the professional paradigm, the number of responding organizations in any given disaster has risen sharply and horizontal relationships between these organizations are emphasized. As a consequence, emergency management has become even more telecommunications-intensive.

The requirements for restoration of electrical infrastructures should be effectively communicated to the Higher Management. Higher Management need to put forth the power sector restoration requirements to the state level and district level disaster coordination committee.

#### **4.3 Capacity development**

**Training & orientation** of various stakeholders needs to be carried out periodically. **Mock drills** would help in understanding the real time scenarios which can be taken care in the recovery plan itself.

#### **4.4 Risk mitigation**

The electrical infrastructure (transmission, distribution and generation) need to be resilient by proper inspection, corrections etc before the onset of cyclone period / flood period and periodically for other natural calamities like earthquake etc. **Stocking levels of critical materials are to be increased as natural disaster season approaches.** Periodic testing and inspection of material stocks is very critical. **Periodical testing and operation from back up SLDC/SRLDC needs to be taken up.** Successful strategies to mitigate flood risk include locating the substation above flood levels, levee protection and elevating sensitive equipment. Control room operation along-with DG, Battery backup etc must be possible at generating stations and substations during flooding. Water transportation needs, availability of dewatering pumps during flooding needs to be firmed up and ensured. Communication Equipment (Satellite phone/wireless sets/microwave etc) very important.

## 5. Preparedness & response

Preparedness consist of *“the knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from, the impacts of likely, imminent or current hazard events or conditions.”* Response measures are those taken immediately after receiving early warning from the relevant authority or in anticipation of an impending disaster or immediately after the occurrence of an event, without any warning.

The following should be considered as part of preparedness for natural disasters like cyclone/floods (for earthquakes it should be done periodically):

### 5.1. Zoning of the area(s) likely to be affected by the natural disaster/mapping of electrical infrastructure

The areas likely to be affected by natural disaster need to be classified. **Mapping of electrical infrastructure** in those areas needs to be carried out. Suitable instructions need to be communicated to the generators.

### 5.2 Transmission/Distribution System

The substations and transmission/distribution lines likely to affected needs to be identified. The spares (transmission towers, distribution system, line hardware, distribution transformers, conductors, substation equipment, fuel etc) requirement and placement of spares at strategic locations needs to be planned. Essential equipments like Pole drilling machines, Power-saws etc may be kept ready at strategic locations. It may be noted that the availability of spares used to replace damaged equipment or parts can reduce recovery time. Proper equipments, mobile van, transport vehicles, JCB, cranes, tractors, machinery etc should be made available. The manpower requirement (expert/skilled/unskilled) needs to be finalised along-with their positioning. Linesman, substation experts, tree trimmers etc would be required to be placed strategically. Mobilisation of manpower within the organisation, other utilities and from other neighbouring states needs to be identified and coordinated.

A detailed distribution-restoration plan is to be prepared. Each substation to be assigned a substation-restoration coordinator who would report to the area-restoration coordinator. One or more feeder-restoration coordinators, who are responsible for each circuit, report to the substation coordinator. Because these coordinators know their areas of responsibility

in advance, they are able to become familiar with their facilities. Each State may follow its own nomenclature for the above.

Water transportation needs during floods needs to be identified. In the aftermath of a major flood, access to substations, transmission towers and other facilities may be possible only by boat.

The insufficiency of reserve power (running out of battery power during prolonged power outages or backup generators failing to start or lacking fuel) is a major hindrance in recovery. **Detailed reserve power requirement should be built in the plan itself.** Batteries, panels and DG sets may be kept at higher elevations at sub-stations to avoid inundation in case of floods.

### 5.3 Control Centres

SLDCs/ALDC should be manned with **additional staff to look into the recovery procedure.** Additional control Centres could be created, if required.

Managing of the surplus power needs to be effectively coordinated by SLDCs to minimise the financial impact.

### 5.4 Studies/contingency measures

- Evaluation of existing facilities based on their criticality and development of plans for recovery in the event of the loss of all key equipment in several of these facilities (e.g., the loss of entire substations or loss for an extended period of one or several key transmission lines). Such contingency analysis should be conducted to determine the impact of this loss on other facilities.
- Bypass of facilities if they sustain significant damage.
- Identification of priority loads and extension of supply. Restoration priorities should reflect the criticality of system restoration infrastructure, public health and safety considerations and the sensitivity and criticality of customer loads.

For example, system restoration infrastructure comprising control centers, sectors supporting emergency repairs and the power grid restoration effort, communication sites, emergency off-site power to nuclear stations, auxiliary power to key substation and generating station facilities should be restored first.

Major facilities that impact public health and safety, major hospitals, critical water treatment plants, major airports and urban load centres are next.

All other customer loads can be restored after that.

**These restoration plans and priorities need to be flexible,** given that the normal supplies (substations, transmission lines and others) for those facilities may have

incurred significant damage and the restoration priority thus possibly affected. For those circumstances, alternate means of supply that differ from the normal supply may need to be considered.

- Black-start readiness of generators.
- Reactive power management - Line/cable charging strategies and other means of voltage and reactive power control is essential as grid may be very weak during these situations.
- Need to disable or adjust certain protective systems, such as those for under voltage, under frequency, synchronization checks etc.
- Availability of synchronizing equipment.
- DG sets readiness at substations with adequate fuel.
- Emergency generators – locations with adequate fuel.
- Usage of distributed generation and renewable power alternatives.
- Greater use of distribution automation and demand-side management, as well as greater deployment of distributed generation and planning for the use of these facilities in the event of contingencies, hold considerable potential to reduce the vulnerability of the existing power system particularly where network is available.
- In addition to restoration capabilities, network interconnections also increase resilience, not by speeding repairs, but by providing alternative power supply routes.
- All regular Vendors who had supplied the substation equipments and line materials to be included in the recovery plan.
- Stores should be kept open round the clock and adequately stocked.
- Sharing of mobile numbers, phone numbers etc to the officials and staff involved in the recovery to be coordinated and ensured.
- Computerised maps/hard copies of substations, towers, poles (Distribution), cables etc along with coordinates to be made available to the respective restoration teams.
- A suggestive list of the action to be taken for disaster preparedness for substation and lines/poles is given at **Appendix -I**.

#### **5.5 Emergency Restoration System (ERS)**

- Placing of ERS at strategic locations.
- Usage of ERS of other Transmission Licensees.
- Need for ERS distribution transformers.
- Spare transformers – numbers and positioning.

#### **5.6 Boarding & lodging arrangements & transport**

Staging sites are to be identified and detailed layouts to be prepared of how those sites would be used (**Appendix –II**). Boarding & lodging arrangements, medical facilities for

the personnel involved in restoration and recovery has to be planned. A pre-arranged plan for logistics, which includes provisions for tents, caterers, portable toilets etc to be set up at predetermined staging sites. Transportation of men and material to the affected locations has to be planned.

First aid practices for different emergencies needs to be put in place.

### 5.7 Communication

Communication is crucial in responding to disasters. The loss of two way communications between a power utility and its repair crews has been a major determinant of the power grid recovery time. Some critical requirements are given below

- Communication from SLDC/ASLDC to Substations, generating stations, staging sites, DISCOM's control centres etc.
- Communication from field-to-field or field-to-HQ etc.
- Coordination with local service providers.
- Charging facilities at field and staging sites. Solar operated mobile charging could also be considered.
- Use of Satellite Phones, own microwave capability, walkie-talkie etc.

### 5.8 Exemptions during contingency

Ensure temporary exemptions from laws that restrict charging, their use of equipment, access to roads, materials, supplies and other critical elements for restoration of electric service to essential loads, including those that have an impact on public health and safety. **Increased delegation of powers (technical and administrative) to field level personnel is required in case of disasters.** Allocation of funds for disaster management needs to be ensured.

## 6. Recovery and Building Back Better

Access to the damaged sites is a major determinant of recovery time in the aftermath of natural hazard. Other factors which affect the recovery time are the extent of the damage, the complexity of required repairs, the availability of spares and transportation arrangements like availability of transport vehicles along with spares at staging sites. However for a given damage level, recovery time depends on the capability of the affected electric utility companies and system operators to respond promptly and

effectively. Emergency response capabilities encompass trained staff, adequate resources and an appropriate organization.

#### 6.1 Execution of Plan

- Detailed Disaster Recovery Procedure needs to be in place. The Procedure needs to be **flexible**. Initially plan should be on recovery on round the clock basis.
- **Assessment of damage and continuous updating and modification of the recovery procedure.**
- Material / spares / manpower / resources dispatch to the affected sites needs to be coordinated in an effective manner which needs to be taken as per updated recovery plan.
- Constituents opined that use of helicopter patrolling/drone patrolling wherever feasible needs to be made available to the recovery team.
- All employees need to be assigned **clear responsibilities** and in may include functions related to system restoration, such as disaster coordination, manpower coordination, responsibility for specific geographic areas, acting as crew guides, tending to the needs of outside personnel (such as lodging and meals) and tracking restoration efforts.
- Utilization of manpower (expert/technical/skilled/unskilled) needed to be coordinated. Lunch, snacks, water etc could be arranged at the working sites rather than moving the personnel from the field to the siting locations.
- Field officials should be empowered to take decisions on the field as per the assessment of damages, prioritisation, amount of work, time period for restoration etc.
- Preemptively interrupting power supply, and pre-staging repair crews, equipment and supplies have proven highly successful in recovery.
- Evaluations of the resources needed “on the ground” for initial showing can be improved. First-day resources do not have to be line resources; they may be tree crews or evaluators.
- Backups for all positions should be identified.
- Setting up of ‘Mini’ control centers. Mini” control centers can help support operational restoration efforts but also provide local visible presence to emergency responders, government officials, other agencies etc. Major substations normally can meet these requirements.
- Establishing repair hubs for distribution transformers including filtration and oil testing facilities along with expert manpower needs to be pre-established at key locations. OEM and repair Staff for SS equipment need to be placed at key locations. Adequate no of ERS distribution transformers also could be considered by all the states.

- Constituents also suggested that helicopter lifting of some materials to remote and inaccessible places and also lifting of separated portion of transmission tower (from the damaged one particularly when damage is at stub level and the remaining portion is not damaged and can be separated) can be considered.
- Taking units / transmission elements out in a planned manner by SLDCs for safety needs and to avoid cascade tripping.
- Improved communications with other agencies. Development of relationships with local governmental agencies and other emergency responders. The transportation of heavy equipment is further complicated by the operational friction that results from the overwhelming and often conflicting demands posed by disasters.
- Additional manpower/material pre-positioned on the fringe of the affected area ready to move in wherever needed, with clear authority and accountability for the jobs assigned.
- Dedicated official to look into communication aspects. Utilities need to look closely at their communication infrastructure and evaluate all alternate communication options.
- Ensuring fuel/power to operate vehicles, equipment, generator etc
- Priorities for repairing electric facilities to be based on the stability of the electric system and restoring service to critical institutions.
- Restoring Black Start identified paths.
- Bypassing damaged facilities, temporary restoration, operating transmission elements at lower voltage level etc. Utility engineers will provide a significant role in the design of a temporary system as well as making necessary changes to the supervisory control and data acquisition (SCADA)/modeling systems to reflect the changes that will be made. Typically, temporary restoration steps will not provide the same “normal” level of contingency design that is built into permanent restoration. Therefore, all systems used to monitor the system, equipment ratings, load flow analysis programs, and alarm points may have to be modified to ensure that operators can effectively monitor and operate the system in its temporary state.
- Distributed generation and renewable power alternatives can also provide viable alternate supply sources.
- Temporary workarounds may help to restore power to customers until more permanent solutions are found.
- At the later stages of restoration, recovery teams needed to be replaced with new fresh teams to sustain the restoration process.

## 6.2 Lessons learnt

- After each disaster event utilities need to come out with lessons learnt and share it with other utilities. Corrective actions from these can be implemented in the Future Disaster Recovery Plans.

- The first threshold is the restoration of power supply to customers. This threshold includes efforts directed at temporary repairs or workarounds, as well as the use of backup generators. The second threshold is the complete repair of the network, so that temporary solutions, including generators, are no longer required.
- It has been seen that the greatest cost savings results from the effective use of outside resources and the effective use of time. Coordinated restoration of damaged generation, transmission and distribution facilities enable optimum use of scarce services and other resources.
- The establishment and operation of staging areas and the procurement of food, shelter, fuel, and security are critical to the efficient use of resources.
- Close coordination with, and support from, government agencies, local bodies and officials is also crucial.
- Constituents stated that strengthening of stub size twice that of 1<sup>st</sup> section of leg member of transmission tower have been observed to have reduced tower damages. Further, they suggested that reduced tower spans in coastal areas have been effective during cyclones.
- Constituents observed that foundation mapping of future sub-stations may be based on 30-50 years of flood level mapping.
- Tower checking before onset of monsoons to see for missing elements or other damages etc. so as to avoid tower failures.
- Use of Concrete poles in 1 out of 4 poles in distribution side, in coastal areas also can reduce the risk of tower damages.

## 6.2 Build Back Better

Globally the approach towards post-disaster restoration and rehabilitation has shifted to one of betterment reconstruction. It is an opportunity to “Build Back Better” (BBB) integrating disaster risk reduction into development measures and making electrical infrastructure resilient to disasters. Use of underground cables and spun poles in distribution system in cyclone prone areas. Replacement with aesthetic poles and with energy saving lighting fixtures etc could also be planned.

## 7. Capacity Development

Capacity development covers strengthening of institutions, mechanisms and capacities at all levels of all stakeholders as decision making of the concerned people is very important in saving of time to bring the system to normalcy. It is an important component of investing in disaster risk reduction. The capacity development themes are;

- Prevention or mitigation for disaster risk reduction
- Effective preparedness and response

- Recovery and Build Back Better
- Electrical safety procedures and manuals
- Accident Prevention Techniques and Reporting procedures
- Standard Safety Earthing Practices
- Disasters and Impacts warning systems

## 8. Conclusion

The need for power utilities to develop, implement and exercise comprehensive outage management plans before disaster strikes is well established. These emergency plans should include emergency repair, temporary repairs or workarounds, assigning of responsibilities, resource identification and positioning and deal with coordination and communication. Emergency rosters of, including on-call arrangements for, qualified personnel available to respond to natural disasters or other incidents should be made. Plans should address communications with other responding organizations, information management and logistics. Emergency operation plans developed by Utilities/System Operators need to be integrated and aligned with emergency response plans developed by local, regional and national agencies to synergise the efforts without duplication of effort. Emergency plans should be regularly updated based on the lessons learnt. Mock exercises are necessary to train personnel and put emergency response systems to the test under realistic conditions.

The availability of spares and replacement parts and equipment for critical assets and facilities is a critical need and often makes the difference between a speedy and prolonged recovery. It is well noted that repairs were faster whenever spare parts were readily available. Assistance by neighbouring states and other power utilities is proven to have resulted in early recovery. If required, mutual aid agreements can be entered upon.

Critical customers need to be identified before disaster strikes, for expedition and prioritisation.

**Increased delegation of powers (Administrative, technical and financial) to field level personnel has to be effective in speedy recovery.**

Once disaster strikes, the emergency plan can be used to establish repair and recovery priorities. This process needs to be dynamic as priorities will change depending on the response and recovery objectives set by decision-makers and emergency managers, and the resources available.

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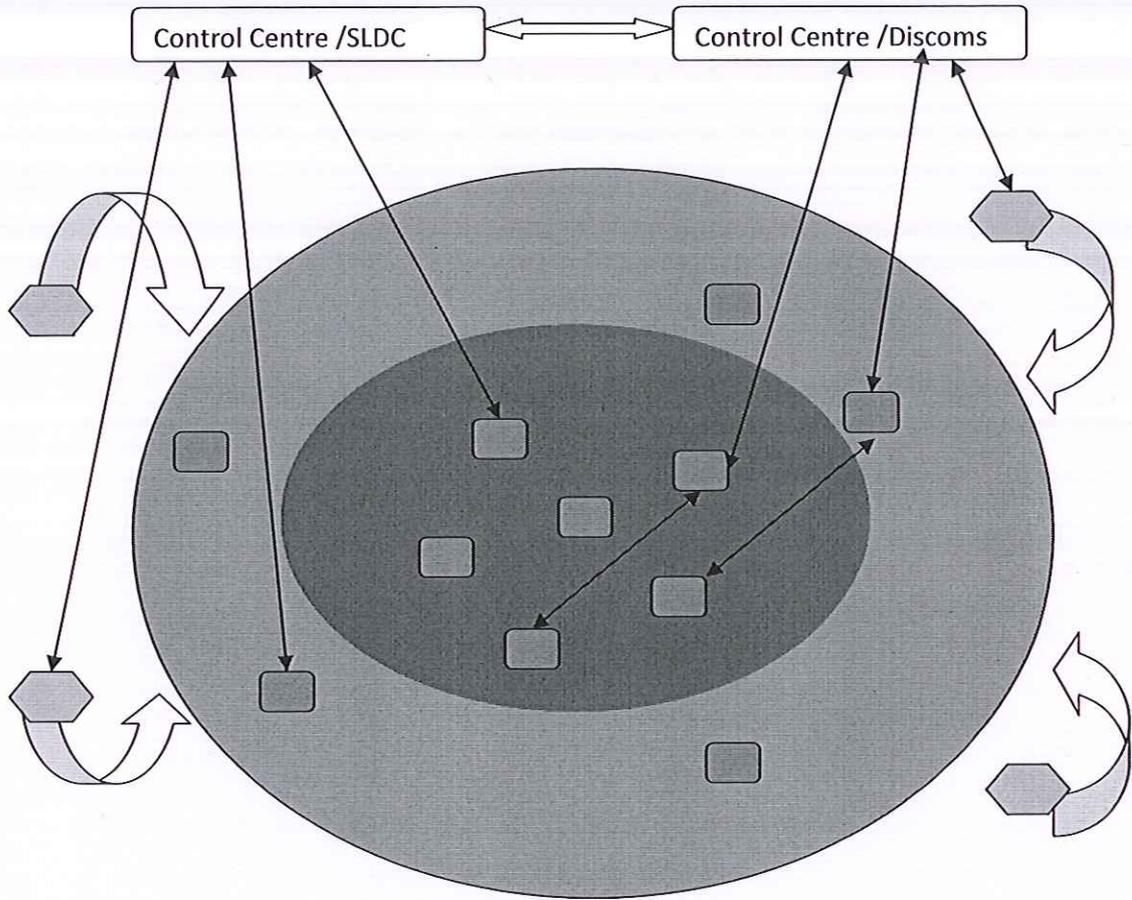
### Preparedness for early rectification during natural disasters at Substations

- ✓ Healthiness of all the equipments in SS should be confirmed.
- ✓ Weak jumpers, insulators and clamps to be replaced.
- ✓ Healthiness of auto and power transformers to be ensured. Adequate oil level in transformers conservator and OLTC has to be maintained. All the OLTC chamber, Buchholz relay and PRV should be properly covered so as to avoid water entry and tripping of Auto/Power Transformers. All the OLTCs are to be kept in operating conditions.
- ✓ Station & CC Battery and Battery charger systems shall be maintained in good condition.
- ✓ Heaters provided in the Marshalling boxes, MOM boxes, temperature indicator boxes (OTI/WTI) of transformers, all mechanism boxes and OLTC mechanism boxes in yard, relay panel, control panels and dc panels in the control room, battery room etc will be kept intact to avoid DC leakage.
- ✓ The earthing system may be effectively maintained and verified.
- ✓ The supply availability for the station transformer may be kept under watch. Alternative feeding supply arrangement may also be made readily available. The changeover switching arrangement to be kept in-tact.
- ✓ All type of available communication system/equipment (DOT, CC, Walki-Talkie etc) to be made available in working condition.
- ✓ Adequate spares for breaker viz closing/tripping coil and other equipment spares to be kept ready to meet out emergency.
- ✓ Hot spots are to be identified well in advance with Thermal Imaging Camera and same has to be rectified.
- ✓ Healthiness of relay, protection system etc will be checked regularly with the assistance of protection wing.
- ✓ Ensuring adequate illumination in the substation.
- ✓ Sand bags for temporary bund and arresting leakage in compound walls may be arranged and stacked in the respective SS in ground level.
- ✓ Dewatering pump should be made ready for bailing out water and avoid flooding.
- ✓ Aged PG clamps to be replaced with new wedge connectors.
- ✓ Weak jumpers and defective insulators to be replaced.
- ✓ Adequate spares viz clamps SS/ST fitting, mid span joint has to be maintained.
- ✓ Healthiness of DG set to be checked and to be hired, if required.
- ✓ Adequate fuel for DG set has to be procured and stored in advance.

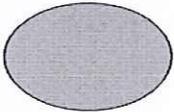
- ✓ Sufficient number of officers with staff to be readily made available in the prone area before the disaster. All the officers and staff needed to be trained periodically to handle disaster and critical situations.
- ✓ The assessment of disaster to be made immediately after occurrence of disaster without any delay.
- ✓ Necessary number and type of vehicles to be hired for rectification works.
- ✓ Necessary funds to be allotted to the disaster prone area for early rectification.
- ✓ The insulators at the coastal areas may be replaced with polymer insulator.
- ✓ The 230 kV and 110 kV sketch of their respective jurisdiction may be kept at SS. A copy of the sketch may be given to the team coming from outside. This may be user friendly to provide route and location for rectification.

### **Preparedness for early rectification during natural disasters for Transmission and Distribution lines**

- ✓ Pre cyclone / pre monsoon line patrol to be carried out and healthiness to be ensured. Defective insulators to be replaced. Weak jumpers to be replaced.
- ✓ Keep all tower drawings, tower schedules, hardware drawings etc readily available.
- ✓ Tree/bush clearance, identification and rectification of low sag conductors.
- ✓ Coping, earthing and refixing of missing parts of towers and to complete any pending works.
- ✓ Hot spots are to be identified well in advance with Thermal Imaging Camera and same has to be rectified.
- ✓ Ensuring availability and healthiness of power saw, walkie-talkie, flash lights / emergency lamps etc.
- ✓ Adequate men and material viz towers, poles, conductors, tower parts, insulators, clamps, SS/ST fittings, mid span joints etc should be made available for round the clock restoration.
- ✓ Crimping tools, chain pulley blocks, ladder, meggers, tong testers, rain coats, helmets, rubber hand gloves and other tool kits and safety equipments need to be ensured.
- ✓ Lorry, jeep, tractor, JCB, cranes, gas cutters etc need to be made available.
- ✓ Take immediate action for replenishment of damages and shortages.



Area likely to be severely affected



Area likely to be partially affected



Staging sites - manpower (skilled/unskilled), material, boarding & lodging, communication with field, communication with other sites, communication with Control centres (Transmission/Distribution)



Peripheral Staging sites – ready to move in to support