

विद्युत क्षेत्र के लिए
संकट एवम् आपदा प्रबंधन योजना

**CRISIS AND DISASTER
MANAGEMENT PLAN FOR
POWER SECTOR**



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**MINISTRY OF POWER
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EXECUTIVE SUMMARY

Background

Power Sector is one of the most important infrastructure of the country, as growth of this sector is directly correlated with the economic growth of the country. Any disruption in Power Sector due to Crisis / Disaster creates hardship to the human beings, as every aspect of human life is directly or indirectly associated with the electricity.

India has experienced many natural disasters such as drought, flood, earthquakes and cyclones during the past. It has also experienced many manmade crises such as terrorist attacks, bomb explosions, strikes, fires etc. The natural disasters / man-made disasters always involve losses / damage of infrastructure of the country. In order to eliminate or if not possible, to minimize damage/disruption in generation, transmission and distribution of electricity sector, it becomes extremely important to evolve crisis / disaster management plan for this sector.

Therefore, the very purpose of preparation of this document is to evolve more proactive, holistic and integrated approach of strengthening disaster preparedness, mitigation and emergency response in event of disaster taking place. The 'Crisis and disaster management Plan for power sector' provides a framework and direction to the utilities in power sector for all phases of disaster management cycle. This document is in accordance with the provisions of Disaster Management Act 2005 and the Guidelines issued by NDMA from time to time and the established practices.

Vision

To make Indian Power Sector disaster resilient, achieve substantial disaster risk reduction, and significantly decrease the loss by maximizing the ability to cope with disasters at all levels of administration as well as at the field level

Hazard Risk & vulnerability Analysis (HRVA)

India, is one of the most disaster prone areas of the world. India has been vulnerable, in varying degrees, to a large number of natural, as well as human-made disasters on account of its unique geo-climatic topographic features, environmental degradation, population growth, urbanisation, industrialization, non- scientific development practices and socio-economic conditions. Hazard Risk & vulnerability Analysis involves vulnerability

mapping, zoning for wind, cyclones, earthquakes, Tsunami, floods etc and building power structures in accordance with the Zone in which it falls and safety factor as per relevant Indian Standard.

Disaster Risk Reduction and Building Resilience

India was, until recently reactive and only responded to disasters and provided relief from calamity. But, in recent times, there has been a paradigm shift and India has become or is becoming more proactive with emphasis on disaster prevention, mitigation and preparedness. In today's scenario, disaster management is a continuous and integrated process of planning, organizing, coordinating, and implementing measures, which are necessary for prevention of danger or threat of any disaster. This covers building resilience at planning, design and operation stage.

Capacity Building

Capacity building in power sector infrastructure involves areas like Prevention or mitigation for disaster risk reduction, Effective preparedness and response, recovery and build back better. This consists of directions for programmes in Building Resilience in Electricity infrastructure, Mock Drill Exercises, Public Awareness Programmes, Risk assessment and Vulnerability study in each area of responsibility etc..

Preparedness and Response

Preparedness & response consists different aspects, which are to be covered as an organisational practice for effective mitigation of any disaster in future. Preparedness & response also gives direction for effective and well organised coordination among different organisations like RPC, RLDC, SLDC,STU,CTU for better preparedness in the situation of disaster /crisis.

Recovery and Building-Back-Better including reconstruction

This includes aspects like measures for quick restoration of power supply, restoration of transmission line, Emergency Restoration Systems (ERS), restoration of Sub-Stations,

restoration of load dispatch centres (LDCs) and Building back disaster resilient infrastructure.

Role & Responsibilities

To effectively deal with disaster situations in power sector, a four-tier structure has been put in place– Central Level, Regional Level, State Level and Local Unit Level, with intervention and response depending on the severity of the disaster /calamity. The composition of this four-tier structure (composition of the Groups) at various levels are as Central Level Disaster Management Group (CDMG), Regional Level Disaster Management Group (RDMG), State level Disaster Management Group (SDMG) and Plant Level Emergency Management Group (EMG). The roles and responsibilities have been set out for each Group and team under these groups.

1. Introduction:

Electricity is the lifeline of the economy as well as of the society. Power supply is the major input for the social and economic welfare of the society of any country. Any disruption in the supply of electricity causes not only loss to the economy, but also creates hardship to human beings, as every aspect of human life is connected with electricity. India has experienced many natural disasters such as drought, floods, earthquakes and cyclones during the history of its civilization. It has also experienced many manmade crisis situations such as terrorist attacks, bomb explosions, strikes, fires etc.

Any crisis / disaster can lead to disruption in generation, transmission and distribution and supply of electricity. It, therefore, becomes extremely important to evolve crisis / disaster management plan to restore the generation, transmission, distribution and supply of electricity to the affected areas in the shortest possible time with minimum damage to infrastructure. Distribution sector is under the purview of state government in which magnitude of damage to infrastructure is high. Underground Hydro stations in operation as well as ongoing area are more prone to emergencies.

This document deals with the various events, which may cause crisis or disasters in the power sector, preventive measures which need to be adopted to avoid any crisis / disaster, ways and means to tackle a crisis / disaster if it occurs in spite of preventive measures. It outlines a hierarchical set up of crisis & disaster management at various levels for effectively and efficiently dealing with crisis and emergent situations as well as roles/responsibilities of various Central/State Departments and Utilities in disaster management as per provisions of Disaster Management Act 2005 and National Policy on Disaster Management 2009.

The Crisis and Disaster are synonymous for power sector, as far as this document is concerned the word Disaster is synonymous with Crisis.

1.1 Over view of Ministry of Power

Ministry of Power, Government of India, is primarily responsible for the development of electricity sector in the country. The Ministry is concerned with perspective planning, policy formulation, processing of projects for investment decision, monitoring of the implementation of power projects, training and manpower development and the administration and enactment of legislation in regard to thermal and hydro power generation, transmission and distribution of electricity etc. The Ministry of Power is

responsible for the Administration of the Electricity Act, 2003, the Energy Conservation Act, 2001 and to undertake such amendments to these Acts, as may be necessary from time to time, in conformity with the Government's policy objectives. Ministry of power has a vital role in disaster and crisis management in power sector. It coordinates the disaster management at central level with national agencies like NDMA and other central ministries of govt. of India.

Organizations under Ministry of Power are as under:

1.1.1 Statutory Bodies

1.1.1.1 Central Electricity Authority (CEA)

Central Electricity Authority (CEA) is a statutory body responsible for the technical coordination and supervision of programmes in power sector and is also entrusted with a number of statutory functions. The Central Electricity Authority prepares a National Electricity Plan in accordance with the National Electricity Policy and notifies such plan once in five years. Any generating company intending to set-up a hydro-generating station also requires the concurrence of the Central Electricity Authority. It advises the Central Government on matters relating to the National Electricity Policy; formulates short-term and perspective plans for development of the electricity system and coordinates the activities of the planning agencies for the optimal utilization of resources to sub serve the interests of the national economy and to provide reliable and affordable electricity to all the consumers.

1.1.1.2 Appellate Tribunal for Electricity (APTEL)

Appellate Tribunal for Electricity (APTEL) is a statutory body constituted for the purpose of hearing cases against the orders of the Regulatory Commissions and the Adjudicating officer.

1.1.1.3 Central Electricity Regulatory Commission (CERC)

Central Electricity Regulatory Commission (CERC) is a statutory body to regulate the tariff of generating companies owned or controlled by the Central Government, to regulate the tariff of generating companies other than those owned or controlled by the Central Government, if such generating companies enter into or otherwise have a composite scheme for generation and sale of electricity in more than one State, to regulate the inter-

State transmission of energy including tariff of the transmission utilities, to grant licences for inter-State transmission and trading and to advise the Central Government in formulation of National Electricity Policy and National Tariff Policy.

1.1.1.4 State Electricity Regulatory Commissions (SERCs)

SERCs are statutory bodies responsible for determination of tariff and grant of license at intra-State level. Main responsibilities of the SERCs are to determine the tariff for generation, supply, transmission and wheeling of electricity, whole sale, bulk or retail sale within the State.

1.1.1.5 JERC for GOA & UTs and JERC for Manipur and Mizoram

These are statutory bodies responsible for determination of tariff and grant of license at intra-State/UT level. Main responsibilities of the JERCs are to determine the tariff for generation, supply, transmission and wheeling of electricity, whole sale, bulk or retail sale within the State/UT.

1.1.1.6 Central Transmission Utility (CTU)

Central Transmission Utility (CTU) is a statutory body to undertake transmission of energy through inter-State transmission system and discharge all functions of planning and coordination relating to inter-State transmission system with State Transmission Utilities, Central Government, State Governments, generating companies etc. Power Grid Corporation of India Limited is the Central Transmission Utility.

1.1.1.7 State Transmission Utility (STU)

State Transmission Utility (STU) is a statutory body to undertake transmission of energy through intra-state transmission system and discharge all functions of planning and coordination relating to intra-State transmission system with Central Transmission Utility, State Governments, generating companies etc.

1.1.1.8 National Load Dispatch Centre (NLDC)

Function of National Load Dispatch Centre (NLDC) is scheduling and dispatch of electricity over inter-regional links, coordination with Regional Load Dispatch Centres for achieving maximum economy and efficiency in the operation of National Grid and monitoring of operations and grid security of the National Grid.

1.1.1.9 Regional Load Dispatch Centre (RLDC)

RLDC is the apex body to ensure integrated and power system in each region. The RLDC is responsible inter-alia for dispatch of electricity within the regions, monitoring grid operations etc. The directions given by the RLDC for ensuring grid stability etc. are required to be complied with by the licensees, generating company, generating stations, sub-stations and any other person connected with the operation of the power system.

1.1.1.10 State Load Dispatch Centre (SLDC)

The SLDCs at the State level have the responsibility of ensuring integrated operations of the power system in State.

1.1.1.11 Grievances Redressal Forum and Ombudsman

Every distribution licensee has a forum for Redressal of Grievances of consumers. Ombudsman is a statutory authority to be appointed or designated by the State Commission to hear and settle the non-redressal of grievances at the level of Grievance Redressal Forum.

1.1.1.12 Bureau of Energy Efficiency (BEE)

The Bureau of Energy Efficiency BEE is responsible for spearheading the improvement of energy efficiency of economy through regulatory and promotional instruments.

1.1.1.13 Damodar Valley Corporation (DVC)

The Damodar Valley Corporation (DVC) is the first multipurpose integrated river valley project. Committed for economic and industrial growth of Damodar Valley Region extending over area of 24,235 sq. km in States of West Bengal and Jharkhand.

1.1.1.14 Bhakra Beas Management Board (BBMB)

Bhakra Beas Management Board (BBMB) is for the administration, maintenance and operation of Bhakra Nangal Project. BBMB manages the facilities created for harnessing the waters impounded at Bhakra and Pong in addition to those diverted at Pandoh through the BSL Water Conductor System. It has also been assigned the responsibility of delivering water and power to the beneficiary States in accordance with their due/ entitled shares. The Board is responsible for the administration, maintenance and operation

works at Bhakra Nangal Project, Beas Project Unit I & Unit II including power houses and a network of transmission lines and grid sub-stations.

1.1.2 Public Sector Undertakings

1.1.2.1 National Thermal Power Corporation (NTPC)

NTPC is the largest power generating company in India for building large size thermal power stations, along with associated transmission systems, to accelerate the integrated development of power sector in the country. NTPC has transformed from a thermal power generator to an integrated power company with presence across entire energy value chain through diversification and backward & forward integration and is also in the development of hydro power, coal mining, power trading, ash business, equipment manufacturing, renewable energy, power distribution, etc.

1.1.2.2 National Hydroelectric Power Corporation (NHPC)

National Hydroelectric Power Corporation Ltd. (NHPC) is into the business of harnessing the vast hydro, tidal and wind potential of the country to produce cheap/ pollution-free and inexhaustible power.

1.1.2.3 Rural Electrification Corporation (REC)

Rural Electrification Corporation (REC) provides financial assistance for rural electrification in the country. Rural Electrification Programmes financed by the Corporation cover electrification of villages, including tribal villages and Dalit Bastis, energisation of pump sets, provision of power for small, agro-based and rural industries, lighting of rural households and street lighting. The Corporation has also been providing assistance to the State Electricity Boards for taking up system improvement projects for strengthening and improving sub-transmission and distribution system and small generation projects like wind energy and hydel projects.

1.1.2.4 North Eastern Electric Power Corporation (NEEPCO)

North Eastern Electric Power Corporation Ltd. (NEEPCO) is for adding to the power generating capacity in the North Eastern Region by installing hydro and thermal power plants and to undertake long term feasibility studies for optimum development of hydro power resources of river basins in North Eastern Region.

1.1.2.5 Power Finance Corporation (PFC)

The Power Finance Corporation Ltd. (PFC) functions as the prime development financial institution dedicated to the growth and overall development of the power sector. The borrower-portfolio of PFC comprises the State Electricity Boards, State Generation Corporations, Municipal run power utilities besides the central and private sector power utilities. The funds provided by the Corporation are in the nature of the additional to Plan Allocation (in respect of SEBs etc.) and based on the merits of the individual projects.

1.1.2.6 Power Grid Corporation of India (PGCIL)

PGCIL was established to facilitate transfer of power within and across the Regions with “reliability, security and economy on sound commercial principles” as its mission.

1.1.2.7 SJVN Limited

SJVN Limited is a joint venture between the Government of India & Government of Himachal Pradesh. SJVN is fast emerging as a major power player in the country. SJVN is successfully operating the country’s largest 1500 MW Nathpa Jhakri Hydropower Station. It has already ventured into Renewable Energy and it also planning to set up thermal power stations.

1.1.2.8 THDC India Limited

THDC India Limited is a joint venture of the Government of India and Government of Uttar Pradesh to develop, operate & maintain the 2400 MW Tehri Hydro Power Complex and other hydro projects and for development of Conventional/ Non-conventional/ Renewable sources of Energy and River Valley Projects.

1.1.3 Autonomous bodies

1.1.3.1 Central Power Research Institute (CPRI)

The Central Power Research Institute (CPRI) is an autonomous society to serve as a National Laboratory for undertaking applied research in electric power engineering besides functioning as an independent National Testing and Certification Authority for electrical equipment and components, to ensure reliability and improve, innovate and develop new products.

1.1.3.2 National Power Training Institute (NPTI)

National Power Training Institute (NPTI) is the national apex body for the Human Resources Development for Power Sector in India. The Headquarters of NPTI is located at Faridabad (Haryana). It operates on all-India basis through its four Regional Power Training Institutes located at Neyveli (Tamil Nadu), Durgapur (West Bengal), Badarpur (New Delhi) and Nagpur (Maharashtra). It functions as a nodal Institute for Power Sector training not only for designing, implementing and supervising the whole power sector training activities but also to create the right type of organisational culture.

1.2 Purpose of the Disaster Management Plan

The purpose of this plan is to define the actions and roles necessary to prepare for and respond to any disaster situation in the Power Sector in a coordinated manner. Disaster Management (DM) Plan is intended to provide guidance to all agencies within the sector with a general concept of potential emergency and roles and assignments before, during, and following emergency situations. A document on crisis and disaster management plan had earlier been prepared by CEA in 2004 which was updated in 2012. The current document now covers roles/responsibilities in line with the Principles laid down by Disaster Management Act, 2005 and policy on disaster management Guidelines for emergency preparedness for thermal & hydro generation, transmission, distribution and renewable energy Sector are being separately brought out by CEA. It provide broad guidelines to the utilities to prepare the documents for crisis and disaster management encompassing the emergency situations to which their plants are vulnerable.

1.3 Scope

Disaster Management (DM) Plan encompasses the activities that enable the various agencies involved in generation, transmission, distribution and supply of electricity to plan for, quickly respond to and to recover from unexpected events and situations. Disaster Management Plan is a tool to provide necessary guidelines for assistance to these organizations for ensuring safety of people, protection of installation and environment and restoration of power supply. It has the following objectives:

- To improve state of preparedness to meet any contingency
- To reduce response time in organizing the assistance.
- To identify major resources, man power material & equipment needed to make the plan operational
- Making optimum use of the combined resources.

The administrative response to disasters has been by and large the responsibility of the State Government and intervention of the Central Government is sought in the case of disasters of large proportions. However, as disaster management is a multi-disciplinary process, all Central Ministries and Departments have key role in the field of Disaster Management. Ministry of Power has designated NLDC as Central Control Room to deal with emergency situations in power sector. CEO NLDC is designated as nodal officer to coordinate with RLDCs to handle emergency situations

1.4 Plan Management (Development, Approval, implementation, Review and Revision)

Chief Engineer (PS&LF Division), CEA will be responsible for developing, maintaining, revising, reviewing and updating the basic Crisis and Disaster Management Plan, annexes, appendices, and supplementary documents, such as checklist, SOPs, etc. for Power sector at the National level. These documents shall be reviewed every year in January to update the names and contact details of officers concerned. The document shall be reviewed in the third year for updating of contents.

At the State level, utilities associated with construction and operation of generation, transmission, distribution and load dispatch centres are required to prepare their basic disaster management plan.

The Crisis/Disaster Management Plan of each utility would be updated by the concerned utility in the month of December and its revised plan furnished to MOP/CEA. The updated plan must take into account the experiences from the past crisis/ disasters, which occurred during the period under review. All the Central Public Sector Undertakings and all the State Utilities involved in generation/transmission/distribution are also required to prepare a Crisis/Disaster Management Plan and are to accord the highest priority to building up their own Disaster Management Capabilities at all levels in consonance with the Guidelines and provisions of Disaster Management Act, 2005.

With a view to periodically review this booklet the inputs, updated information would be obtained from stakeholders. For this purpose, a Permanent Standing Committee under Chairmanship of Member (Planning), CEA, with representatives of CPSUs, State utilities/IPPs & other concerned organizations is proposed to be constituted.

2. Hazard Risk and Vulnerability Analysis (HRVA):

India has a highly diversified range of natural features. Its unique geo-climatic conditions make the country among the most vulnerable to natural disasters in the world. Disasters occur with very high frequency in India and while the society at large has adapted itself to these regular occurrences, the economic and societal costs continue to rise. In addition to the natural disasters Power Sector is affected by Crisis situations also.

Crisis/Disasters

“Crisis” is defined as an event of acute danger, which can cause sudden disruption of power supply. The event is caused either due to human error / equipment failure or sabotage by anti -social elements.

“Disaster” refers to a catastrophe, mishap, calamity or grave occurrence from natural or manmade causes which are beyond coping capacity of affected community. It leads to disruption of normal life including that of the power supply. Natural or other disasters can strike suddenly anytime and anywhere.

As far as this document is concerned the word ‘Disaster’ is synonymous with ‘Crisis’.

History of Disasters:

Major disasters which have occurred in India are as follows:

List of Major Disasters in India				
Sl. NO	Name of Event	Year	State & Area	Affected/Losses
1.	Indo-Nepal Earthquake	2015	Nepal and Northern India including Bihar, Uttar Pradesh and West Bengal.	More than 8,600 people dead in Nepal, 17 people died in Bihar, Rs. 33,500-35,000Cr
2.	Indo-Pakistan	2014	Jammu & Kashmir	Rs. 5.000-6,000Cr.

3.	Cyclone Hud-Hud	2014	Andhra Pradesh	Rs. 22,000 Cr.
4.	Cloud burst & Floods	2013	Uttarakhand	6,000 people dead, Rs. 3000 Cr.
5.	Cyclone Phailin	2013	Coastal Odisha and Andhra Pradesh	12 million People affected. 44 people have been reported dead from Odisha; Rs. 4,600 Cr
6.	Cyclone Nilam	2013	Tamil Nadu	Rs.200 Cr; 100 People dead
7.	Assam floods	2013	Assam Flood in Brahmaputra river and its tributaries	12 districts out of 27 in the state where more than 100,000 people affected; Rs 200 Cr loss
8.	Himalayan Flash Floods	2012	Landslides and flash floods in North India	31 people dead while 40 are reported to be missing
9.	Sikkim Earthquake	2011	North Eastern India with epicentre near Nepal Border and Sikkim	At least 111 People killed.
10.	Cloud Burst	2010	Leh, Ladakh in J&K	At least 255 people died 9000 people were directly affected; Rs 133 Cr
11.	Drought	2009	252 Districts in 10 States	-NA-
12.	Floods	2009	Andhra Pradesh, Karnataka, Orissa, Kerala, Delhi, Maharashtra	300 People died; Rs 25-30 Cr
13.	Kosi Floods	2008	North Bihar	527 deaths, 19,323 livestock perished, 2,23,000 houses damaged, 3.3 million persons affected; Rs 1980 Cr

14.	Cyclone Nisha	2008	Tamil Nadu	204 deaths; Rs 3400 Cr
15.	Maharashtra	2005	Maharashtra State	1094 deaths, 167 injured, 54 missing; Rs 450 Cr (direct financial loss)
16.	Kashmir Earthquake	2005	Mostly Pakistan, Partially Kashmir	1400 deaths in Kashmir; Rs 10,000 Cr (86,000 deaths in total)
17.	Indian ocean Tsunami	2004	Coastline of Tamil Nadu, Kerala, Andhra Pradesh, Pondicherry and Andaman and Nicobar Islands of India	10,749 deaths, 5,640 missing 2,79 million people affected 11,827 hectares of crops damaged 300,000 fisher folk lost their livelihood; Rs 5,200 Cr.
18.	Gujarat Earthquake	2001	Rapar, Bhuj, Bhachau, Anjar, Ahmedabad and Surat in Gujarat State	13,805 deaths 6.3 million people affected; Rs 2,100 Cr
19.	Orissa Super Cyclone	1999	Orissa	Over 10,000 deaths; Rs 19,600
20.	Cyclone	1996	Andhra Pradesh	1,000 people died, 5,80,000 houses destroyed, Rs 72,500 Cr. Estimated damage
21.	Latur Earthquake	1993	Latur, Marathwada region of Maharashtra	7,928 people died, 435,000 acres of land affected; Rs 1,100
22.	Cyclone	1990	Andhra Pradesh	967 people died, 435,000 acres of land affected; Rs 1.100 Cr
23.	Drought	1987	15 States	300 million people affected
24.	Cyclone	1977	Andhra Pradesh	10,000 deaths hundreds of thousands homeless 40,000 cattle deaths
25.	Drought	1972	Large part of the country	2000 million people affected

2.1 Hazard, Risk and Vulnerability mapping

India has been vulnerable, in varying degrees, to a large number of natural, as well as human-made disasters on account of its unique geo-climatic topographic features, environmental degradation, population growth, urbanisation, industrialization, non-scientific development practices and socio-economic conditions. The factors either in original or by accelerating the intensity and frequency of disasters are responsible for heavy toll of human lives and disrupting the life supporting system in the country. Clearly, all these contribute to a situation where disasters seriously threaten India's economy, its population and sustainable development. In fact, India is one of the ten worst disaster prone countries of the world.

The basic reason for the high vulnerability of the country to natural disasters is its unique geographical and geological situations. As far as the vulnerability to disaster is concerned, the distinctive regions of the country i.e. Himalayan region, the alluvial plains, the hilly part of the peninsula desert, and the coastal zone have their own specific problems. While on one hand the Himalayan region is prone to disasters like earthquakes and landslides, the plain is affected by floods almost every year. The desert part of the country is affected by droughts and famine while the coastal zone is susceptible to cyclones and storms. Out of the 35 states and union territories in the country, 27 are disaster prone. Almost 58.6 per cent of the landmass is prone to earthquakes of moderate to very high intensity; over 40 million hectares (12 per cent of land) are prone to floods and river erosion; of the 7,516 km long coastline, close to 5,700 km is prone to cyclones and tsunamis; 68 per cent of the cultivable area is vulnerable to drought and the hilly areas are at risk from landslides and avalanches.

2.2 Natural calamities and their Zoning

Hazards and disasters are two sides of the same coin neither can be fully understood or explained from the standpoint of either physical science or social science alone and are inextricably linked to the ongoing environment changes at global, regional and local levels. Environmental hazards exist at the interface between the natural events and human systems. Disaster in power sector can occur due to natural calamities such as:

- Floods/cloud burst
- Cyclones/Hurricanes
- Earthquakes

- Landslides
- Tsunamis

The impacts of these disasters and their multiplier effects on economy, national development and severity of affected infrastructures are well known but needs to be adequately quantified. Natural calamities like earthquakes, cyclones, floods, tsunamis etc., have been scientifically and statistically studied based on data collected the world over. It has become possible to predict their intensities with certain degree of confidence so that structures/ equipment/ machinery, etc. can be designed to withstand the effect of these forces. Seismic loads as well as wind loads have been measured/instrumented in the country by various organizations like India Meteorological Department, Geological survey of India etc. As regard to floods, Central Water Commission has established network of G&D sites for the measurement of various parameters of discharge of major rivers and forecasting the floods.

2.2.1 Risk Assessment of electricity infrastructure

As already discussed in earlier chapters India is among the world's most disaster prone areas. In every disaster, electricity infrastructure including buildings, tall structures, foundations in generation plants, towers lines, substations in transmission & poles, towers, substations, RMU in distribution are vulnerable to damage. The concept of disaster zoning identifies the areas having similar parameters on the average. Suitable margins and factor of safety are to be considered in design of structures to sustain the severity according to the zone characteristics. However, the intensity suddenness and extent of any natural calamity are beyond any perfect assessment and have to be effectively managed in the event of its occurrence.

2.2.2 Floods

India is one of the most flood prone countries in the world. The principal reasons for flood lie in the very nature of natural ecological systems in this country, namely, the monsoon, the highly silted river systems and the steep and highly erodible mountains, particularly those of the Himalayan ranges. The average rainfall in India is 1150 mm with significant variation across the country. The annual rainfall along the western coast and Western Ghats, Khasi hills and over most of the Brahmaputra valley amounts to more than 2500 mm of rainfall. Most of the floods occur during the monsoon period and are usually

associated with tropical storms or depressions, active monsoon conditions and break monsoon situations.

2.2.1.1 Incidences of flooding

Recently there have been number of incidences of flooding of Hydro Power Stations in operation. Earlier also some incidence of flooding of Hydro Power Stations during construction or O & M stage had taken place. Incidences of flooding of Power Stations which have been noticed are as shown in Table.

Table: Incidences of Flooding of HE Stations

S. No	Dated	Name of Power Station	Type of Turbine	Cause of Flooding	During Const./ O&M Stage
1.	27.06.2008	Kulhal Power Station (3x10 MW.), UJVNL Uttarakhand	Vertical Shaft Kaplan	At 01.00 hrs. heavy rain at Kulhal area brought along with boulders, debris, shrubs, garbage, mud which started coming inside the power house due to blockage of entire path of water stream to go to Siphon and water diverted to power house thus flooded the power house up to the level of machine hall area, Control Room, LT Room etc. with a depth 4-6 Inches.	O&M
2.	27.08.2006	Dehar HE Project (6x165 MW), BBMB, Punjab	Francis	Leakage from shaft gland sealing of turbine of Unit 6.	O&M
3.	11.07.2006	Rangit HE Project, (3x20MW), NHPC, Sikkim	Francis	While removing the blockage in the Penstock tapping, for cooling water system to generating units, water started coming at full pressure from penstock and rose up to service bay level.	O&M
4.	04.09.2005	Nathpa Jhakri HE Project (6x250MW), SJVNL,	Francis	Detachment of blind flange at the T- Junction of Pressure equalizing pipe of Unit No. 4 and non-ceiling of the DT gates properly even after two	O&M

		Himachal Pradesh		attempts.	
5.	01.08.2000	Nathpa Jhakri Power House, SJVNL, Himachal Pradesh	Francis	Unprecedented flood of 6500 cusecs passed the project (Dam site to power house reach) raising TRT outfall level. Flood water entered PH through TRT.	Construction
6.	28.06.2005	Ghatghar HE Project (2x125 MW), Maharashtra	Francis-Reversible Turbine	Because of heavy rains, a major land slide occurred near lower intake structure causing dislodging of 2 lakh cum of material which damaged RCC diversion wall in left side of approach tunnel to intake structure that resulted in material (debris) entering into TRT and ultimately to power house complex through link tunnels and approach tunnel.	Construction
7.	August 2004	Urgam SHP (2x1500 kW), UJVNL Uttarakhand	Horizontal Shaft-Pelton wheel	Project damaged due to flash flood caused due to cloud burst. Kalp ganga river brought down heavy boulders alongwith it and changed the course towards Power House causing intensive damage to switchyard & flood protection work and washed away vital structures.	O&M
8.	27.07.2003	Indira Sagar HE Project (8x125 MW), NHDC, Madhya Pradesh	Francis	Heavy rains before flooding raised the water level in the river. Tawa and Bargi dams upstream of the project. With increase in water level and release of water from Tawa dam the river water entered TRC towards Tail Pool Area on D/S of Power House.	Construction
9.	04.06.2003	Periyar (4x35 MW) HE Project TNEB	Francis	Due to the heavy corrosion in drain pipe, water gushed into Rotary valve pit from turbine end, turbine floor flooded.	O&M
10.	30.06.1995	Peryyar (4x35 MW) HE Project TNEB	Francis	Due to the bursting of the spiral casing drain pipe leading into the draft tube hydraulic floor flooded.	O&M

11.	12.04.2001	Maneri Bhali Stage-I HE Project (3x30 MW) UJVNL Uttarakhand	Francis	The upper draft tube cone which was bolted with the pivot ring through 32 nos. of studs completely came out from its original position by one and half feet and was resting on guide plate. This caused the flooding of power house.	O&M
12.	28.08.2000	Chilla Power Plant (4x36 MW), UJVNL Uttarakhand	Vertical Kaplan	Draft tube window of Unit-4 was washed off which resulted in flooding of power house.	O&M
13.	06.06.2000	Sobla- I HE Project (2x3 MW), UJVNL, Uttarakhand	Pelton Wheel	Due to high flood the PH structure and column foundation collapsed Partly, leaving the structure overhanging.	O&M
14.	11.12.1998	Vaigai HE Project, (2x3MW), TNEB	Vertical Shaft Kaplan Turbine	Due to heavy down pour the surplus water splashed into the roof opening of valve house located adjoining spillway course and started flooding the valve house and in turn power house.	O&M
15.	03.10.2009	Sri Sailam Right Bank HE Project, (7x 110 MW), APSEB, Andhra Pradesh	Francis	Unprecedented high flood resulted in high Tail Water Level over-topping the protection wall by about 1 m and flooding the Power House completely.	O&M
16.	15.10.1998	Sri Sailam Right Bank HE Project, (7x 110 MW), APSEB, Andhra Pradesh	Francis	Flood water entered into the Sri Sailam Right bank power house from the downstream of Sri Sailam reservoir, scouring away a portion of the coffer dam which separates the power house from the main course of the river.	O&M

17.	17.08.1998	Doyang HE Project, (3x25 MW), Nagaland NEEPCO	Francis	Massive landside took place on 17.08.98 on the left bank of Doyang river in a location about 1/2 km downstream of the outlet of Diversion Channel thereby completely blocking the river flow. The water rose to EL 263.50m and flowed backwards into the power house overtopping the downstream Ring Bund. The water entered the power house through Draft Tube Gate No. 1 which had been completed but was partly open as work was still in progress in that unit.	Construction
18.	13.11.1992	Servalar (1x20 MW) HE Project, TNEB	Francis	Water entered in the power house over flowing the tail race.	O&M
19.	25.06.1985	Servalar (1x20 MW) HE Project, TNEB	Francis	Water entered during flooding in the power house from the dummy plate of the penstock.	Construction
20.	10.09.1992	Salal-I HE Project (3x115 MW), NHPC, J&K	Francis	High Flood discharge caused splashing water in the reservoir to enter the Dam toe power house which rose up to the lower hung portion of generator.	O&M
21.	27.07.1986	Salal-I HE Project (3x115 MW), NHPC, J&K	Francis	Flash Flood of 238 mm (recorded) on account of highest rainfall since 1978 submerged stator and rotor of unit- I and stator of unit -2 and machinery lying in TRT.	Construction
22.	April 1991	Pillur (2x50MW) HE Project, TNEB	Francis	For Flushing of silt, the scour vent in the Dam was opened, after depleting the water in the reservoir. The silt could not flow in to the river because of the concentration, mounted in front of the scour vent and entered in to nearby Power House.	O&M
23.	1983	Matatila HE Project (3x10.2MW)	Francis	Flood in River caused water to enter cable trenches and cable tunnel.	O&M

24.	1974	Loktak (3x35 MW) HE Project, NHPC, Manipur	Francis	Leakage from Draft tube plug.	Construction
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2.2.1.2 ANALYSIS OF FLOODING INCIDENTS

Only 24 incidents of flooding of Hydro Power Station have been listed above where as the actual incidents of flooding which might have taken place may be much more. Some incidents of flooding might not have been reported and in other cases even if reported, information and data may have been lost due to passage of time. Therefore, there is need to issue guidelines/instructions and prescribing a format for reporting the incidents of flooding and then this information and data should be maintained at a central location and update from time to time. In case of incidents involving loss of human or animal life, electricity rules have made it mandatory for all installation to report such incidents. Similar practice needs to be followed in case of flooding of Hydro Power stations.

Analysis of these incidents provides very valuable information which has been classified under different categories as under:

- (i) Out of 24 incidents, 17 incidents have occurred in Hydro Power Stations under O&M stage and 7 in construction stage.
- (ii) 19 incidents happened in Hydro Power Stations having Francis turbine because in case of Francis turbine, tail race level is almost at the generator floor level and major part of power house is under water.
- (iii) In case of projects under construction, in four out of seven incidents flood water entered through TRT/Tail pool.
- (iv) Inadequate capacity of drainage and dewatering pumps and improper sealing of DT gates was a major hindrance in preventing the flooding incidents.
- (v) Due to submergence of drainage and dewatering pumps control panels resulting is non-availability of drainage and dewatering pumps also hindered prevention of flooding incidents.

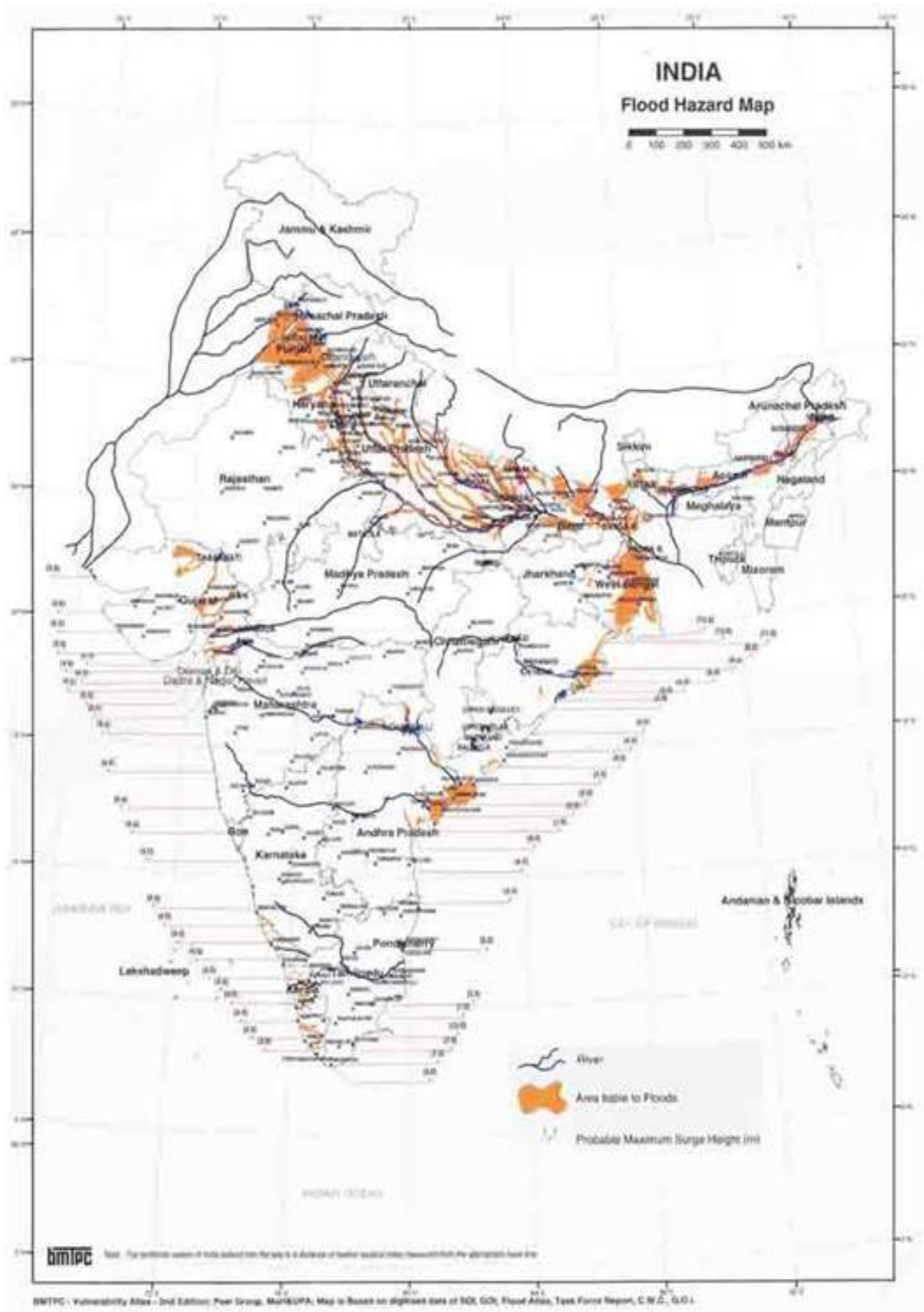
On analysis of the nature of flooding of the power stations, it is observed that the extent of the damage and rehabilitation period could have been minimized had adequate measures been taken at design stage, construction stage or during operation of the Power houses. In some cases, even flooding of Power house could have possibly been prevented. The learnings from the analysis need to be adopted suitably.

2.2.1.3 Flood Plain Zoning

Twenty-three of the 35 states and union territories in the country are subject to floods and 40 million hectares of land, roughly one-eighth of the country's geographical area, is prone to floods. Floods occur in almost all rivers basins in India. The main causes of floods are heavy rainfall, inadequate capacity of rivers to carry the high flood discharge, inadequate drainage to carry away the rainwater quickly to streams/ rivers, ice jams or landslides blocking streams. Typhoons and cyclones also cause floods. Flash floods occur due to high rate of water flow as also due to poor permeability of the soil. Areas with hardpan just below the surface of the soil are more prone to floods as water fails to seep down to the deeper layers. The areas prone to floods are given below:

Areas liable to Floods in India
Region/States
Punjab, Uttar Pradesh, Northern Bihar, West Bengal, Assam, Arunachal Pradesh, Odisha, Coastal Andhra Pradesh, Kerala, Parts of Gujarat, Kashmir Valley

FLOOD HAZARD MAP OF INDIA



The basic concept of flood plain zoning is to regulate land in the flood plains in order to restrict the damage by floods, which are likely to occur from time to time. The flood plain zoning as such aims at determining the locations and the extent of areas likely to be affected by floods of different magnitudes/ frequency and to develop these areas in such a fashion that reduces damage to a minimum. Central Water Commission (CWC) has carried out flood plain zoning in some of the river basins in the country. As per the concept of flood plain zoning, the flood has been classified in the following three categories as shown in Figure:

- a) Prohibitive zone
- b) Restricted zone
- c) Warning zone

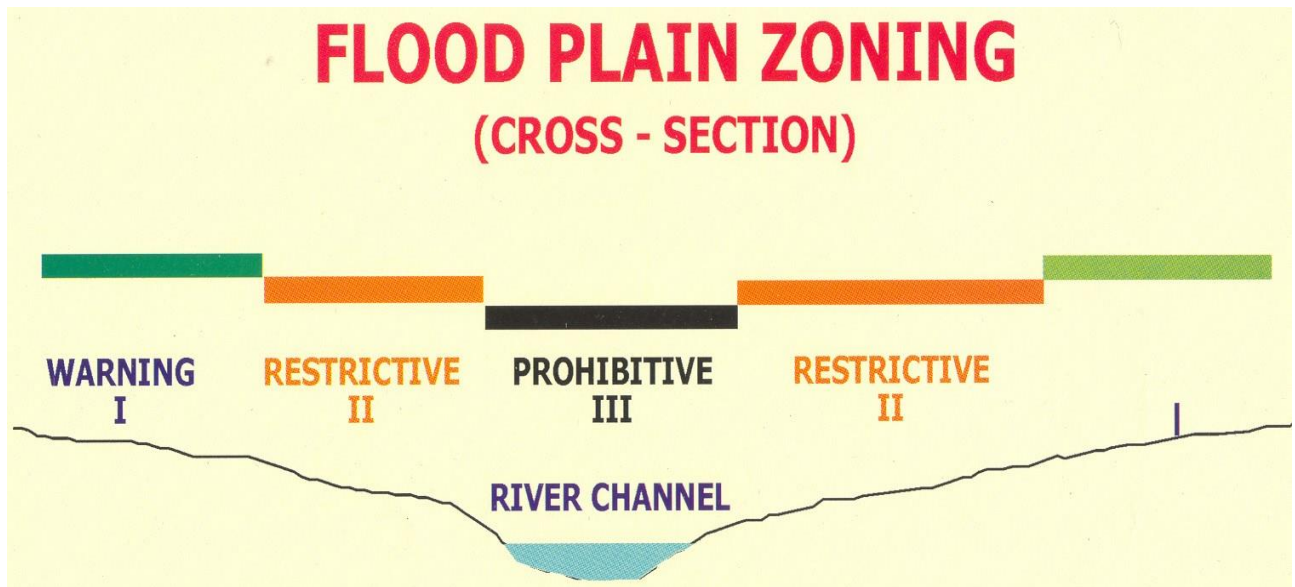


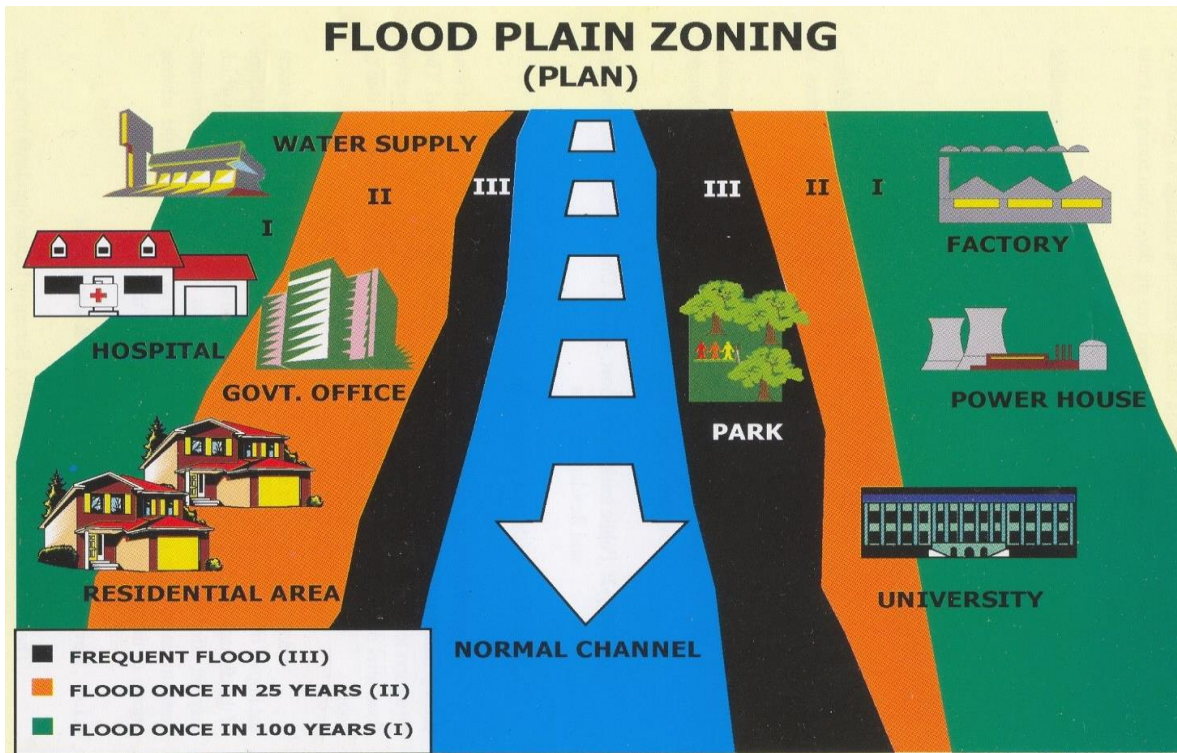
Figure : Flood plain Zoning

For the purpose of regulating land use in different flood zones, different type of buildings and utility services have been grouped under three priorities as given below:

Priority-1: Defence installations, industries and public utilities like hospitals electrical installation, water supply, telephone exchange, aerodromes, railway stations, commercial centres, etc.,

Priority-2: Public institutions, Government offices, Universities, Public Libraries and Residential Areas

Priority-3: Parks and Playgrounds



As per said zoning, no power project should be located within the flood zone corresponding to a 100 years' frequency or the maximum observed flood level. The formation level of power plants is kept at least 1.0 m above any damage due to floods.

Dam Burst computer simulation studies should be normally done to assess the impact of the failure of major dam on downstream side and for making the assessment of the damages likely to occur. Such studies reveal to some accuracy the areas which may get affected in case of a failure of dam and as such the future development downstream the dam can be accordingly regulated so as to minimize the adverse impact of the disaster on account of the failure of the dam.

2.2.2 Cyclones

The major natural disaster that affects the coastal regions of India is cyclone and as India has a coastline of about 7516 kms, it is exposed to nearly 10 percent of the world's tropical cyclones. About 71 percent of this area is in ten states (Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Puducherry, Andhra Pradesh, Odisha and West Bengal). The islands of Andaman, Nicobar and Lakshadweep are also prone to cyclones. On an average, about five or six tropical cyclones form in the Bay of Bengal and Arabian sea and hit the coast every year. Out of these, two or three are severe. When a cyclone approaches the coast, a risk of serious loss or damage arises from severe winds,

heavy rainfall, storm surges and river floods. The effect of a storm surge is most pronounced in wide and shallow bays exposed to cyclones such as in the northern part of Bay of Bengal. On an average, five or six tropical cyclones occur every year, of which two or three could be severe. Most cyclones occur in the Bay of Bengal followed by those in the Arabian Sea and the ratio is approximately 4:1. The incidence of cyclonic storms, with wind speeds between 65 km/h and 117 km/h and severe cyclonic storm with wind speeds between 119 km/h and 164km/h, reaching Tamil Nadu and Andhra Pradesh is high during the north east monsoon season ie. October – December, whereas the highest annual number of storms, severe storms occur in the Odisha - West Bengal coast.

2.2.2.1 Zoning for Wind Load:

IS 875 Part-III indicates the wind speeds and wind load intensities in various parts of the country based on measured and collected data on wind speeds. The classification of zones as per wind speed and cyclone in India are given in table below.

Cyclone Zones in India	
Zone	Region/States
Zone A (Wind speed > 55 m/s) Very high Damage	Ladakh, Assam, Tripura, Mizoram
Zone B (Wind speed > 50 m/s) Very high Damage	Coastal areas of Gujarat, Tamil Nadu, Andhra Pradesh, Orissa, West Bengal
Zone C (Wind speed > 47 m/s) Very high Damage	Indo Gangetic Plain, Punjab, Kutch Region

The power plant structures are to be designed taking into account the wind loads and its effect on the structures as per the said code Wind design parameters have been averaged over a relatively long period of time (i.e. 1.0 minute wind to 1.0 hour wind) and require a gust factor greater than 1.0 to be applied for design of structures, systems, or components (SSC). More recently the fastest 3 second duration gust wind is being defined for SSC design purposes (incorporated in IS 875). A wind speed having a return period of 100000 to 1000000 years should be used to define these wind loads in the Extreme Category.

.In case of very tall structures like chimney and natural draught cooling towers, model studies in wind tunnel must also be invariably carried out to minimize the possibility of any damage to these tower structures under extreme wind conditions.

The Cyclone hazard map of India (gives the vulnerability map of hazard due to cyclone).

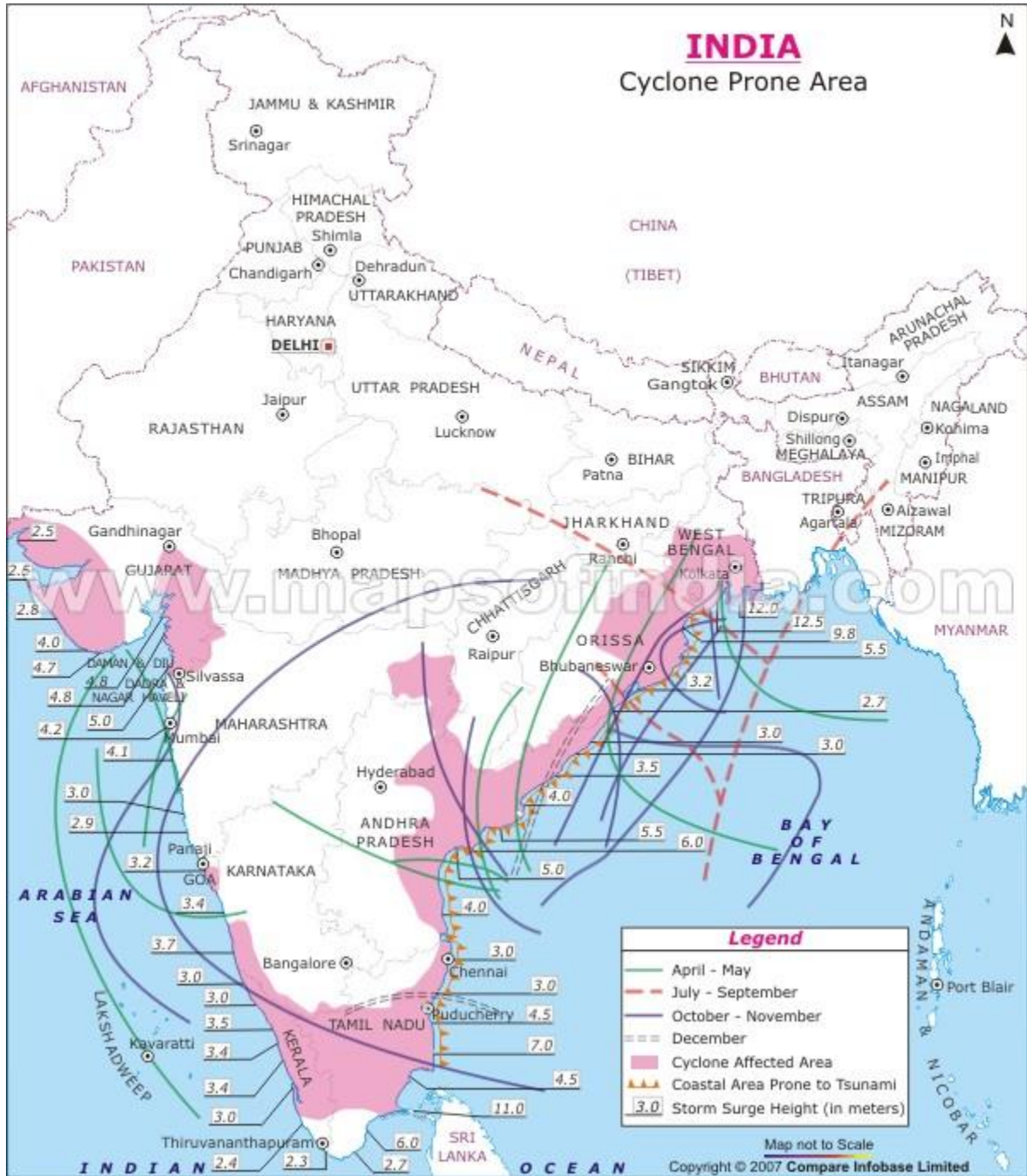


Figure : Cyclone and wind hazard Map

Cyclonic winds prediction & simulation

Indian Meteorological Department (IMD) has been working in predicting the cyclonic events with help of satellites and numerical weather prediction tools. Prediction of

cyclone and its landfall occurrence can be done accurately up-to 12 hours validity by IMD. Cyclonic events and their damage to power infrastructure is defined by IMD as follows:

S.No.	Cyclone Type	Wind Speed (Kmph)	Inundation distance from coast line	Damage
1	Severe	88-117	Upto 5 km	Moderate
2	Very Severe	118-167	Upto 10 km	Large
3	Extra Severe	168-221	Upto 10-15 km	Extensive
4	Super	222 & above	Upto 40 km	Catastrophic

Above Table shows the relation between cyclone severity and damage to power lines. Cyclonic winds due to Phailin, Nilam, Hud-Hud and other events in Bay of Bengal belt had 3-minute sustained maximum wind speed of about 260 kmph. While the design wind speed used for making these monopoles with adequate factor of safety is up to 200 - 220 kmph.

2.2.3 Earthquakes

Globally, earthquakes result in a loss of about 50,000 lives every year. Earthquakes over 5.5 magnitude on the Richter scale are progressively damaging to property and human life. However, there are many other factors that influences the damage pattern. Massive earthquakes generally occur near the junction of two tectonic plates, e.g., along the Himalayan range, where the Indian plate goes below Eurasian plate. The Indian sub- continent situated on the boundaries of two continental plates is very prone to earthquakes. Some of the most intense earthquakes of the world have occurred in India. Fortunately, none of these have occurred in any of the major cities

India has highly populous cities and the constructions in these cities are not earthquake resistant. Regulatory mechanisms are weak, thus any earthquake striking in one of these cities would turn into a major disaster. Six major earthquakes have struck different parts of India over a span of the last 15 years.

The entire Himalayan Region is considered to be vulnerable to high intensity earthquakes of a magnitude exceeding 8.0 on the Richter Scale, and in a relatively short span of about 50 years, four such major earthquakes have occurred in the region: Shillong, 1897 (M 8.7); Kangra, 1905(M.8.0); Bihar–Nepal, 1934 (M 8.3); and Assam–Tibet, 1950 (M 8.6). Scientific publications have warned that very severe earthquakes are likely to occur anytime in the Himalayan Region, which could adversely affect the lives of several million people in India.

2.2.3.1 Zoning for Earthquakes

Earthquakes occur due to movements along faults that have evolved through geological and tectonic processes. The extent of the impact of an earthquake depends on its magnitude, location and time of occurrence. Geological Survey of India and India Meteorological Department are mainly monitoring the earthquake hazards of the country. **Bureau of Indian Standard (BIS) code IS: 1893 deals with the earthquake resistance design of various structures including structures for power plants.** As per the code, the country has been demarcated from the point of view of intensity of seismic loads in four Zones i.e. Zone-II to Zone-V. According to latest seismic zoning map brought out by the Bureau of Indian Standard (BIS), over 65 percent of the country is prone to earthquake of intensity Modified Mercalli Intensity Scale (MSK) VII or more.

Seismic Zone	II	III	IV	V
Prob. Max. Intensities (MSK Scale)	IV Or Less	VII	VIII	IX Or More

Earth quake Zones in India		
Sl.No.	Zone	Region/States
1	Zone V (Highest Risk areas with intensity MSK IX or greater)	Kashmir, the western and central Himalayas, North Bihar, the North-East Indian region and the Rann of Kutch
2	Zone IV (High Risk areas liable to MSK VIII)	Indo-Gangetic basin including Delhi, Jammu and Kashmir, Parts of Maharashtra, Gujarat
3	Zone III (Moderate Damage Risk Zone which is liable to MSK VII)	Coastal Areas, Andaman and Nicobar Islands, Parts of Kashmir, Western Himalayas
4	Zone II (Low damage Risk zone liable to MSK VI or less)	Most of Deccan & Chota Nagpur Plateau, Rajasthan

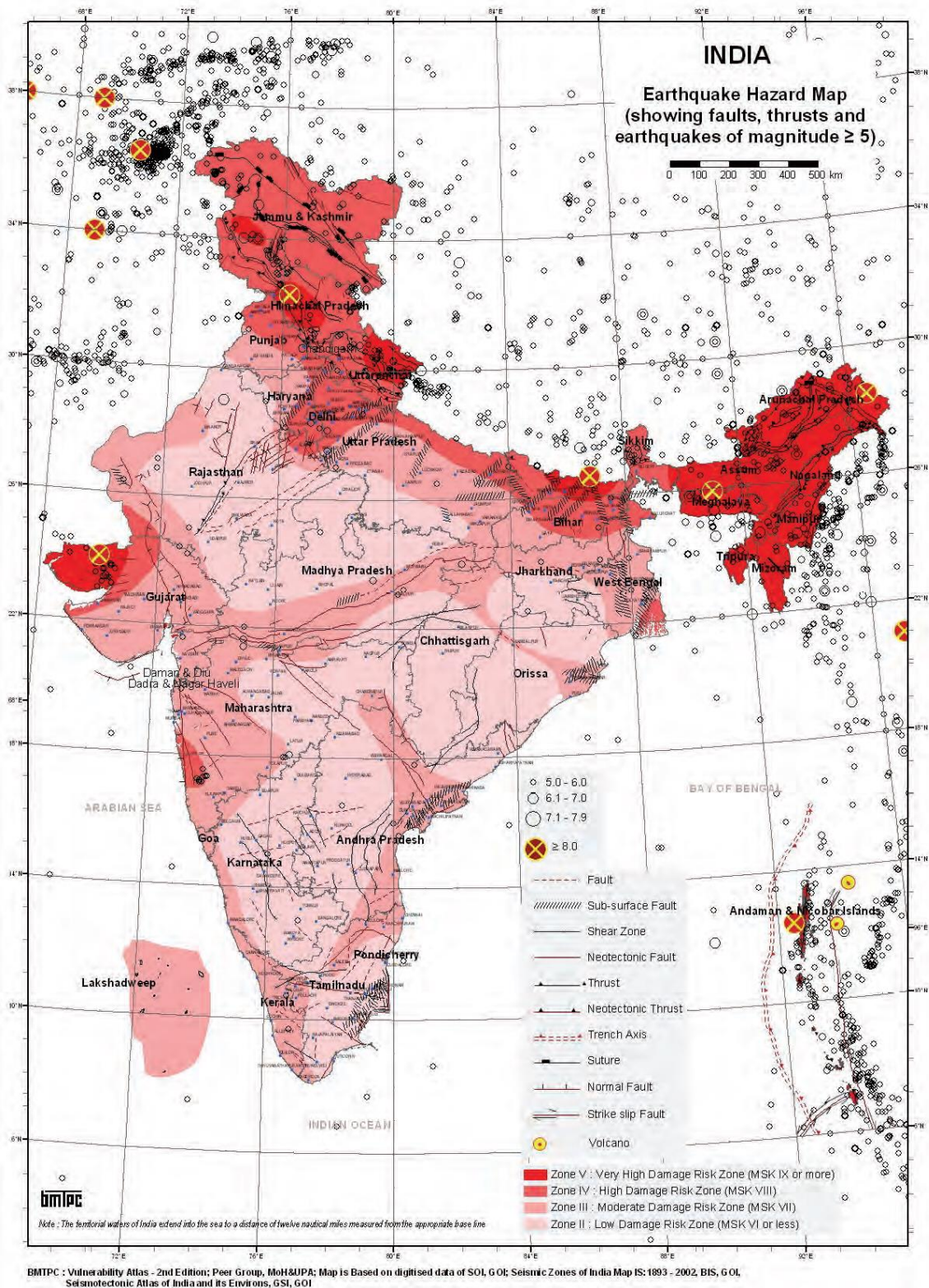


Figure: Earthquake Hazard Map

Power supply installations are either located to avoid high seismic zones or designed based on BIS Code. In case of Hydroelectric projects and especially large dams, site specific seismic studies of the project area need to be carried out and the design of structures finalized accordingly. The instrumentation should be carried out both in dams &

power House area during construction. For major dams, Government of India, Ministry of Water Resources under Central Water Commission (CWC) has set up a committee, which examines the whole issue of design seismic parameters. The recommendations of the committee are to be adopted for the design of large dams in the country.

2.2.4 Landslides

Landslides mainly affect the Himalayan region and the Western Ghats of India. Landslides are also common in the Nilgiri range. It is estimated that 30 percent of the world's landslides occur in the Himalayas. The Himalayan Mountains, which constitute the youngest and most dominating mountain system in the world, are not a single long landmass but comprises a series of seven curvilinear parallel folds running along a grand arc for a total of 3400 kilometres. Due to its unique nature, the Himalayas have a history of landslides that has no comparison with any other mountain range in the world. Landslides are also common in Western Ghat. In the Nilgiris, in 1978 alone, unprecedented rains in the region triggered about one hundred landslides which caused severe damage to communication lines, tea gardens and other cultivated crops. A valley in Nilgiris is called "Avalanches Valley". Scientific observation in north Sikkim and Garhwal regions in the Himalayas clearly reveal that there is an average of two landslides per sq. km. The mean rate of land loss is to the tune of 120 meter per km per year and annual soil loss is about 2500 tonnes per sq km.

Landslide monitoring systems

The disaster management network has to harness the local knowledge based warning systems for landslide hazards. The monitoring of hazardous locales by educated, aware, and sensitized communities is the most valuable and reliable information base for developing an effective early warning system. Local committees or groups have to be identified and trained to discern early warning signs, gather information and disseminate them to the appropriate OM cells. There have been marked improvements in the quality, timeliness and lead time of hazard warnings, mainly driven by scientific and technological advances. For landslide monitoring identifying the incipient instability of slopes and early warning of ensuing landslides is possible through systematic mapping, slope instrumentation, monitoring and real-time data analysis. Modern technology offers a number of high resolution instruments that can capture, monitor and transmit data for real-time analysis and forecasting.

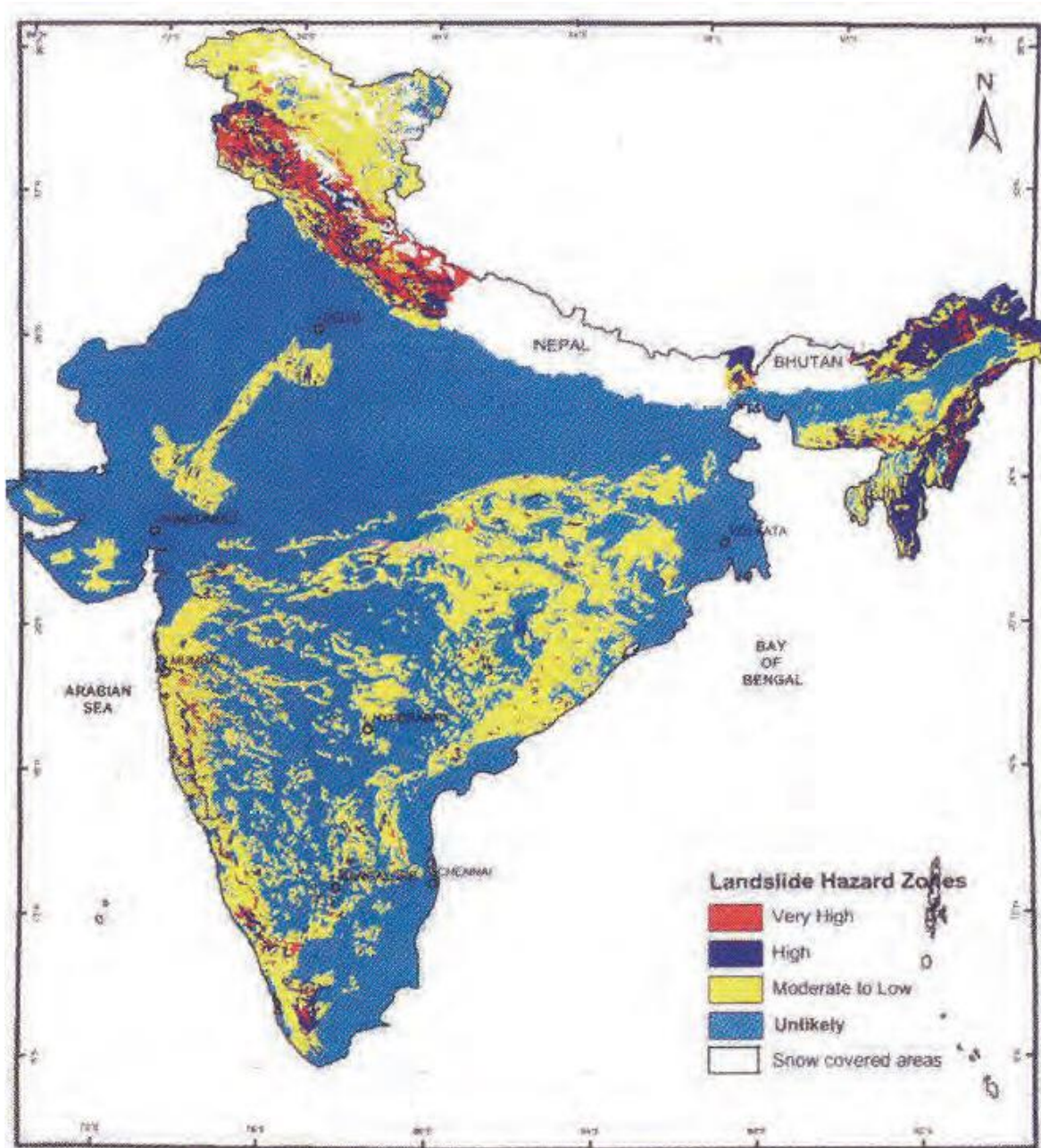


Figure - shows the landslide hazard zones in India Simple devices commonly used for early warning against landslides in the recent past are:

1. Wire or special switches, actuated by the pressure of moving debris to give signal.
2. Electrical switch poles which turn to an upright position upon displacement.
3. Photo-electrical barriers, especially for rapidly moving debris flows or earth flows.
4. Pulsed radar for snow avalanches.
5. Fiber optic sensors and technology.
6. Acoustic emission technology.
7. Auto-actuated photographic systems.
8. GPS observations.

The nodal ministry in consultation with the Technical Advisory Committee (TAC) and collaboration with the MoM-GSI; State Disaster Management Authority; Central Scientific Instrument Organization; Wadia Institute of Himalayan Geology; IITs, Universities and other academic institutions develop warning systems through research projects. Figure shows the landslide hazard zones in India

2.2.5 Tsunami

Tsunamis and earthquakes happen after centuries of energy build up within the earth. A tsunami (in Japanese 'tsu' means harbour and 'nami' means wave) is a series of water waves caused by the displacement of a large volume of a body of water, usually an ocean. In the Tamil language it is known as "Aazhi Peralai". Seismicity generated tsunamis are result of abrupt deformation of sea floor resulting vertical displacement of the overlying water. For earthquakes occurring beneath the sea level, the water above the reformed area is displaced from its equilibrium position. The release of energy produces tsunami waves which have small amplitude but a very long wavelength (often hundreds of kilometre long). It may be caused by non-seismic event also such as a landslide or impact of a meteor

2.2.5.1 Tsunami Zoning

Tsunami in the deep ocean may have very long wavelength of hundreds of kilometre and travels at about 800 km per hour, but amplitude of only about 1 km. It remains undetected by ships in the deep sea. However, when it approaches the coast its wavelength diminishes but amplitude grows enormously, and it takes very little time to reach its full height. Tsunamis have great erosion potential, stripping beaches of sand, coastal vegetation and dissipating its energy through the destruction of houses and coastal structure.

Potential Tsunami genic zones may be seen from Figure below. For Tsunami to hit the Indian coast according to INCOIS(Indian National Centre For Ocean Information Services), it is necessary that the earthquake of magnitude more than 7.0 on Richter scale should normally occur. The possible zones for such an event to occur are Andaman - Sumatra or Makran (Pakistan). Not all the major earthquakes are Tsunami genic.

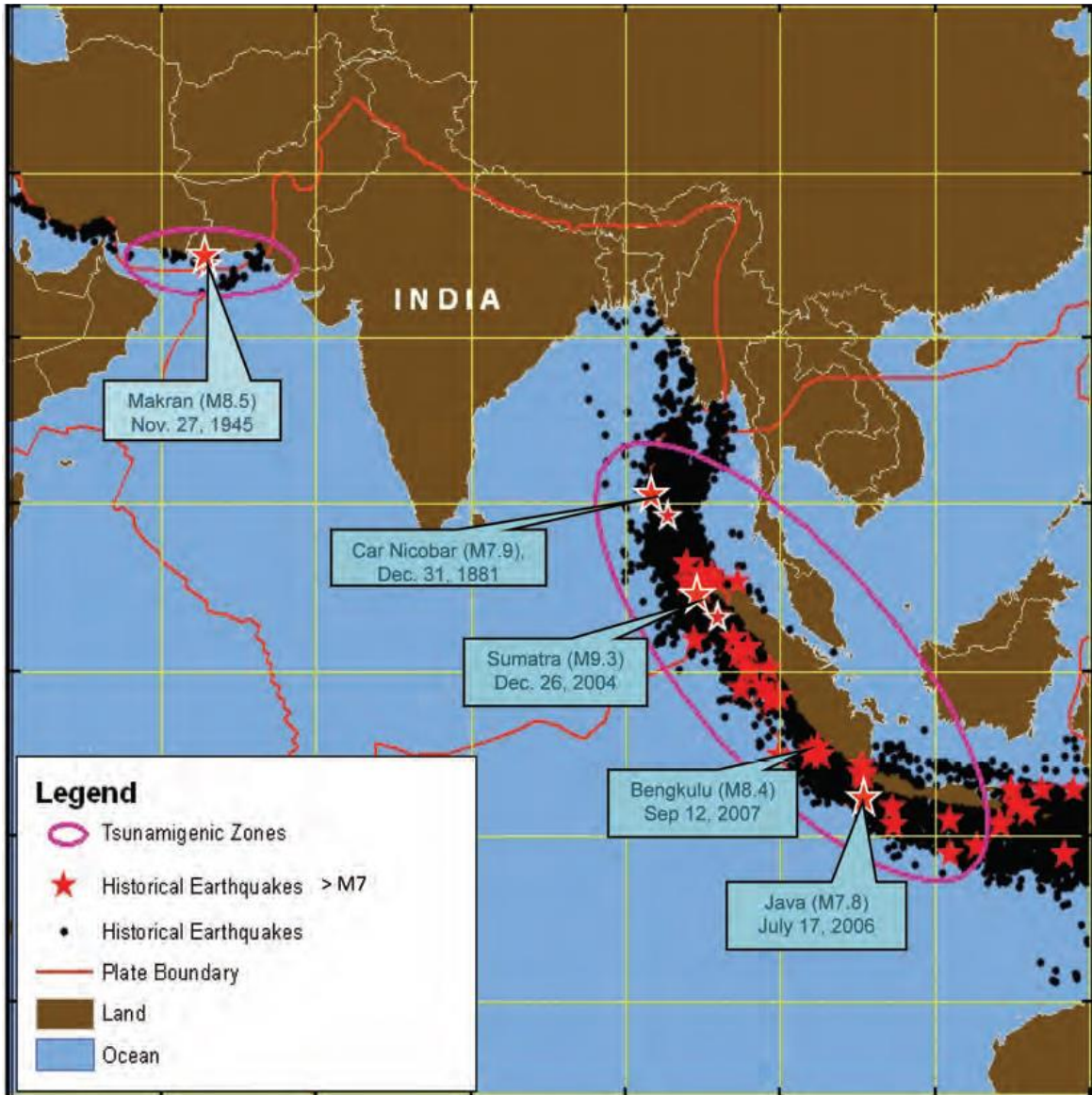


Figure: Potential Tsunami genic zones

2.2.6 Multi Hazard vulnerability

A state may be vulnerable to multi hazards. The natural calamity severity map classifying states on the basis of vulnerability to multiple hazards is given in Figure.

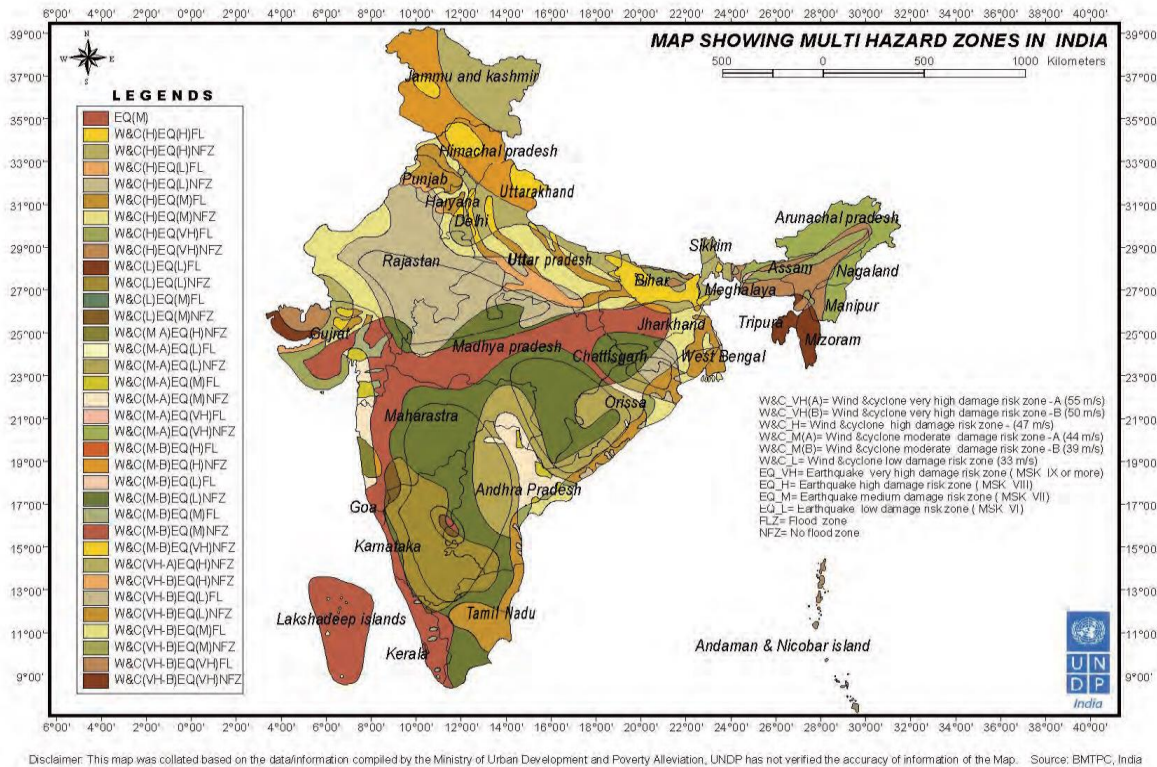


Figure: Multi-hazard zone of India

A Table classifying states on the basis of vulnerability to multiple hazards is given below:

State	Wind/ cyclone	Landslide	Flood	Drought	Snow/ Avalanche	Earthquake	Tsunami	Remarks
Uttar Pradesh & Uttarakhand		✓				Zone V		Most Critical
West Bengal						Zone IV	✓	Most Critical
Andhra Pradesh & Telangana	Zone B			✓			✓	Most Critical
Assam	Zone B					Zone V		Most Critical
Odisha	Zone B			✓			✓	Most Critical
Gujarat	Zone B			✓		Zone V	✓	Most Critical
Bihar						Zone V		Most critical
Tamil Nadu	Zone B			✓			✓	Most Critical

State	Wind/ cyclone	Landslide	Flood	Drought	Snow/ Avalanche	Earthquake	Tsunami	Remarks
Maharashtra		✓		✓		Zone IV	✓	Most critical
Jammu & Kashmir	Zone A	✓			✓	Zone V		Most critical
Himachal Pradesh		✓			✓	Zone V		Most critical
Kerala		✓					✓	Critical
Rajasthan				✓				Critical
Punjab								Critical
Madhya Pradesh				✓				Critical
Karnataka		✓		✓			✓	Critical
Arunachal Pradesh		✓			✓	Zone V		
Sikkim		✓				Zone IV		
Haryana						Zone IV		
Meghalaya						Zone V		
Tripura	Zone A					Zone V		
Manipur		✓				Zone V		
Delhi						Zone IV		
Mizoram	Zone A					Zone V		
Nagaland		✓				Zone V		
Goa							✓	



Vulnerability analysis

Technically, vulnerability assessment can be done through following steps namely:

- 1) Defining system with elements or element set considered for analysis.
- 2) Identifying the hazards and threats on the element.
- 3) Modelling hazard environment and fixing the damage scale to measure the adverse consequences.
- 4) Analyze the element for similar hazard environment (mostly simulated) using technical tools.
- 5) Post-process the amount of damage in analyzed element with respect to pre-defined damage scale
- 6) Declare element's risk as a fragility/vulnerability function with intensity of hazard considered and updating the same. The power structures & building in areas prone to multi hazards should be designed taking into consideration all the hazards.

2.3 Crisis situations

Crisis situation can arise in Power Sector in the event of the following:

- Terrorist threats / attack & sabotage
- Bomb threats & bomb explosions
- Strike
- Fire
- Accidents due to human error/ equipment malfunction
- Cyber-attack etc.
- Grid failure

2.3.1 Terrorist Threats and Attacks

Of all the form of disasters, terrorism happens to be the deadliest form in terms of loss of life and damage to the property. Acts of terrorism have grown over a period of time. Power generating plants, dams, substations, transmission lines and load dispatch centres form prime target for such terrorist groups. These installations need to be protected against acts of terrorism. The terrorist related aspects could be dealt with by making use of advancement of technology in the areas of surveillance and proper intelligence network.

2.3.2 Bombs Threats, Hoax & Bomb Explosions

Bomb explosion in Generating stations / Sub-stations/Load dispatch centres etc., can lead to major crisis through disturbance in grid & disruption in power supply. In the event of bomb explosion or a bomb threat, special measures need to be adopted under the expert's guidance.

2.3.3 Strikes

Strike by any section of the employees in a Generating station/ Sub-station/Load dispatch centres or construction workers could lead to a crisis and can bring the system to a grinding halt if adequate steps to run the Generating station/Sub-station/ Load dispatch centres are not taken. This could ultimately lead to black out in areas which could be as

small as a locality or as large as a State or Region. It could also lead to disruption in movement of traffic through railways, medical/health services, water supply and result in overall situation of chaos and disturbances. It is therefore, essential that strikes and threats are dealt with appropriately so as to build sufficient alternative and backups to deal with the crisis situation, if it occurs.

2.3.4 Fire

Like natural calamities, fire is a big threat and causes loss to human life and property. However, disasters due to fire normally remains localized to a particular installation until and unless tripping of the entire power plant causes disturbance in the transmission grid by way of over loading and leading to tripping of other power stations/ transmission lines connected with the grid.

The most common cause of the fires is known to be electrical short circuits and fire triggered by the inflammable materials. The damages caused by the fire accidents generally take excessive time for restoration. The consequent loss in electricity generation adds to the miseries. Fire safety measures are adopted right at the design stage. Proper upkeep of fire protection equipment/ systems would ensure timely availability of the system for putting out the fires before they could result in a disaster. The crisis on account of fire could be greatly averted or reduced by adopting the modern and state of the art technology for fire detection and monitoring system. Notwithstanding the above, the fire incidents do take place. The success of fire safety measures would lie in minimizing the damages and early restoration of the plants and equipment.

Analysis of causes of fire incidents reveal that majority of the fires could perhaps be prevented and extent of damage minimized, if fire safety measures were strictly enforced. Early detection of fire and swiftness in firefighting can definitely turn major disaster to minor accidents.

In power sector accidents taking place on account of human error or due to malfunctioning of any equipment are also causes of crisis situations.

2.3.5 Accidents due to human error/ equipment malfunction

The other source of crisis in power sector can be accidents taking place on account of human error or due to malfunctioning of any equipment.

2.3.6 Grid failure

Failure of grid suddenly cripples electricity services halting all activities in affected areas. This seriously impacts vital services like Hospital, transportation, communication etc. stalls, law & order issues suddenly crop up. Grid operators must be ready to handle the crisis and arrange emergency power for faster restoration of Power system in affected area.

Sudden collapse of big Generators may cause black out and crisis situation almost similar to above. Proper crisis management plan should be in place for start up power and faster restoration of generation.

2.3.7 Emerging Concerns

2.3.7.1 Cyber Attack

The operation of critical electrical infrastructure in India may be at risk due to increasing cyber incidences that may impact normal operations. The electrical infrastructure depends on electronic control systems for its operation which are cyber physical systems i.e. physical systems control and operated by a IT system. Due to this power system become prone to cyber-attacks as in case of IT systems. Since any damage to cyber physical system is always cause loss of time and money, cyber security of power system is critical. Cyber-attacks are increasing threats to the control systems used in the critical infrastructures in the world today. Cyber-attacks may not be as easily identified and many of the attacks may go unnoticed even to the companies for long periods of time. Even though the resources and tools for cyber-attacks are becoming more commonplace and readily available, companies that own and operate or make up the critical infrastructures are often unaware of the problem and may have poor cyber security designs and weak protection.

Power System operations and control was initially local, including automated isolation and concentrating on continuity/ reliability of the system and of the supply. However, with the introduction of Information & Communication Technology (ICT) based control systems, efficiency, reliability and operational flexibility of Power System has increased many folds. These control systems like SCADA/ EMS can be operated in isolation and also in

connected mode with corporate network as well as internet. The result is exposure of the Power Systems controls to cyber space and thus becoming vulnerable to Cyber-attacks. Cyber-attacks can be perpetrated both by outsiders as well as insiders and may be caused by design faults, employee errors, firewall misconfigurations, tardy software updates and circumvention of existing security elements such as IDS and IPS systems. Such attacks can have far-reaching and detrimental effects on power systems controls and could lead to the destabilization of the supply capabilities of the energy sector and lead to cascading effect on the national economy itself. Cyber threats to system can take many forms e.g. failure of a system/ element to act/ react in designed way due to virus, software bugs, intrusion and congestion in the underlying/ supervising system and it may lead the misguidance to the operating engineers and there by taking false decision in real time operation. Dependence of normal system operation on ICT, so much so that operator's/ power system personnel are not aware of and not well versed in alternate method to control/ operate the system. Non availability of ICT systems is also a form of cyber security vulnerability.

While it is not possible to protect or eliminate the vulnerability of all critical infrastructure, the strategic improvements in security can make it more difficult for attacks to succeed and can lessen the impact of attacks that may occur. Cyber intrusions are costly to power sector and many could be prevented by adopting safe design cyber security standards.

The impact of cyber vulnerabilities is proportional to the criticality of the functions and systems being impacted. The cyber security vulnerabilities in generation sector are localized and its impact can shut down one unit or plant. The effect of vulnerabilities in centralized systems e.g. SCADA etc. used in transmission sector is wide and has potential impact on the synchronous operation of entire power system, leading to grid collapse.

As far as distribution sector is concerned where bulk of Smart Grid activities are visible, the impact of compromise of a centralized SCADA / DMS can lead to disruption of services to critical customers like hospitals, metro rail etc. which is critical for the units involved but at the same time not global and widespread.

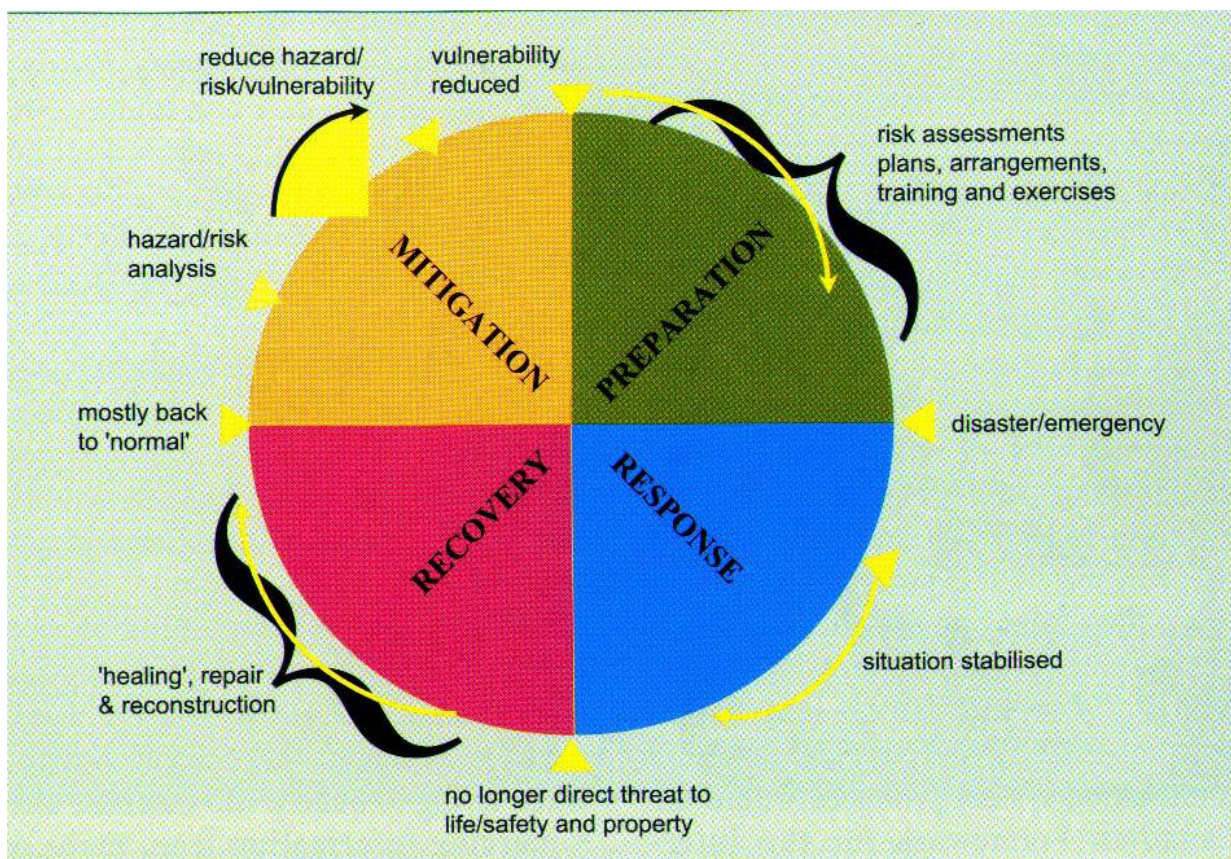
Smart grids will also change the institutional map of the power sector creating a new ecosystem of players extending well beyond today's network of system operators, distributors/ retailer and end-users. However, opening the electricity system to third party innovation will require dealing with new issues such as interoperability, cyber-security, and consumer privacy. Smart grid is more and more dependent on IT system and automated operation of grid elements including consumer centric decision.

With the advent of Smart Grid applications, the cyber space in the power sector has increased and so have the cyber security vulnerabilities. Increasing number of entry points and paths will be available for potential adversaries. An attack on smart meters and smart appliances may lead to commercial loss apart from breach of privacy to individual consumers at distribution level.

3. Disaster Risk Reduction and Building Resilience

India was, until recently reactive and only responded to disasters and provided relief from calamity. It was a relief driven disaster management system. India also has the world's oldest famine relief codes. In recent times, there has been a paradigm shift and India has become or is becoming more proactive with emphasis on disaster prevention, mitigation and preparedness.

Disaster Management today is a continuous and integrated process of planning, organizing coordinating, and implementing measures which are necessary for prevention of danger or threat of any disaster, Mitigation or reduction of risk, Capacity Building, Preparedness, prompt Response, Severity or Magnitude assessment, Evacuation, Rescue, Relief Rehabilitation & Reconstruction.



Prevention

Prevention means activities to avoid the adverse impact of hazards and means to check from turning into disasters. Examples: avoiding construction in seismically active areas or designing/building the infrastructure to bear the disaster.

Mitigation

Mitigation means various structural and non-structural activities undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards.

Preparedness

Activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuance of timely and effective early warnings and the temporary evacuation of people and property from threatened location

Response

Specific actions taken immediately after a disaster to provide support to those affected. These activities are immediately initiated by the community itself and then by the district, state, national or up to international levels. These are actions and functions undertaken to face the disaster when it occurs. These include warning to vulnerable population, evacuation to avoid further damages, search and rescue, restoration of key infrastructure etc. A quick and effective response requires adequate planning and preparedness.

Relief

An act of helping or alleviating the conditions of person who are suffering from the effects of disaster/calamity. A relief plan provision of assistance or intervention during /immediately after a disaster to meet the basic needs of affected people.

Reconstruction

These include long term measures e.g. houses, livelihoods, infrastructures etc. Which are capital intensive and need careful planning. Community participation also provides good opportunity to plan developmental activities which are more robust and disaster resilient.

3.1 Mainstreaming DM Plan in developmental projects

Mainstreaming DM plan into developmental projects focuses on the hazards that causes disaster and implement efforts to eliminate or drastically reduce its direct effect. Building resilience of infrastructure to recurrent disaster due to climate change is an integral part of sustainable development and climate change adaption.

3.1.1 Risk analysis for Electricity Infrastructure

Electricity Infrastructure is dispersed throughout the country and is being severely affected by the effects of climate change. Transmission & Distribution lines traverse through geographically varied terrain and are much more exposed to various kinds of hazards.

Risk analysis of electricity infrastructure to natural hazards has gained even more importance in view of extreme weather events due to climate change. For estimating threat to the power system infrastructure, fragility and vulnerability analysis is to be carried out for civil structures like buildings, tall structures, foundations in the generation infrastructures, towers, gantry structure, and foundation in transmission and distribution facilities.

Accurately assessing climate risks is difficult because of the uncertainty in predicting the level and timing of climate threats. While uncertainty caused by climate change is unavoidable, electric utilities can manage risks by considering different climate scenarios and potential impacts on their assets, the investments options available and

the robustness of the proposed options. The power sector has always been affected by the physical impacts of climate, including extreme events. But the sector faces new

and enhanced risks. The past two decades have seen greater scale and frequency of extreme events and the last three decades have been excessively warmer at the Earth's surface than any preceding decade since 1850

6.1.1 Risk Assessment

Risk assessment of electric power generation stations, transmission and distribution infrastructure is an important step in ensuring reliable power supply and quick restoration even in times of extreme weather events and natural disasters. Aim of

such analysis is to present methods for finding quantitative risk involved in power wheeling networks to devise effective strategies for prevention, mitigation, response, and recovery. Risk analysis involves vulnerability assessment of the inventory classes and hazard assessment of the site I region of interest. Vulnerability analysis can be used to identify intensity of hazard events that can lead to critical situations and plan possible ways of restoration. This will be helpful for policy and decision-makers to evaluate strategies and measures for critical infrastructure planning and protection.

3.1.2 Building Resilience in Electricity infrastructure

Resilience needs to be built in **Planning, design as well as well as operational stage** of Infrastructure. There has been significant development in strategies for disaster preparedness. Various measures for bringing resiliency in the system are described below:

3.1.2.1 Planning stage

- **Strengthening of Civil Structures:** Planning buildings, foundations, chimney, tower, poles and structures with next generation materials like hollow carbon fibre reinforced alloys, high ductile strength steel (Fe-500 D) etc. constitutes a primary hardening strategy. For generating station, this involves higher Plinth in flood prone areas, strengthened building, use of composite materials etc. For transmission systems, this usually involves building substations on a raised platform, upgrading aluminium structures to galvanized steel, lattice or concrete. For distribution systems, upgrading concrete poles to steel, or a composite material, and installing support wires and other structural supports may be done.

3.1.2.2 Design stage

Earthquake Resistant Design and Construction Standards

IS 1893 (Part 4): 2005 deals with earthquake resistant design of *the* industrial structures (plant and auxiliary structures) including stack-like structures. The stack-like structures are transmission, distribution, and communication towers, chimneys and silos. The design approach adopted in this standard is to ensure that structures possess minimum strength to withstand minor earthquakes (as per Design Basis

Earthquake) which occur frequently, without damage; resist moderate earthquakes (as per Design Basis Earthquake) without significant structural damage though some non-structural damage may occur; and withstand a major earthquake (as per Maximum Considered Earthquake) without collapse.

The elevation above the tide level (at the time of the tsunami) reached by water is called the run-up elevation. Run-up elevations vary considerably from point to point along the coast and are very sensitive to the shape of the coastline as it relates to the direction of the source mechanism for the wave. Data of run-up elevations for the whole coastline may be collated and used as, a reference for designing Structures.

Cyclonic winds are characterized with fluctuating component, which cause sudden loading (like impact). Uprooting of poles is due to such reversal of winds. In design stage, these cyclonic winds are simulated and used for structural analysis of proposed

design. Possible ways of wind simulation are available in commercial software and open source web tools. One such tool is used to simulate cyclonic wind of about 55 miles (mean wind component - 36.76 m/s; fluctuating component - 21.25 m/s) at 12 m level. Same concept is applicable for lattice steel towers.

Further following actions need to be taken:

- Standardization of equipment ratings, common inventory management systems, etc.
- In flood prone areas, substation should be built on raised platform above defined flood level and overhead lines should be strengthened. Strengthening of existing building that contain Vulnerable equipment, and moving equipment to upper floors /Elevated substation where it will not be damaged in the event of a flood should be done.
- Thermal power Plant area drainage should cater to Storm Water runoff resulting from a three (3) hour rainfall intensity with a return period of 50 years whichever is higher. The general site drainage system shall be designed for a 1 in 50 year frequency rainfall event for the power block area and for the main access roads.
- Use of underground Cable System in Cyclone Prone areas.

- Flood damage can also be prevented by elevating Critical infrastructure or by using GIS Substation, saltwater –resistant equipment which is less Susceptible to damage resulting from inundation. Floodwalls Can be established around Substation, and floating or amphibious concepts could also be potentially used
- Steel is a fundamental Construction material of building and its application in Reinforced Concrete building is highly crucial. For better resilient Construction building and elements, it is recommended to use high ductile strength steel (Fe-500 D).

3.1.2.3 Operational stage

- Replacement of existing overhead distribution system with underground cable System in cyclone prone areas.
- Conversion of bare overhead conductor to ABC cables where underground system cannot be adopted in near future.
- Dams to mitigate Flash Flood/ Cloud bursts: storage dams mitigate flash floods by Storing flow and sudden flow of water Caused by flash floods for cloud bursts in the reservoir and releasing it slowly downstream of Storage dams with ROR (run of the river) projects in each basin is required to mitigate flash floods.

3.1.3 New Technology for Resilience Infrastructure

Electricity infrastructure like substation and transmission/distribution lines is designed to operate under differing climatic conditions throughout the year. However, climate change could pose additional challenges yet to be accounted for in current planning and design. For addressing the above challenges, transmission/distribution lines, substation and structural aspect of the design shall incorporate additional safety factors than Prescribed in existing standards and codes. Codes and standards also need to fill the gaps based on dynamic changes occurring due to climate change.

- The interconnecting transformer and its foundation, building and other equipment are required to be designed to withstand the earthquake as per required accelerations.

- Use of cable transit system which prevents any water ingress and provides effective accelerations.
- Transmission line design standards specify different reliability level and terrain category based on the voltage level and configuration. For the location which is vulnerable to natural hazard, one (1) level higher reliability level terrain condition may be adopted.
- In order to mitigate the effects of increased wind speeds on power transmission due to changes in climatic pattern, technologies like cables, Utility tunnels, Gas insulated lines (GIL) & HVDC EL PIPES should be explored.
- Anti-icing systems to be used in power lines in hilly areas prone to snowfall. These include anti icing coating and other ice Phobic materials. De-icing systems can also be explored which reduce the deposited ice by thermal/mechanical forces along with monitoring systems.
- Use of composite insulator and silicone coated ceramic insulators in heavily polluted areas along with monitoring systems.
- Use of lightning location systems to design the earthing system for transmission line so that frequency of flashovers in critical line carrying bulk power is brought to an acceptable level. Lightning Arrester may be use in lightning prone areas to protect the equipment installed at various location from the damaging effects of lightning.
- Use of new technology conductors like High temperature low sag (HTLS) and Thermal ACSR (TACSR) can be used for distribution line having Capacity constraints due to thermal loading.
- Use of Importance Factor higher than Prescribed by the standard while designing Control Room Buildings.

4. Capacity Building

4.1 Capacity building

All the Power Sector utilities will carry out capacity building in following areas.

Key Aspects	Thematic Areas
Prevention or mitigation for disaster risk reduction	Building Resilience in Electricity infrastructure Mock Drill Exercises Public Awareness Programmes Cyber Security Mock Drills
Effective preparedness and response	Risk assessment and Vulnerability study in each area of responsibility. Response and recovery Responsibilities of Teams Black Start Facilities Emergency Restoration Systems (ERS)
Recovery and Build Back Better	Post event investigation & analysis and strategy for the future

CEA, being a nodal agency for Disaster Management in power sector would be conducting trainings, workshops, seminars and conferences for capacity building of the concerned officers for Disaster Management in different organizations of power sector.

The General information on Do's and Don'ts in respect of Power Sector including precautions to be taken during emergency/crisis situations should be put in public domain for reference and guidance of general public.

For capacity building, inputs/experience of utilities/ stakeholders would be helpful to sensitize the organizations regarding need for effective disaster management. Utilities/ stakeholders could share their experiences among themselves.

4.2 Mock Drill Exercises

In order to take preventive action, periodic mock drill exercise is to be undertaken in the various areas of Generation, Transmission and Distribution of the power sector by considering various crisis situations like Terrorist threats / attack & sabotage, Bomb threats & bomb explosions, Strike, Fire, Accidents due to human error/ equipment malfunction, Cyber-attack etc. With a view to ensure the preparedness of various utilities in handling the emergent/crisis situations, mock drills are required to be undertaken regularly. Depending on the vulnerability of the installations/plant, mock drills to handle such situations need to be undertaken. A quarterly report in this regard indicating the outline of crisis situation, response of the various teams, observations and effectiveness for handling the emergency situation and scope for improvements etc. are to be sent to CEA for submission to Ministry of Power. The utilities are also required to ensure that at least one mock drill for every crisis situation to which the installation/plant is vulnerable is undertaken.

4.3 Mock Drill for Cyber Security

- i) In view of IT framework and the security of information, utilities have to develop a crisis management plan and undertake to periodic mock drill exercise
- ii) Utilities needs to continuously interact with CERT to imbibe all the new tools for mitigating any risks from various cyber-attacks.
- iii) Utility needs to appoint a cyber-security officer in their IT cell for cyber security.
- iv) Specific agency to monitor & review of the entire exercise and ensure its healthy monitoring.
- v) New organizations and public-private partnerships such as the Smart Grid Interoperability Panel (SGIP) and the Cyber Security Working Group are taking on these issues and developing solutions. Smart grid technologies will allow new sets of regulated and unregulated services such as power quality, reliability and balancing services.
- vi) Deployment policies must include market or other arrangements that allow these services to be monetized and then included in business case consideration. Coordinating the deployment of new market mechanisms needed to monetize smart grid benefits will simplify the regulatory review and approval process and accelerate the deployment process.

4.4 Learning from Mock drill exercises

The adverse observations made on each event of Mock drill should be taken in to account and it should be ensured to prevent occurrence of such undesirable events. It should also be ensured that the mistakes made by any official during the Mock drill exercises should not be repeat in future.

5. Preparedness and Response

5.1 Preparedness

For effective preparedness to face the disasters and to avoid last minute arrangements in panic conditions, the following aspects shall be covered as an organizational practice:

- i. Well-documented emergency plans.
- ii. Data on availability of resources and buffer stock of restoration materials
- iii. Identification of key personnel: with their skills and experience of the disaster management.
- iv. Allocation of budget for emergencies.
- v. "Delegation of power" at various levels for disaster conditions.
- vi. Mutual assistance agreements signed by all power utilities for sharing men and material resources on demand.
- vii. Alternative failsafe Communication system due to failure of conventional communication system.
- viii. Plan for using outsourced manpower, services etc.

Other Essential Requisites for preparation to handle Any Crisis/ Disaster

- Fire alarm and extinguishing system to be checked regularly for its healthiness and regular drill should be carried out for its operation by involving the officers and staff of that Unit so that they also know how to operate the system.
- Safety audit must be carried out at each generating station and substation on a yearly basis.
- There should be perfect interaction on continuous basis between various disaster management groups and state intelligent agencies against terrorist attacks. This is particularly very much necessary for Nuclear and Hydro stations.

- State level support groups shall identify category-wise all the generating sub-station grid centres and load dispatch centres based on their strategic importance. The highest vulnerable centres shall be provided the highest type of security.
- The islanding schemes (electricity grid) of each state must be updated on continuous basis in consultations with the regional electricity board.
- Each Regional Power Committee and Regional Load Dispatch Centre must identify all the generating stations/grid sub-stations and load dispatch centres according to their critical importance with respect to safe operation of the electricity grid. The highest critical station must be provided the highest security arrangement and it may go on reducing to the least risk element, without jeopardizing the safety of electricity grid.
- State level Support Group shall meet at least once in six months. PMG at National level has to meet once in 12 months for exchange of views and also for updating the Disaster Management plans.
- All State and Central Power Utilities shall constantly review the equipment/system design standards and practices based on the new developments and the state of art technologies and design practices available at that time. The equipment, which frequently creates problems need to be replaced.
- Each Power station /Power Utility shall create a fund for meeting the requirement of disaster management plan. The disaster management fund would be 1% of the annual revenue of the station/Utility. These fund would be non-lapsable and would be accumulated. The management funds would be at the full discretion of emergency management group once emergency has been declared.
- Carry out comprehensive state wide drills periodically (at least once in every three months) to test capabilities. Emergency scenarios shall be developed to test the emergency plans and operational response at all levels through mock drill exercises. At the end of each exercise, an evaluation of the response call shall be carried out to take care of any deficiency noticed.

- Underground Power house should be provided with exit routes at different locations and these exit routes need to be displayed for the staff working in the power house to come out in case of any emergency like fire/flooding etc.
- Smoke evacuation system should be provided in case of fire in underground stations.

5.1.1 Deployment of Trained Personnel

Authorized users of secured control rooms and different key areas which are prone to the crisis situation in the Power Sector should be adequately trained and thoroughly screened and certified. Certification of the users shall entitle a person with different set of user access permissions to critical assets and areas prone to the Crisis. Other Users with indirect access to the power sector assets should be trained for awareness. Each user action to be logged and monitored to check the employee behaviour at various levels for possible internal vulnerabilities, which are hard to tackle and do more harm.

5.1.2 Public Awareness Programs

Organizing Public Awareness Programmes is very important when prior information is available about a situation that may lead to a disaster in near future. The people living around the project can play a vital role in event of disaster. For this purpose, Public Awareness programme should be conducted regularly to make the general public aware about potential hazards likely to occur in project area. Emphasis may be given to the following aspects.

- Pamphlets and booklets containing details Dos & Don'ts in the event of crisis/emergency situations and hazards associated with electricity generating stations be prepared and be made available to the general public.
- Permanent notice boards be fixed at all the suitable places in the area displaying information maps, escape routes, precautions to be taken and emergency communication details of nodal officers be displayed.
- Help from local youth organizations, voluntary organizations, educational institutions be sought to conduct educational session to make people aware about the safely measures and rescue operations in the event of a disaster.

5.1.3 Response and recovery

- Perceive the threat
- Asses the hazard
- Identification of resources need and their deployment viz. technical experts, manpower, equipment, spare parts & other material.
- Select control strategy
- Control hazard
- Field/Site surveys, damage assessment
- Post event investigation & analysis and strategy for the future.

5.1.3.1 First Information/ Perceiving the threat

Strategies for disaster management are very much based on information. As such, it is important to formulate and activate proper information and warning systems. The first source of information may be a local operator's observation or message from state/central government agencies/authorities.

A trigger mechanism must be established in the Disaster Management Plan to initiate the action for mitigation of Disaster, as soon as the information is received from any person or organization in respect of any calamity which is likely to occur or has occurred. The information should immediately reach the Emergency Management Group through chain of command be made known to all the key personnel in the organization such as:

- Head of Technical Services.
- Head of internal security.
- Head of safety.
- Chief Medical Officer.
- Deputy Commandant, Security Services.
- Inspector (Fire).
- Engineer-in-charge of Transport (Auto Base).

- Head of materials
- Head of HR
- Head of Finance

A list of key personnel along with their communication details shall be informed to all concerned. An illustrative check list of who has to do what is required to be prepared by each organization for its each station, in case of emergency.

The Emergency Management Group (EMG), depending upon the nature of emergency is required to take the following actions:

- **Pre-alert Notification:** This type of notification is mainly used for disseminating an important piece of information concerning slowly developing emergencies which can either be rectified or would take some time before they turn into a crisis/disaster.
- **Alert Notification:** An alert notification implies that although a crisis/ disaster is not imminent, aggravation of the situation could lead to crisis unless condition improves. Plant Level EMG and Local Officials should be alerted that an unsafe situation is developing:
- **Warning Notification:** A warning notification implies that a crisis/ disaster is imminent; and advance action may be initiated for minimizing the damages/ rescue operations. The warning notification, indicating the magnitude of crisis/ disaster should be communicated to other power Station in the region and in case of hydropower projects, to the authorities concerned with the important structures located on the downstream stretches of the river.
- **Notification Responsibility:** In case of developing crisis situation, the project authorities shall be responsible for issuing proper notification to District/ state / central level agencies, depending upon the severity of the crisis / disaster.

5.1.3.2 Preparation for setting up of a Control Room (Field Level)

The control room is to be set up for the effective coordination of the various events and happenings during the time of disturbance. This control room is entrusted to collect all the information and compile it to be ready for the timely communication to the concerned

people. It would be a nodal point to communicate with the Regional Control Room and other outer outside agency. This control room will be operating round the clock.

5.1.3.3 Control room at state/ regional/ National level

It is essential to have an integrated approach at National Level to monitor and effectively deal with the emergency situation arising out of the crisis/disaster in the power sector. It is, therefore, decided to have a four tier controlling system as follows:

- National Load Dispatch Centre (NLDC) as Central Control room with headquarters at New Delhi.
- Regional/ Load Dispatch Centre (RLDCs) as Regional control room.
- State Load Dispatch Centre (SLDCs) as State level control room.
- Power Plant / Grid sub-stations level control room.

Ministry of Power, Government of India has designated National Load Dispatch Centre (NLDC) as Central Control room to deal with natural & man made emergency situations/disasters in power sector. CEO, Power System Operation Corporation (POSOCO/NLDC), would act as its nodal officer. To facilitate dissemination of information by the Nodal Officer of Central Control Room, effective coordination of NLDC with nodal officer(s) of RLDCs and in turn SLDCs is of vital importance for which laid down mechanism may be adopted. In addition, the interface of Central control room with nodal officers of Central Public Sector Undertakings (CPSUs) as well as State level control rooms is also required.

Nodal Officer, Central Control Room would act as information source desk for all related developments in the event of disaster. Similarly, Regional Disaster Management Group (RDMG) would act as information source desk for all related developments in the event of disaster affecting region in line with responsibility of CDMG. The concerned RLDC would be Regional Control Centre in case of natural and manmade emergency/disaster and RLDC in charge would act as the Nodal Officer for the same. The State level nodal officer(s) would be required to interact with the State GENCO/DISCOMs as well as Regional control rooms depending upon the magnitude of emergency/crisis situations.

The main objective of the effective coordination amongst the control rooms will be to pool up all the possible resources to effectively handle the emergency situations in power sector.

Sharing information with print, radio and television media is an important aspect of Disaster Management. Designated Spokespersons of Government should be accessible to media for providing information on disaster/emergency situations in power sector, for which a communication outreach strategy may be adopted by co-ordination with Ministry of Power & Nodal Officer, Central Control Room.

Additional Director General dealing with Power in the Press Information Bureau, Ministry of Information and Broadcasting, Government of India would interact and disseminate periodical information to the media on the emergent/crisis situations in Power Sector.

5.1.4 Formation of Committees/teams

It would be desirable to form certain committees who could be given specific responsibilities for certain activities required to be carried out during crisis period. The details of these committees may be as follows:

5.1.5 Essential Staff

In plants immediately affected or likely to be affected as decided by the EMG, efforts shall be made to shut down the plant and make the process units safe. This work shall be carried out by the plant supervisors and essential operators.

It will be the responsibility of the EMG to identify the above essential staff and form a Task force, which reports at defined locations so that they can be readily contacted. It will also be the responsibility of the EMG to remove all non-essential staff to assembly points.

5.1.5.1 Responsibilities of Teams

5.1.5.1.1 Task Force

1. Identify source of hazard and try to neutralize/contain it
2. Isolate remaining plant and keep it in safe condition
3. Organize safe shut down of the plant, if necessary

4. Organize all support services like operation of fire water pumps, sprinkler systems, etc.
5. Any other responsibility as decided by Team Leader, looking into the circumstances at the time of the crisis / disaster.

5.1.5.1.2 Maintenance Team

- 1) Attend to all emergency maintenance jobs on priority basis
- 2) Take steps to contain or reduce the level of hazard that can create a crisis/disaster
- 3) Organize additional facilities as required
- 4) Any other responsibility as decided by Team leader, looking into the circumstances at the time of the crisis / disaster.

5.1.5.1.3 Security Team

- 1) Man all the gates
- 2) Bar entry of unauthorized persons and non-essential staff
- 3) Permit with minimum delay the entry all of authorized personnel and outside agencies, vehicles, etc. who have to provide assistance
- 4) Allow ambulances / evacuation vehicles on priority basis.
- 5) Any other responsibility as decided by Team leader, looking into the circumstances at the time of the crisis / disaster.

5.1.5.1.4 Administrative team

- 1) Rescue casualties on priority basis
- 2) Transport casualties to first aid post, safe places or medical centres
- 3) Account for personnel

- 4) Help in search for missing personnel
- 5) Pass information to the kith and kin of fatal and injured persons
- 6) Any other responsibility as decided by Team leader, looking into the circumstances at the time of crisis/disaster.

5.1.5.1.5 Safety team

- 1) Arrange required safety requirement
- 2) Arrange to measure polluted gas concentration in case of gas leaks at various location
- 3) Record location.
- 4) Collect and preserve evidence in connection with accident, guide authorities on all safety related issues.
- 5) Any other responsibility as decided by Team Leader, looking into the circumstances at the time of crisis/disaster.

5.1.5.1.6 Medical team

- 1) Arrange first aid material / stretcher and reach accident site quickly
- 2) Arrange for immediate medical attention
- 3) Arrange for sending the casualties to various hospitals and nursing homes etc.
- 4) Ask specific medical assistance from outside including through medical specialists in consultation with the EMM.
- 5) Any other responsibility as decided by Team Leader, looking into the circumstances at the time of the crises / disaster.

5.1.5.1.7 Fire Fighting Team

In case fire erupts and emergency is due to fire, the fire Team shall be responsible to:

- 1) Rush to the fire spot to extinguish the fire
- 2) Seek help from external firefighting agencies as required.
- 3) Evacuate persons affected due to whatsoever reasons
- 4) Any other responsibility as decided by Team leader, looking into the circumstances at the time of disaster.

5.1.5.1.8 Auto Base Team

- 1) Make the whole auto base vehicles ready to proceed for evacuation or other duties when asked for
- 2) Send at least one mechanic to the site of incidence where he may help in attending minor defects in ambulance, fire renders or other vehicles
- 3) Arrange petrol / diesel supply
- 4) Make all arrangements regarding transportation
- 5) Any other responsibility as decided by Team leader, looking into the circumstance at the time of disaster.

5.1.5.1.9 Communication Team

- 1) Maintain the communication network in working condition
- 2) Attend urgently repairs in the communication system, if required
- 3) Any other responsibility as decided by Team Leader, looking into the circumstances at the time of disaster.

5.1.5.1.10 Support Teams

Head of Personnel:

- 1) Contact statutory authorities.

- 2) Arrange for relievers and catering facilities
- 3) Give information to the media
- 4) Arrange shelters for affected in medical centres nursing homes etc.

Head of Material:

- 1) Arrange for urgently required materials through cash purchase or whatever means

Any other responsibility given by Station In-charge.

Head of Finance

- 1) Arrange for funds for various relief measures as well as emergency purchase of materials, sending his representative for emergency purchase
- 2) Any other responsibility given by station in-charge

5.1.5.2 Essential Services Committee

The committee will be responsible for :-

- i) Maintaining continuous supplies of food, medicines etc.
- ii) Liaison with District Authorities for necessary assistance.
- iii) Making emergency arrangements.
- iv) Finalizing notices, hand bills, circulars to be issued to striking worker and other appropriate action.
- v) Keeping the station In charge fully informed about latest situation on maintenance of emergency arrangements.
- vi) Provision of facilities like rest/ sleep at nights, daily needs etc. in the plant premises.

5.1.5.3 Power Generation / Grid Operation Committee

The committee will be responsible for operation and maintenance of units already commissioned. A separate control room will be established which will be manned by responsible officer round the clock. A list of sincere and committed workers along with their quarter numbers and locality in the township should always be available with the control room so that duty roaster can be prepared accordingly and protection assured to them and their family members.

The committee will decide exact deployment of technical and non-technical staff available. The officer-in charge of Control Room should remain in touch with Security – in charge so that loyal workers are escorted during shift change timings. The Committee will also be responsible to maintain supply of materials required to keep the power plant running. Spares, fuel oil and coal should be kept ready according to requirement.

5.1.5.4 Other Facilities required for handling disaster

5.1.5.4.1 Communication Facilities

Communication & information management is the key to any crisis response & recovery plan. Use of Modern day information technology has to play a greater role in the Software system incorporating risk assessment, creating procedures, establishing command & control structure, monitoring crisis response activities and integration with various agencies/groups would need to be incorporated as a part of emergency management. Use of satellite communication system can be effectively made to coordinate the activities of various agencies involved in the relief and restoration work and expedite restoration of normalcy in the shortest possible time

Alternative Communication arrangements independent of power line communication and normal telephone department should be provided as those are likely to be disconnected during commotion or due to sabotage / fire etc. These arrangements should be in the form of wireless links with other stations, SEBs regional and Central Control Room in order to avoid islanding conditions.

Power stations should have walkie-talkie sets of appropriate capacity to cover the farthest point of the installation for effective communication.

Each station should have few vehicles with public address system, which can be used to make necessary announcements. Similarly, main gate/ gates may also have public address facilities for making announcement.

5.1.5.4.2 Lighting

Emergency lights, DC operated invertors and diesel generators must be arranged for providing relief when the power supply gets affected both in the normal or disaster situation.

5.1.5.4.3 Recovery Equipment and Spares Inventory

In case of any crisis/ disaster, it is necessary to have inventory of recovery equipment and spares available with various power utilities so that these could be pressed into service within the shortest possible time.

5.1.5.4.4 Transport and Other Arrangements

Arrangements for adequate number of vehicles for movement of people and materials must be ensured. Medical facilities around the clock shall be made available to the staff engaged in the restoration activities. Arrangements for drinking water supply must also be ensured.

5.1.5.4.5 Black Start Facilities

Arrangements for start-up power source for each major installation must be identified. Regional Load Dispatch Centres have to make necessary plans.

5.1.5.4.6 De-watering Pumps

During floods the immediate concern is to minimize the impact of flood water on generator and other equipment. Availability of de-watering pumps is, therefore, considered necessary for stations located in flood prone areas.

5.1.5.4.7 Mobile DG sets

Sufficient number of mobile DG sets should be available and should be moved immediately to provide emergency relief & to meet the need of dewatering pumps.

5.1.5.4.8 Solar Energy Systems and Photovoltaic System

Solar energy systems and photovoltaic systems are particularly viable and suitable during the initial periods of crisis/ disaster. These non-conventional sources of energy can be easily disassembled before the disaster strikes/hits and then put back again once it passes. Another renewable energy option that may be highly applicable is a portable unit to convert biogas into electricity. Woody debris created by storm, hurricanes and floods could be put to use for generating valuable power. The renewable energy sources are of great use for homes, business and institutions that lose electrical service but remain accessible during the blackout periods.

The non-conventional sources of energy such as solar cells, photovoltaic power systems and diesel generating set are of great value especially when factored against the high cost and rampant looting that often accompanies blackouts. The renewable energy sources can play an important role in reducing the exposure to risks of natural disasters and in speedy recovery because distributed renewable energy power systems are much less prone to being knocked out of service from a single catastrophic natural disaster than are centralized power systems.

5.1.5.4.9 List of Contractors

The local project Authorities of disaster prone areas should keep a list of competent contractors/agencies who can be assigned the various components of restoration activities in the event of a disaster.

5.2 Crisis Management Plan

Besides the natural disasters, there are many man-made of technology oriented physical events, which result in a significant disruption in the normal business of electricity supply. These may include severe accidents caused due to fire explosion, handling of hazardous

materials, act of terrorism cyber attack, strike by plant employees or disruption in supply of essential inputs like coal/fuel etc. such events may affect generating plant, transmission system or distribution system with or without loss of human life or physical injuries. The crisis management plan shall be able to respond quickly and effectively to such unexpected events and situation. In majority of cases, such situations are localized in nature and this should be handled by the plant / installation level emergency management group supported by state level group. Only in those cases, where central assistance is required in terms of administrative or policy initiative and / or are having wider ramifications, the central level Power management Group should be associated. However, in all cases, the information flow to State regional & central level must continue.

5.2.1 Terrorist Attack

Terrorist attack is normally local in nature confined to small area. The response mechanism shall be as per the advice of Emergency Management Group set up at each plant/installation. Everybody should act without panic and rumours according to the well-defined instructions already assigned to each one of key employees and workers. To protect against a terrorist attack, the plan shall include the following:-

- 1) Strong security arrangements at all entry points to the power stations/sub-stations / load dispatch centres.
- 2) Information to District Administration to take appropriate security action.
- 3) Only the authorized persons may be allowed to gain entry into the complex.
- 4) Continuous internal security must be in force at all times.
- 5) Close watch must be kept on the suspicious persons, unattended vehicles around complex.
- 6) Modern communication & information system shall be provided with suitable back ups.

System Security

There should be 100% fool proof security mechanism for the following services;

- 1) Automated access control system

- 2) Alarm points
- 3) Identification of employees, visitors
- 4) CCTV
- 5) Crisis Management policies and procedures

5.2.2 Bomb Threats & Bomb Explosion

5.2.2.1 Basic steps to be carried out in the event of a bomb threat:

- A thorough search should be carried out by the security and police agencies who are well versed in dealing with such situations
- In case a bomb being found or a suspected, sand bags be placed around the object to reduce the impact of damage in the event of an explosion.
- The nearest police or army unit who invariably have trained personnel for this purpose should be called for disposal.

5.2.2.2 Action plan to Deal with Bomb & Bomb Threats

- i) All efforts in case of bomb threat or bomb explosion are to be coordinated by Emergency Management Group (EMG).
- ii) Ear-mark evacuation area.
- iii) Develop an evacuation signal and route.
- iv) Outline mechanism for liaison with security, fire and medical agencies.
- v) Select and specify the search team.
- vi) Display telephone numbers of bomb disposal squad, fire and medical agencies, security agency and police etc. prominently.
- vii) Impart proper training to security personnel.
- viii) Record the threat call for facilitating investigation.

Steps to be taken in dealing with parcel bomb or suspected parcel / letter

- a. Do not open letters/parcels of the following nature:
 - (1) senders name not written
 - (2) Name is miss-spelt.

- (3) There are holes in the envelopes for safety wires.
 - (4) There are protruding wire (s) or tin foils.
- b. Parcels/ letters with smell of oil/perfumes, shall be as under:
- (1) Do not cut or open suspected letter or parcel.
 - (2) Separate the suspected letter or parcel and keep it in a safe place separately.
 - (3) Ask for help from Bomb Disposal Squad. A bomb threat drill should be periodically carried out for being prepared to deal with such threats as when they occur.

5.2.2.3.1 Physical Security Aspects of Installations

Security Measures at premises boundary

- 1) The perimeter wall around the project area should be made as straight as possible around the premises. The inlet/ outlet and tunnels if any, should be provided with strong iron gratings at frequent intervals to deny entry of criminals and anti-social elements.
- 2) There should be peripheral road inside and outside of the perimeter wall (maintaining clear zones of 3 meter on both sides) to carry out mobile patrolling
- 3) There should be watch towers at certain intervals with communication facilities.
- 4) Perimeter wall should be properly illuminated. There should be provision of portable flood lighting and emergency lighting.

Fence security alarm system shall be provided at all power stations/grid stations. The system will have a centralized control at the main security post. This would assist to spot out the intruder who can be captured who can be captured by the security personnel or the dog squad.

5.2.2.3.2 Security Measures for Entry Into Premises:

- 1) There should be minimum number of entry gates. Separate in and out gates should be provided for pedestrians, vehicles and materials.
- 2) The plant premises should be got declared as protected place and entry to the premises and movement of material should be made only through the proper passes.

3) It should be impressed upon villagers / people living close to the power stations / Grid sub-stations / transmission lines and associated communication facilities in remote area, that their cooperation is crucial for protecting these installation from any harm from anti-social elements and mala fide intentions/ mischief of people on strike during disturbed / crises situation as well as in normal period.

4) All the vital installations inside the plant need to be separated by fencing and entry of the employees should be allowed only through special passes.

5.2.4 Strike by Plant Personnel

In any organization there are three broad categories of employees viz. executives supervisors and workmen. Employees in all these categories can get organized in the form of unions/ organizations/federations and take part in strikes. The possibility of executives going no strike may be very remote and it is felt that the speedy redressal of grievances and motivational factors should form a part of the strategy to keep the executives away from resorting to such extreme steps as going on strike. No withstanding the above, a plan needs to be prepared for handling crisis arising out of strikes. Each station shall prepared a "Manning pattern of the operation of power station/ grid sub station ".

5.2.4.1 Precautionary stage

This stage will occur when the prior information is available about the disturbance that might occur in future. Normally such a situation occurs, when a strike notice is given by one or more unions. Under such a situation the effect of strike is expected to be fairly wide spread. Various decisions/ acts to be taken in this phase are as follows:-

- 1) Concerned departments and various committees within the power station/ power system should be alerted immediately.
- 2) Disturbance situation should assessed with regard to the type of personnel/unions involved, it's likely spread and status of the corrective action/ negotiations initiated.
- 3) Appropriate Government and Labour Department should be informed in writing, specifying the background leading to the agitation and the assistance required from Government / Labour Deptt.
- 4) Sufficient water be arranged in tanks, drums, etc., in different areas to meet emergency situation.

- 5) Sufficient reserve stock of coal, fuel oil and other consumable items needed for keeping the plant in operation should be kept ready.
- 6) Adequate provisions should be made (for food, cots, mattresses, etc.,)for executives and other running staff to stay inside the power house/ grid sub stations premises for prolonged period during the strike.
- 7) Legal status of the strike should be examined and communicated to all concerned.
- 8) The various committees should be made ready to carry out their specific jobs as listed above.
- 9) The dangers and the threats during strike need to be assessed and appropriate planning done counteract such events.
- 10) Arrangements be made for additional-power for running the power station.

5.2.4.2 Disturbed Stage

Whenever the disturbance situation occurs, the following actions / decisions need to be taken by the management in the order or priorities given hereunder:-

1. Activate all security measures both within the plant as well outside the plant.
2. Inform local authorities, respective regional load dispatch centre and the personnel within the plant.
3. Review attendance within the plant and their placement. Switch over to two shift operation of 12 hours each and issue instructions to the concerned personnel regarding the same and their placement in two shifts.
4. Activate control room which will form the power plant / grid sub-station as well as outside the plant.
5. Activate the various committees
6. Review the legal status of the strike and communicate to all concerned. Press release may also be considered at appropriate stage.
7. Review the shortfall of personnel in various areas and explore the possibility of obtaining them through regional and Central Control Room.
8. Activate service functions like armed / un-armed security transport for executives & the sincere and committed workers, canteen, accommodation, etc.
9. Evaluate the scope for further negotiations with the unions and initiate action on the same.
10. Receive reports from Intelligence Groups/loyal workers and take necessary action.

11. Monitor constantly various activities both within the plant and outside the plant and take suitable action, which may be required/ deemed fit.

12. Communicate with the regional control rooms about the situation, Frequent meetings with the Head of the Departments and outer Executives of the plant and necessary to apprise them of the management strategy. It is essential that the morale of those employees who have not joined the strike is maintained at a very high level. This is a prerequisite for smooth operation of Power station/ grid, sub-station during the strike situation.

13. The Union's propaganda is to be countered by clarifying management points in hand-outs/circulars to be distributed to all. Subsequently, notice may be issued to caution/advise the workers of the probable consequences of participation in strike or go slow. All Heads of the Department of the plant would personally advise their employees to disassociate from illegal strikes go-slow.

5.2.4.3 Training Needs

The technical as well as non-technical staff in power stations and substations needs to be trained for manning the essential areas during the strike.

5.2.4.4 Power Station

1) Technical Staff

In view of the complex technology involved in the bigger size units (i.e.200MW and 500 MW), it is expected that the actual operation of these stations is carried out comparatively with higher component of executives in the staffing pattern. Smaller size units are normally operated by supervisors. Keeping the executives in the control room and other critical areas is strategically advantageous for maintaining proper generation in the eventualities of strikes and other disturbances.

In may be possible to run the Power station with the help of executives and some semi-skilled/ unskilled persons during the disturbance period. A double shift operation instead of three shifts has to be undertaken. The area wise details of various positions where supervisors and workmen are to be substituted by executives may be prepared for thermal and hydro Power stations.

In the case of maintenance activities, however only preventive maintenance and essential / critical break down maintenance may be carried out by executives in emergency situation.

Major breakdowns in case of prolonged strike cannot be attended to by the skeleton staff, and external assistance could be availed from other organizations such as SEBs, CPSUs like NTPC/NHPC/THDC/NLC/PGCIL etc. through the regional support groups identified at regional level.

Requirement of unskilled labour for helping the executives in various manual activities may have to be sought from outside agencies and could be posted at various locations as per the requirement.

2) Non-Technical Staff

Besides operation and maintenance, the other support services like personnel, finance, material management etc. also need to be manned during crises period.

5.3.3.2 Grid Sub-Stations and Transmission System

The same pattern, although less complex as compared to the Power station will hold good for the sub-stations and transmission system. The area-wise details where supervisors and workmen are to be substituted by executives may be prepared.

In an organization where the ratio of executive to non-executives is very low, the executives are normally not involved in actual operation and line operations of the various plants and equipment. Thus, there is a need for extensive training of these executives to enable them to run power stations / power systems and to provide essential services. In the grid operation, where executives are normally not involved in the switching operation and the safety code/rules etc. are not practiced by them, this need is still more important and very essential. It is, therefore, important that the organization have well conceived plans to provide these skills to a sufficient number of executives so that operations are carried out smoothly in case of emergency.

5.3.4 Action Plan to Manage the Crisis Due to Strike

The crisis due to strike may occur in a planned or un-planned manner. While in the former case a proper notice is normally given to the management by the aggrieved group and management has adequate time to plan its course of action well in advance, in the latter case the management is totally taken by surprise due to wild cat strike, a civil disturbance or a natural calamity.

There may be three stages viz. normal, warning and disturbed stage, action plan needs to be drawn specifically for all the three stages.

5.3.4.1 Normal stage Action Plan

The various preparatory works are to be done under normal circumstances so as to be ready to face any emergency conditions. The following activities may be performed during normal stage.

1) List of vital Installation

The vital installations, both from security and operation considerations, are to be identified. The installations identified from the security point of view should also indicate the intensity of checks to be made i.e. whether these should be guarded continuously or periodic inspection will be adequate.

2) Personnel Required

Minimum number of personnel required to run the power station during the period of disturbance needs to be identified. A list of the retired persons from the power station during the past 2-3 years may also be maintained so that their services could be utilized such eventualities. The list also needs to be updated periodically.

A list of resourceful contractors who would be able to supply skilled/ non-skilled man-power in the event of emergency should be maintained for each project/ facility/site.

3) Review of the Grid Operation

During disturbed situation, when the regular people are either not present or are less in number and there is a possibility, of generation falling down drastically or key transmission elements not being available, it would be necessary greater vigil and care in grid operation so as to avoid cascade tripping and total collapse of the system.

4) Security Measures

Normally, Central Industrial Security Force (CISF) or General Security Staff of the power station is responsible for security and fire prevention measure in the projects in the installation. Their role in the disturbed situation is quite significant. Their role, therefore, needs to be clearly defined and a common understanding is to be established between the station management and the commandants of the CISF/ security in-charge.

5) Fire Protection

Though fire can occur in any part of the plant, some areas are more prone to fire than others. The fire prone areas must be identified well in advance so that the initiated to take precautionary measures can be put in place. A ready assessment of fire equipment available within the installation as well as within the adjoining areas should be available. In case fire protection equipment is outside the installation the method of accessing them should also be known to the concerned people. In certain cases, mutual assistance agreement needs to be entered with the nearby organization to share the fire fighting equipment. This agreement should be drawn during the normal times. The method of handling various types of fire with different type extinguishing equipment may be listed in order to avoid confusion or any other type of hazards. The information on the fire protection to cover the various aspects mentioned above may be collected in appropriate manner.

6) Safe Storage of Vital Record

To avoid the destruction of vital records of power station/ grid sub-station/load dispatch centre, it is essential that the same are duplicated and kept in safe place to protect them from accidental fire as well as sabotage.

7) Technical and Administrative Records of Station/Grid sub-station

During the disturbances the regular staff may invariably not be available and the power plant has to be run by the executives and personnel from other areas or plants. It is therefore, essential that important technical and administrative documents records are made available to them to operate the plant in the best possible manner.

8) Strike by Executives

Even though there is remote possibility of Executives going on strike, the short and long term measures are to be formulated, to take care of this eventuality. The services of senior supervisory staff are to be taken in place of executives for operation & maintenance of power stations.

9) Cyber Attack

Impact of Cyber Attack in Generation Sector:

- Generating plants are located as Energy pockets at strategic locations. Any cyber attack can put the whole plant down and lead to outage of the generation capacity.
- However, cyber attack at one node may not disrupt multiple plants and grid operation planning takes care of one plant disruption contingency..
- Vulnerability on Control systems used for set of Plant can lead to a possible safety incident in case exploited simultaneously e.g. zero day bug on DAS.

Impact of Cyber Attack in Transmission Sector:

- Power Transmission is geographically spread across the country. To efficiently monitor and effectively control deployment of SCADA system is necessary. Compromise of the SCADA/EMS systems will jeopardize controlling/monitoring of grid which will impact reliability of the Power System.
- A coordinated cyber Incidence at critical grid nodes (substations) can also cause disruptions in the Integrated Operation of Grid.
- Cyber attacks on sub-station automation systems can cause damage to equipment in the substation and safety of operating personnel, the impact of which will be localized but could be severe depending on criticality of node.

Impact Of Cyber Attack in Distribution Sector:

- IT penetration in Indian Distribution sector for control and operation is relatively low. These are presently concentrated in MIS, Metering and Billing. Cyber Incidence in Distribution may not affect the operation of the Grid. However, Distribution systems operations are increasingly being centralized and any cyber incidence at Central Location can cause power supply failure. A disruption to critical infrastructure/customers like Hospitals, Metro, and Railways etc is of strategic concern.

Immediate Measures for Prevention of Cyber Attack

All the power utilities should contact the respective CERTs and prepare Crisis Management Plan (CMP).

a. Identification of Critical Cyber assets/areas: There is need for formal identification/ notification of critical cyber assets for:

- i) Major Power Station Control rooms
- ii) All LDC i.e. NLDC, all RLDCs and SLDCs.
- iii) All EHV-AC Substations (≥ 400 kV)
- iv) HVDC stations (≥ 500 MW).
- v) Generating Plants
- vi) Distribution Grid feeders to critical infrastructure

b. Risk assessment and Vulnerability study in each area of responsibility.

- i) Generation plants
- ii) All Load Dispatch Centres
- iii) All Transmission Substations
- iv) Distribution substations

c. Creation & Enactment of Cyber Security Policy covering all the stakeholders of Cyber space in Indian Power system.

d. Product Deployment

- i) Deploy secured network architecture for control centres.
- ii) Deploy various network security products like firewalls, IDS/IPS, VPN, IPsec and Central logging server in line with CERT-In guidelines.
- iii) Deploy physical access control devices to Power Utility premises like CCTV cameras, Biometric scanning etc.
- iv) All Application or proprietary software to be deployed in the Power System applications shall be tested for cyber vulnerabilities.
- v) To follow all the guidelines suggested by ISGTF / CERT-IN

e. Process management:

- i) Continuous evaluation of vulnerabilities.
- ii) Device Configuration management.
- iii) Cyber security audit process management
- iv) Process of Obscurity
- v) Process of Segregation
- vi) Necessary screening before choosing process of outsourcing

f. Personnel & Training Management:

- i) Authorized users of secured control rooms (Zone Blue) in the Power Sector should be and thoroughly screened and adequately trained and certified.
- ii) Certification of the users shall entitle a person with different set of user access permissions to critical cyber assets.
- iii) Other Users with indirect access to the critical cyber assets should be trained for Cyber security awareness.
- iv) Each user action to be logged and monitored to check the employee behaviour at various levels for possible internal vulnerabilities, which are hard to tackle and do more harm.

g. Mock Drill

- i) In view of IT framework and the security of information, utilities have to develop a crisis management plan and undertake to periodic mock drill exercise – ISGTF can issue guidelines in this regard.
- ii) Utility needs to continuously interact with CERT to imbibe all the new tools for mitigating any risks from various cyber attacks.
- iii) Utility needs to appoint a cyber security officer in their IT cell for cyber security.

iv) Specific agency to monitor & review of the entire exercise and ensure its healthy monitoring.

6. Recovery and Building-Back-Better including reconstruction

6.1 Disaster Management Plan for Failure of Electricity Grid

6.1.1 Indian Electric Grid

The electricity grid in India has an installed capacity of 298 GW as of 31st March, 2016. Renewable Power plants constituted 13% of total installed capacity and Non-Renewable Power Plants constituted the remaining 87%. The gross electricity generated by utilities is 1,168 TWh (1,168,359 GWh) and 183 TWh (183,611 GWh) by captive power plants during the 2015–16 fiscal. The gross electricity generation includes auxiliary power consumption of power generation plants. India became the world's third largest producer of electricity in the year 2013 with 4.8% global share in electricity generation surpassing Japan and Russia.

6.1.2 Grid Operation in India

Grid Management in India is carried out on a regional basis. The country is geographically divided in five regions namely, Northern, Eastern, Western North Eastern and Southern. All the states and union territories in India fall in either of these regions. All five regional grids are operating in a synchronous mode, which implies that the power across these regions can flow seamlessly as per the relative load generation balance. Each of the five regions has a Regional Load Despatch Centre (RLDC), which is the apex body, as per the Electricity Act 2003 (EA 2003), to ensure integrated operation of the power system in the concerned region. The RLDCs for North, East, West, South and Northeast regions are located at Delhi, Kolkatta, Mumbai, Bangalore and Shillong respectively. Load Despatch Centres The RLDCs coordinate amongst themselves both offline as well as online for maintaining the security and stability of the integrated pan India grid. In line with the federal structure of governance in the country, every state has a State Load Despatch Centre (SLDC), which is the apex body to ensure integrated operation of the power system in the state. Power System Operation Corporation Limited (POSOCO). POSOCO was formed in March 2010 to handle the grid management functions of POWERGRID. It is responsible to ensure Integrated Operation of State, Regional and National Power Systems to facilitate transfer of electric power within and across the states, regions and

trans-national exchange of power with Reliability, Security and Economy. Power System Operation Corporation Limited (POSOCO) POSOCO was formed in March 2010 to handle the grid management functions. It consists of 5 Regional Load Despatch centres (RLDCs) and a National Load Despatch centre (NLDC). POSOCO is responsible to ensure Integrated Operation of State, Regional and National Power Systems to facilitate transfer of electric power within and across the states, regions and transnational exchange of power with Reliability, Security and Economy.

Integrated operation of All India National Grid is vast and complex grid demands utmost vigil and care from the view point of crisis and disaster management. Attacks at key grid sub-stations, power station, transmission lines or cyber-attacks on computer-based load dispatch centres could black out the entire region for considerable period of time. In the event of a grid failure, coordinated actions are required to be taken at the generation stations, substations and transmission lines under the directions of NLDC/RLDC (s) and SLDC (s) for speedy restoration of power supply. Black Start / Restoration Procedures are already available in each Region as well as NLDC for use in the event of partial/complete failure of the grid identifying inter-alia the start-up power availability and restoration procedures.

Disaster Preparedness for Quicker Response

Disaster preparation and mitigation strategies need to be adopted to reduce the impact and extent of damage to electricity infrastructure in case of occurrence of disasters. Some of the measures include mobile substations which can temporarily replace damaged substations to restore power supply, emergency restoration systems which can be deployed in case of damage to transmission towers. Underground cable systems may be installed in cyclone prone areas instead of overhead lines. Also, the grid needs to have inherent flexibility to deal with variations in demand and supply of power. The next sections deal with the above solutions in detail.

6.1.3 Measures for Quick Restoration of Power Supply

Following measure are essentially required for quick restoration or power supply after a black out:

1. The start-up procedure for the generating units should be known to everyone and working level personnel should start the machines (other than technical and safety issues of the machine) as per direction given by SLDC/RLDC as after informing management's.
2. Shift duty personnel should be detained till the restoration process is completed before handing over charge to next shift.
3. Survival / Auxiliary / Start-up power should be provided to the collapsed system till requirement on priority basis power and should be utilized for other purposes only after meeting these power requirements.
4. Priority should be accorded in restoration as under:
 - Survival/start –up power to nuclear units
 - Survival Power to deep gassy mines and Important and critical loads
 - Restoration of Power supply generating stations & Load Despatch Centre(s)
 - Start-up power to hydro and gas units
 - Formation of self-sustaining islands around the generating station as per laid down procedure
1. Area Load Despatch concept should be adopted during start-up to avoid jamming of communication system as for ease in decision making.
2. A list of landline telephone numbers of all the sub-stations with STD codes should be available in the plant as well as SLDC/RLDC/NLDC as communication is the essential requirement and time is the essence during the restoration process.

3. Loading of generator supplying the start-up Power should not exceed 80% of its capacity. Efforts should be made to keep the generator operating on lagging side: if not possible, at least to: near unity power factor.

6.1.3.1 Restoration of Transmission Lines

Transmission lines are the arteries of the Electricity grid and these are most prone to damage due to earthquake, cyclone, terrorist attack, flood, etc. Following points should be essentially considered for restoration of transmission lines.

1. Disaster Management Groups should be constituted at the level of concerned State utilities.
2. Intimation regarding movement of such identified personnel to disaster site should suffice and no sanction / approval from their standing hierarchy should be required.
3. In every utility, looking after O&M of transmission lines, section-wise responsibility should be clearly defined and they should have contingency plan for various emergencies. The process of restoration /guidelines under different conditions should be laid down and documents should to be made available to all disaster Management Committee/Task Force members.
4. The substation and other control centres should have details of the key front line personnel/task force members who are identified for handling the restoration process in the event of disaster so that deployment of these personnel to the affected areas can be made without any delay.
5. Availability of the resources meant for tackling the disaster/restoration process should be listed and the same should available to the concerned members.
6. Each “Key front line personnel Team” shall be provided with mobile satellite telephone for ensuring instantaneous response/mobilization to the front on occurrence of a disaster.

7. For the restoration of transmission lines, Emergency Restoration System (ERS) should be provided/made use of. The ERS, communication and other equipment's should be maintained properly so that it can be used without any delay.
8. The transformer taps should be checked for desired setting to minimize voltage difference.
9. Energising of high voltage lines and cables should be avoided until enough generating capacity is available.
10. Spare towers and conductors should be available with the agency having the responsibility of O&M of transmission line.
11. Strategic locations should be decided for spares on centralized/ regional /zonal basis.
12. In case of advance warning, the restoration team should reach at convenient place nearest to the expected affected area in order to reach the spot at the earliest. The team would assess the extent of damage and inform the higher coordinating authorities.
13. Alternate feed point should be identified for traction, defence location and other essential services.

6.1.4 Emergency Restoration Systems (ERS)

CEA has issued guidelines for requisition of ERS and advisory has been issued by Ministry of Power to all state utilities. In the case of damage to transmission line, temporary arrangements for restoration of power supply can be made with the help of ERS, which consists of special type of light weight modular structures, with light weight polymer insulators and number of stays. This facility is currently available with power Grid Corporation of India and GRIDCO, Odisha. It is, however, suggested that based upon the past experience of disaster prone areas, one set of ERS for each such area should be procured and kept in store at strategic locations.

Present status of availability of ERS sets in POWERGRID:

Sl. No	Region	Availability of ERS sets	Additional ERS sets to be procured
1.	NR-1	3	0
2.	NR-2	2	0
3.	ER-1	3	0
4.	ER-2	2	1
5.	WR-1	2	0
6.	WR-2	4	0
7.	SR-1	1	1
8.	SR-2	1	1
9.	NER	2	1

As per Central Electricity Authority (grid standards) regulations,2010, Each transmission licensee shall have an arrangement for restoration of transmission lines of 400 kV and above and strategic 220 kV lines through the use of Emergency Restoration System in order to minimise the outage time of the transmission lines in case of tower failures.

6.1.4.1 Restoration of Sub-Stations

Substations are the nerve centres of the Electricity Grid. In case of any disaster the preparedness of the substation for restoration is a must. Following points need to be considered for handling various eventualities:

1. Ever Utility owning and operating the substations should carry out an in depth analysis of all the possible contingencies and should prepare plans for such contingencies.
2. Standing instructions should be available in written form at each substation to take care of various contingencies.
3. Alternate communications system should be available with every key substation.
4. The power backup facilities like D.G Set and inverter should be maintained properly and checked periodically for readiness of operation in case of any emergency.
5. Each substation should follow the instruction given by concerned SLDC, RLDC and other coordination agencies.
6. The fire-fighting equipment and the bore wells should be maintained and checked periodically. Mock firefighting exercises should be done on regular basis.

7. The transportation arrangements in case of any emergency should be decided in advance.

Mobile Substations

A substation is a high-voltage electric system facility. It is used to switch generators, equipment, and circuits or lines in and out of the system. It is also used to change AC voltages from one level to another. Some substations are small with little more than a transformer and associated switches. Others are large with several transformers and dozens of switches and other equipment.

Weather and natural disasters are the main cause of electrical outages, although most often these have a larger impact on the power lines leading to and from the substations than on the substations and transformers themselves. Some natural disasters can harm substation operations and create a need for mobile substation systems. The most likely are intense storms and cyclones. Cyclones are powerful enough that if they strike a substation, the equipment might be destroyed and require replacement. Floods also can cause massive damage either from the force of the water or shorting out and thus damaging equipment.

Mobile Substations' deployment capability (roughly 12 to 24 hours) is a major advantage to utilities. This flexibility allows them to be switched from one task to another relatively easily and they can be used to restore power supply in disaster affected areas e.g. 12-24 hours which otherwise may take several days to weeks. Along with weather and other natural outages, potential purposes for a Mobile Substation include planned maintenance, temporary increases in substation capacity, forced outage repairs and sabotage & attacks.

A Mobile Substation includes the trailer, switchgear, breakers, emergency or station power supply, a compact high-power-density transformer, and enhanced cooling capability. When needed, the Mobile Substation enables temporary restoration of grid service while circumventing damaged substation equipment, allowing time to procure certain long lead-time grid components.

6.1.4.2 Restoration of Load Dispatch Centers (LDCs)

RLDCs and SLDCs play vital role of coordination and controlling the restoration procedure for the Regional Grids. In case of black out, following points should be specially considered:

1. The responsibilities of each personnel should be clearly defined at the time of any emergency.
2. Backup Power supply and voice/data communication facilities must be provided at these control centres and these should be regularly checked to take care of the failure of the conventional equipment.
3. Minimum survival Power/start up power required for power stations and the location where black start facilities are available should be listed region wise and should be available with NLDC/RLDCs /SLDCs.
4. RLDCs/SLDCs should inform the power station, which have black start facilities to take immediate action.
5. For extending start-up power, from one constituent to another, clear authority should be given to SLDC indicating clearly the line through which such start-up Power is to be extended, quantum of Power and the normal time period. Concerned SLDC should be empowered to resort to load shedding or to bring up generation, wherever possible, to extend start-up Power to neighbouring constituents during any crisis.
6. Hydro Units / Gas Turbines should be run, if possible, to provide start-up Power and control voltage, if required reducing MW loading MVAR depending on voltage.
7. Constituent-wise priorities of load which is to be connected in steps should be documented and while releasing loads priority should be given to traction loads, underground coal mines /deep gassy mines AIR/TV/ Telephone exchange, hospital, pumping station, etc.

8. Some 132 KV lines in the system, which are normally kept off, may be required to be used during start-up procedure. Such lines should, therefore, be tested once in month for healthiness.
9. Extension of power supply to mines particular for deep gassy mines shall be provided from the nearest sources of power available (may be even from islands survived) in shortest possible time in case of total grid collapse. This should be considered as essential service at the time of system restoration as it involves human lives.
10. NLDC shall coordinate neighbouring regions after any partial or total grid collapse for extending the supply to the affected region. Also NLDC will coordinate with RLDCs for smooth restoration process. RLDC would play proactive role with regard to status determination, islands survived and co-ordinate for extending start-up power from the survived islands. SLDC may co-ordinate with Captive Power Plants for extending start-up Power to the nearest Power station.
11. While extending power to the traction network during the system restoration process, phase balancing should be kept in mind.
12. The traction network should be available showing details of neutral section, feeding points mentioning the utilities feeding the traction substation in NLDC/RLDC/SLDC. Details of traction load along with traction transformer capacity, average/ contracted demand and connected phase of the traction substation of concerned Railway(s) should be listed out clearly.

6.2 Building back disaster resilient infrastructure

It is the best practice to encourage resilient recovery with optimal incentives. The optimal combination of regulation and incentives (both financial and non-financial) can stimulate a resilient recovery. Effective government incentives can be localized depending on the particular characteristics of each region's infrastructure and private sector capacity.

Leading practices for rebuilding resilient infrastructure are as follow:

- Formulate long-term vision, guided by community and regional growth strategies.

- Prioritize projects based on strategic importance, potential value, and available resources.
- Assess land-use impacts and construction regulations.
- Incorporate economic, sustainability, and livability goals.
- Evaluate financing alternatives; capitalize on private-sector financing and experience.
- Provide transparency and close control over funds and capital projects.
- Establish centralized capital project management and risk oversight.

7. Role & Responsibilities

7.1 Institutional arrangements for Disaster Management in Power Sector

To effectively deal with disaster situations in power sector, a four-tier structure has been put in place– Central Level, Regional Level, State Level and Local Unit Level, with intervention and response depending on the severity of the disaster /calamity. Natural calamities may be broadly grouped into major and minor types depending upon potential to cause damage to human life and property. Though the prime focus of activities would be at the actual installations that are affected due to impending or actual event, it is envisaged to have a comprehensive disaster management system in place with initiatives/ support at regional and central level especially in case of major disasters affecting the plant, installation or site.

The composition of the Groups at various levels is outlined below:

- i. Central level Disaster Management Group (CDMG)
- ii. Regional Level Disaster Management Group (RDMG)
- iii. State level Disaster Management Group (SDMG)
- iv. Plant level Emergency Management Group (EMG)

To effectively deal with disaster situations in power sector, composition of the Groups at various levels and their responsibilities are outlined below:

7.2 Composition of Central Level Disaster Management Group (CDMG):

Composition of Central Level Disaster Management Group is as follows:

- a) Secretary (Ministry of Power, Government of India) - Chairman
- b) Chairperson, CEA
- c) CEO, Power System Operation Corporation (POSOCO)
- d) Chairman of RPCs
- e) CMDs of NTPC, NHPC & Power Grid Corporation of India Limited
- f) Chief Engineer(PS&LF), CEA - Convener

Responsibilities:

- a) To facilitate development of comprehensive disaster management plan & policy formulation for power sector.
- b) To interact with the National Disaster Management Group.
- c) To facilitate support from other national & state level agencies.
- d) To coordinate for any assistance in terms of men and materials at national level.
- e) To act as information source desk for all related developments in the event of a disaster.

7.3 Regional Level Disaster Management Group (RDMG):

Composition of Regional Level Disaster Management Group is as follows:

- a) Member Secretary (RPC) - Chairman
- b) Secretary in-charge of Rehabilitation and Relief of the effected State of the Region
- c) Representatives of each State Civil Defence
- d) Regional HODs CPSUs (NTPC, NHPC, PGCIL etc.)
- e) CMDs State TRANSCOs/Power Departments
- f) Head of RLDC - Convener

Responsibilities:

- a) To provide inter-state emergency & start up power supply
- b) To coordinate early restoration of regional grid.
- c) To participate in damage assessment.
- d) To facilitate resource movement to affected state (s) from other regional states

7.4 State level Disaster Management Group (SDMG):

Composition of State Level Disaster Management Group is as follows:

- a) Principal Secretary / Secretary (Energy) of the State - Chairman
- b) MDs of Generation, Transmission, Distribution companies

- c) Representatives of health and welfare agencies
- d) Chief fire safety officer
- e) Inspector General of Police
- f) GM (SLDC) - Convener

Responsibilities:

- a) To mobilize resources for restoration
- b) To ensure that disaster management plans are in place
- c) To mobilize financial resources
- d) To facilitate inter-agency support
- e) To coordinate information
- f) To facilitate damage assessment

7.5 Plant level Emergency Management Group (EMG):

Composition of Plant Level Disaster Management Group is as follows

- a) In-charge of the installation
- b) Plant safety manager
- c) Chief Plant Operation Administration
- d) Representative of District Administration

Responsibilities:

- a) To direct action in the affected area taking into consideration the priorities for safety of plant personnel, minimize damage to plant, property and the environment
- b) To direct fire and security personnel for immediate action.
- c) To ensure that all non-essential workers/staff in the affected area are evacuated to safer places
- d) Set up communication points
- e) Report all development and requirements/ assistance needed
- f) Preserve all evidences so as to facilitate any inquiry into the cause and circumstances which caused or escalated the emergency

- g) To coordinate with District Administration for necessary finance, medical facilities law & order etc.

Emergency Management Group (EMG) shall maintain the following:

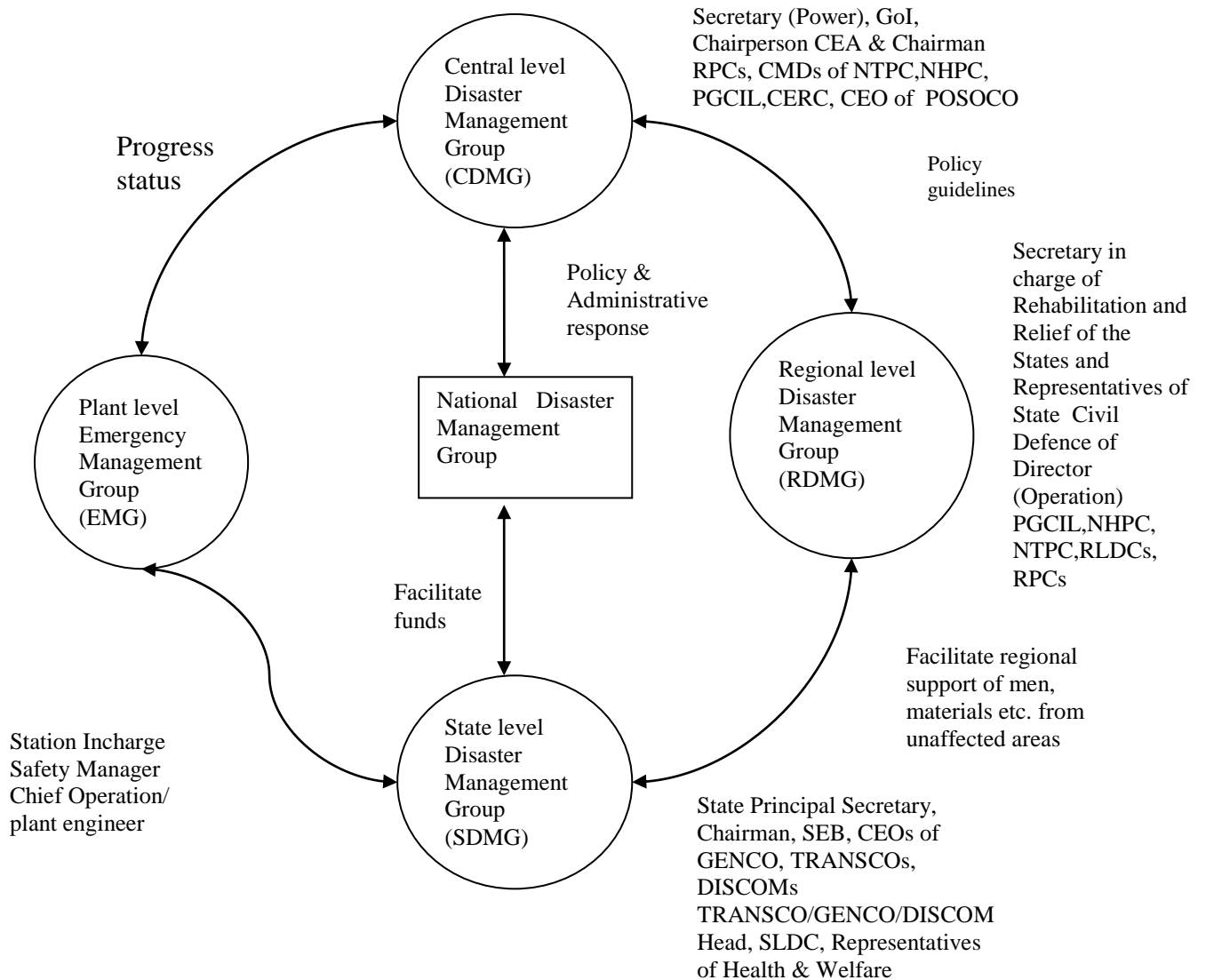
1. Safety data pertaining to all hazardous materials likely to cause emergency.
2. Procedure of major and special firefighting materials etc.
3. Procedures for tackling harmful gases and other chemical leakages.
4. Emergency call out list of persons for emergency control, key personnel, fire safety, First aid, Medical, Security, police and District Administration Authorities.
5. Emergency manuals, Blown up area maps, District Public address system, Emergency lights etc.
6. Identification of personnel for Mock drills & training
7. List of essential raw materials, spares, tools and safety kits & its arrangement to fight emergency situation, ensure public safety, and faster restoration of supply.
8. List for agencies with contact number for outsourced man power, special services and necessary plan.

7.6 Essential Staff

In plants immediately affected or likely to be affected as decided by the EMG, efforts shall be made to shut down the plant and make the process units safe. This work shall be carried out by the plant supervisors and essential operators.

It will be the responsibility of the EMG to identify the above essential staff and form a Task force, which reports at defined locations so that they can be readily contacted. It will also be the responsibility of the EMG to remove all non-essential staff to assembly points.

7.7 Inter-group relationships in Disaster Management System and an overview of composition of these Groups and their responsibilities are depicted in Figure



7.8 Damage Assessment

Immediately following a disaster, an initial damage assessment must be performed by the plant level emergency management group (EMG) to assess the impact of disaster on the electrical infrastructure. The assessment should provide a rough estimate of the type and the extent of damages, including probable cost and the need for financial assistance. When the information has been collected, it should be transmitted to the state

government. Once the state government has received the preliminary incident damage assessment information, the state government carries out damage assessment. When the state and local resources are inadequate to effectively respond to an emergency or disaster, the central assistance shall be sought by the State.

7.9 Financial Arrangements

During the disturbance period, the various heads of the departments need more financial power to meet the various contingencies. The enhancement of financial powers/ impress money shall be available for the disturbance period. Arrangements for cash flow of adequate financial resources must be made so that the restoration activities do not get hampered because of shortage of funds. The authorized signatory may be designated for each strategic location that can take on the support decision. Each Power station /Power Utility shall create a fund for meeting the requirement of disaster management plan. The disaster management fund would be 1% of the annual revenue of the station Utility. These funds would be non-lapsable and would be accumulated. The management funds would be at the full discretion of emergency management group once emergency has been declared.

State government declare the disaster in the state and send memorandum to central government for central assistance. On receipt of memorandum from the state government, the government of India constitutes inter-ministerial central team for assessment of situation in the wake of disaster.

Ministry of Power provide the relief for repair of damaged power sector infrastructure of immediate nature. The assistance will be given to damaged conductors, pole and transformers up to the level of 11kV as per the norms of assistance issued by SDRF and NDRF from time to time.

7.10 Post event investigation & analysis and strategy for the future

It is very important that an analysis and identification of lessons learnt is carried out after a disaster has occurred and everything has been restored to normal. The purpose is to take a stock of what worked and what did not work, and identify gaps in the current system and specific ways of improving disaster preparedness. This shall be followed by

the preparation of updated Disaster preparedness plans. This information would be shared with stakeholders.

