

# **Distribution Planning Code**

**Version 1.0**

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## **1. INTRODUCTION**

This Distribution Planning Code specifies the technical and design criteria, and the procedures to be applied by the Licensee in planning and development of the distribution system.

## **2. APPLICABILITY**

The Distribution Planning Code applies to all Distribution Licensees, all system users including the embedded generators and parties who are authorized to carry out distribution/supply activities and are connected to a Licensee distribution system.

## **3. OBJECTIVES**

Objectives of this Distribution Planning Code are to

- (a) enable the distribution system to be planned, designed and constructed to operate in an economical, safe and reliable manner conforming to the relevant Acts of Parliament, Regulations, Rules, Licences and Guidelines, standard specifications including other relevant manuals and construction standards;
- (b) facilitate the use of the distribution system by any person connected or seeking connection to it.
- (c) establish technical conditions and standards for acceptable performance at the interface between the Licensee's system and Users' systems
- (d) facilitate the exchange of system data between Users and Distribution Licensees, between Distribution Licensees and Transmission Licensees, and between the various distribution Licensees.
- (e) to provide sufficient information for a User to assess opportunities for connection, and to plan and develop its system so as to be compatible with the Licensee's distribution system.

## **4. RESPONSIBILITIES**

Distribution Licensee shall be responsible for

- (i) Identifying the problems of the distribution system and proposing solutions in respect of voltage levels, loading of equipment, switchgear ratings, power quality, system loss, reliability and security of supply.
- (ii) planning the expansion of the distribution system to meet the forecast demand taking into consideration the impact of the connection of new users to the system such as large customers, embedded generators, any other Licensees or any other parties connected to the system who carry out distribution/supply activities on exemptions.
- (iii) To plan the system ensuring that the Distribution system will have the capability to meet the laid down standards in relation to voltages, loading of switchgear, equipment ratings, power quality, system loss, reliability, and security of supply.
- (iv) Preparation of Distribution System Development Plan as laid down in this Code
- (v) Reviewing and recommending the changes in planning standards contained in this Distribution Planning Code on a periodic basis.
- (vi) Monitor the implementation of the planned proposals

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Distribution system users shall be responsible for,

- (i) providing all data requested by the Distribution Licensee to carry out its planning and development activities
- (ii) making submissions for improving the planning function.

## **5. SYSTEM STUDIES**

Distribution Licensee shall carry out the following system studies.

- (a) Sales and demand forecasting studies
- (b) Load flow studies
- (c) Short circuit studies
- (d) Reliability and security studies
- (e) System loss studies
- (f) Power quality studies

The outcome of each of these studies should be included in the report on Distribution Development Plan, described in section 7.

### **5.1. SALES AND DEMAND FORECASTING STUDIES**

Distribution Licensee shall prepare a sales and demand forecast for each area/branch of its operational area for five years (commencing from the year during which the forecast is prepared) incorporating demand growth patterns, future development plans and proposed large scale projects in the respective localities, effect of Demand-side Management (DSM) measures, etc.

It shall include the following, but not limited to,

- (a) Number of customers in each customer category
- (b) Forecast annual sales and individual demands for each customer category
- (c) Load factors, power factors, contribution to peak factors for each customer category
- (d) Monthly specific consumption of each customer category
- (e) Energy sales during the TOU tariff periods
- (f) Energy losses for LV retail, LV Bulk and MV Bulk customer categories, and the total losses for the Licensee's Distribution system
- (g) Energy and Demand purchases in each interval of the time of use tariff
- (h) Historical data of (a-g) for the two preceding years

Combining the sales and demand forecast of such entities, the Distribution Licensee shall prepare a forecast for each Division and then for the entire Authorised Area.

A basic spreadsheet model is considered adequate for the preparation of sales and demand forecast.

### **5.2. LOAD FLOW STUDIES**

#### **5.2.1. MV SYSTEM**

Load flow studies shall be carried out for the MV system once in two years, for a planning horizon of 10 years. Reporting based on the above analysis, included in the Distribution System Development Plan described in section 7, shall include;

- (i) Analysis of the existing system
- (ii) Demand forecast
- (iii) Future requirement analysis with forecast demand to meet the voltage standards, thermal load standards, security standards, system loss criteria and economic criteria given in section 8
- (iv) Future development proposals for expansion, reinforcement and augmentation of the existing MV networks which shall include but not limited to the following;
  - Proposed new grid/primary substations and substation augmentations
  - Proposed MV express lines and distribution gantries, if any
  - Proposed re-conductoring of MV lines
  - Network expansions and reconfigurations
  - Reactive power compensation (MV capacitors)
  - Any other improvements.

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- (v) Financial and economic evaluation of the future development proposals, discount rates for which will be published by the Commission.
  - (vi) Recommendations for implementation of development proposals

### **5.2.2. LV SYSTEM**

Licensee shall model typical LV schemes for metropolitan, urban, semi-urban and rural areas and other related studies to determine the standard transformer capacities, types of conductors, number of feeders, length of LV feeders etc. to ensure that all customer installations fed from such schemes are provided with an electricity supply within the statutory requirements. Energy/demand losses in such schemes can be considered as technical losses of LV networks.

With such typical systems as the base, the Distribution Licensee shall prepare 'LV network design guidelines' which shall be used for planning, expansion and development of the LV system.

Based on the above 'LV network design guidelines' and localized demand growth rates established through trend analysis, the Licensees shall prepare a LV System Development Plan for a planning horizon of five years formulating programs for expansion, reinforcement and augmentation of existing LV networks, addition of new distribution transformers to achieve the standards laid down in this Code.

This shall separately identify the rural electrification projects undertaken by the Licensee in compliance with the Government's rural electrification policy.

### **5.3. SHORT CIRCUIT STUDIES**

The Distribution Licensee shall perform short circuit studies at least once in five years or when a substantial rise in fault level at the transmission/medium voltage is forecast. The Distribution Licensee shall obtain such information from the Transmission Licensee. Fault level increases can be caused due to the addition of new generation to the transmission network, transmission network expansion, addition of embedded generation or due to enhancement of grid substation capacities. With these studies, the Distribution Licensee shall determine the three phase maximum fault level and minimum fault levels for all system nodes and single phase fault levels for critical nodes. The main objective of these studies is to identify the under-rated switchgear, carry out the necessary protection studies and to formulate action plans to remedy the situation. The Distribution Licensee shall keep the relevant system users informed of the fault level details.

Based on the above studies, the Distribution Licensee shall provide in Distribution System Development Report, the effect of fault levels on system equipment and the remedial action proposed to ensure that all equipment used in the Licensee's distribution system are within the design limits.

### **5.4. RELIABILITY STUDIES**

The Distribution Licensee shall perform studies to determine the frequency and duration of customer interruptions in the distribution system, as defined in the Section 8. Such data shall be segregated according to the outage caused due to distribution system faults, planned interruptions and upstream (Transmission) failures.

It is preferable to compile this information for each operational entity within the Distribution Licensee's authorised area, ie Area, Branch, Division, and also for the entire Distribution Licensee network. The loss of sales and economic cost due to loss of supply<sup>1</sup> shall be evaluated.

The Distribution Licensee shall calculate the relevant indices, loss of sales and cost of unserved energy on a monthly basis and prepare a report annually, analyzing the reliability indices, revenue losses and economic losses, and proposing recommendation to improve the same along with the targeted indices for the ensuing year. This report shall be included in the Distribution System Development Plan described in section 7.

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<sup>1</sup> The cost of unserved energy for each province will be determined by the Transmission Licensee. Please see the "Least-cost Generation Planning Guidelines".

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## 5.5. POWER SUPPLY SECURITY STUDIES

Security standards define the ability of the distribution system to provide electricity to end-users with a specified level of continuity and quality of supply.

Section 8 sets out the levels of security required, classified in a range of Group Demands, connection types and the maximum interruption times permissible.

The Distribution Licensee shall analyze the failures every quarter and identify the instances where security criteria have not been met, and examine whether such situations have arisen due to deficiencies in system design.

Annually, the Distribution Licensee shall be required to prepare a report (and include it in the Distribution System Development Report) identifying the instances where security criteria have not been met due to system inadequacies and actions proposed to remedy the situations along with the proposed plan to improve the security of supplies in the Licensee's distribution system.

## 5.6. SYSTEM LOSS STUDIES

The level of power and energy losses within the distribution network is a measure of the efficiency of the system. The Distribution Licensee shall perform studies to identify, classify and quantify the losses (i) at MV level, (ii) bulk customer transformer level, and at (iii) LV retail customer level. Losses in each of these levels shall be segregated into technical losses and non technical losses.

In each Tariff Order issued by the Commission, the caps on distribution technical losses and non technical losses that could be passed on to the customers during a tariff period will be prescribed.

The Distribution Licensee shall prepare a report detailing the action program for managing the levels of losses through effective network planning and operations. This report shall be included in the Distribution System Development Plan described in section 7.

## 5.7. POWER QUALITY STUDIES

The Distribution Licensee is responsible for monitoring power quality within its franchise area, and for managing its system to achieve conformity to accepted industry standards for power quality.

Power quality shall be defined by the variations of voltage, current and frequency with respect to the accepted industry standards which are laid down in Section 8.

Power quality of the Licensee's distribution system shall be assessed by monitoring

- (a) System frequency
- (b) Voltage magnitudes
- (c) Harmonic frequencies
- (d) Voltage imbalances
- (e) Short duration and long duration voltage variations
- (f) Phase displacement between the phases deviating from 120°

at different points in the distribution system.

### Voltage Imbalances

The degree of voltage unbalance in a three-phase system is defined as the ratio between the RMS values of the negative sequence component and the positive sequence component of the voltage.

Degree of voltage imbalance is also defined as:

Voltage unbalance (%)

$$= \frac{\text{Maximum deviation from the average of the three phase voltages}}{\text{Average of the three phase voltages}} \times 100$$

If phase voltages are  $V_1, V_2, V_3$

$$\text{Average of the voltages, } V_{\text{avg}} = (V_1 + V_2 + V_3) / 3$$

$$\text{Deviation of phase 1 voltage, } \Delta V_1 = |V_1 - V_{\text{avg}}|, \text{ similarly for phase 2 and phase 3.}$$

$$\text{If } \Delta V_m = \text{Max} (\Delta V_1, \Delta V_2, \Delta V_3), \text{ then}$$

$$\text{Voltage unbalance} = \Delta V_m / V_{\text{avg}}$$

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This type of imbalances generally will occur owing to large single phase loads, and monitoring/measurement will require recording devices and further analysis.

Conducting such measurements shall be limited to new large customer (contract demand  $\geq 1$  MVA) loads that are to be connected to the system. Measurements on other customer loads shall be at the discretion of the Distribution Licensee.

### **Voltage Fluctuations**

Historically, incandescent lamps have been taken as a reference for flicker that is noticeable to the human eye. With most incandescent lamps being replaced with discharge lamps, a standard based on the above concept is considered adequate for ensuring power quality with regard to voltage fluctuations.

Conducting detailed studies and measurements of voltage flicker in the Licensee's distribution system is recommended, and shall be at the discretion of the Licensee.

### **Harmonics**

Presence of harmonics can cause damages to the equipment of the system users and also will affect the performance of the Licensee's equipment. To minimize the likelihood of such disturbances and damages, the Distribution Licensee shall undertake studies to assess the harmonic contents especially of large customers to ensure that maximum harmonic currents/voltages are within the standards laid down in Section 8.

Distribution Licensee shall prepare a report and include it in the Distribution System Development Report described in section 7, on the quality of supply by measuring the harmonic levels at the point of common coupling with large customers (contract demand  $\geq 1$  MVA) and proposing actions to bring those within permitted levels.

## **6. DATA FOR STUDIES**

### **6.1. DISTRIBUTION SYSTEM DATA**

The Distribution Licensee shall commission and maintain a Geographic Information System (GIS) to store the distribution system data. This shall be linked to the billing database and shall have the facility to collect system data through GPS receivers.

The Distribution Licensee may acquire/develop software to extract information from the GIS to carry out the relevant system studies detailed in Section 5.

### **6.2. SALES DATA**

The Distribution Licensee's billing database shall be the sources for historical sales data for different categories of customers.

### **6.3. LOAD DATA**

Energy/demand meters installed at (i) the boundaries of the Licensee's distribution system, and (ii) the Licensee's bulk customer installations shall be the sources for determining the load characteristics of the Licensee's Distribution system and the bulk customer categories.

Until such time the energy meters in LV retail customer installations are equipped with the facility to acquire load data, the Distribution Licensee shall conduct load research studies to determine the load characteristics of each such customer category.

### **6.4. DATA REQUIREMENTS**

#### **6.4.1. DATA TO BE PROVIDED BY SYSTEM USERS**

##### **Large Customers**

Upon a written request issued by the Distribution Licensee, all customers with a contract demand exceeding 250 kVA shall provide the Distribution Licensee annually, the customer's energy and demand forecasts for five succeeding years. If the customer has self generating facilities, standby or otherwise, then such data shall be shown separately.

Such customers shall also specify the types of loads to enable the Distribution Licensee to categorize such loads as constant current, constant power or constant impedance.

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If the customer has (i) an embedded generation facility or (ii) large motors (>100kW) or (iii) reactive compensation equipment connected at 33 kV or 11 kV, then details of such equipment shall also be provided upon request.

### **Embedded Generators**

Embedded generators shall provide information relating to each of its embedded generating plant connected to the distribution system. It shall be the responsibility of the embedded generator to inform the Distribution Licensee whenever changes are effected to its operation, switching or grounding arrangements.

#### **6.4.2. DATA TO BE PROVIDED BY THE DISTRIBUTION LICENSEE TO THE SYSTEM USERS**

Distribution Licensee shall publish its approved Distribution System Development Plan in the web to enable the users or prospective users to extract information to plan/design their distribution systems.

However, if any customer seeks clarification on the system design parameters, the Distribution Licensee shall provide him will all necessary information such as design/existing fault levels, grounding requirements, maximum allowable fault clearing times, etc.

## **7. REPORTS**

Distribution Licensee shall submit a Distribution System Development Plan once in every two years to the Commission by 30<sup>th</sup> April of each year. However, the first such submission will be due on 30<sup>th</sup> May 2011.

This plan shall comprise, but shall not be limited to, the following:

- a. Executive summary
- b. Reports described in Section 2.3 which shall include
  1. Energy and demand forecast
  2. MV system development plan
  3. Reactive power compensation plan
  4. LV development Plan including rural electrification
  5. Standard ratings of equipment, distribution substations/ networks
  6. Reliability assessment
  7. Security level assessment
  8. Financial evaluation of development proposals
- c. Progress review of the implementation of planned proposals for the previous two years.
- d. Changes/amendments proposed for the Distribution Planning Code.

Capital expenditure should be prepared in the format provided by the Commission and annexed herewith.

## **8. PLANNING AND OPERATING STANDARDS**

### **8.1. SYSTEM PLANNING STANDARDS**

#### **(a) Reliability Criteria**

The system shall be planned to maintain voltages and thermal loading in networks in city areas and rural areas to provide performance of the network, as stated below;

	Medium Voltage (33, 11 kV)	Low Voltage ( 230/400 V)
Metropolitan	N-1	N-0
Urban areas	N-1	N-0
Rural Areas	N-0	N-0

#### **(b) Voltage Regulation**



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Voltage profile shall be planned within the following limits under normal operating conditions;

Metropolitan	± 6%
Urban areas	± 6%
Rural Areas	± 6%

Supply voltage levels under all three categories above shall be maintained within ±10% in all areas under emergency conditions.

**(c) Thermal Load Limits**

Under normal operating conditions, overloading of conductors and transformers shall be avoided. Under emergency conditions, the loading of the remaining elements should not exceed their emergency ratings specified and overloading of transformers shall be as defined in the IEC 60354, Guide for Overloading of Transformers.

The Licensee is responsible for documenting the emergency thermal limits of conductors and transformers, available for submission to the Commission on request, and for managing system loading within these prescribed limits.

**(d) Economic criteria**

- Establishment of cost of losses
- Reliability: loss of sales and economic cost of unserved energy
- Economic selection of conductors and cables
- Economic selection of distribution transformers

## **8.2. OPERATING STANDARDS**

**(a) Reliability Guidelines**

The reliability levels shall be assessed using the internationally accepted standard reliability indices given below;

- SAIDI
- SAIFI
- CAIDI

**(b) Power Quality Guidelines**

**Voltage Imbalance (recommended, not for immediate implementation)**

Unbalance caused by individual loads should be kept within 1.3%, although short term deviations (less than 1 minute) may be allowed up to 2%.

**Voltage Fluctuation (recommended, not for immediate implementation)**

A 3% general limit on the allowable magnitude of voltage changes, regardless of shape,

**Harmonics**

For harmonics IEEE 519 shall be used as the applicable standard.

**(c) Guidelines for System Losses**

For each Tariff Period<sup>2</sup>, the Commission shall impose a cap on technical and non technical losses for medium voltage network, LV bulk transformers and the LV retail network.

**(d) Guidelines for Customer & System Power Factor**

Power factor at customer points and in general within the system shall be monitored using the energy/demand meters. It is necessary to maintain the power factor close unity to improve the effective utilization of the network, reduce power losses and improve the supply voltages.

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<sup>2</sup> Please see the current version of the "Methodology for Tariffs", PUCSL.

**(e) System Security Guidelines**

Area	Voltage	Group demand	Restoration time after an outage	Remarks
<b><i>Distribution Substations</i></b>				
Metropolitan	11 kV/400V	1 MVA	Repair time	
Urban	11 kV/400V, 33 kV/400	400 kVA	Repair time	
Rural	11 kV/400V, 33 kV/400	160 kVA	Repair time	
<b><i>132 kV, 33 kV Incomers to Primary Substations</i></b>				
Metropolitan	132 kV , 33 kV	60 MVA	Immediately	Where double circuits are available
Urban	33 kV	20 MVA	-do-	-do-
Rural	33 kV	20 MVA	-do-	-do-
<b><i>132 kV, 33 kV Incomers to Primary Substations</i></b>				
Metropolitan	132kV ,33kV	60 MVA	50% within 30 minutes, Balance within 1 hour	Fed from single circuits
Urban	33 kV	20 MVA	-do-	-do-
Rural	33 kV	20 MVA	50% within 1 hour, Balance within 3 hours	-do-
<b><i>11 kV/33 kV feeder from Primary Substation to open point</i></b>				
Metropolitan	11 kV/33 kV	Up to 6 MVA	50% within 30 minutes, Balance in repair time	Where at least one other substation or switching point is available
Urban	11 kV/33 kV	Up to 6 MVA	50% within 45 minutes, Balance in repair time	-do-
Rural	11 kV	Up to 6 MVA	50% within 2 hours, Balance in repair time	-do-
<b><i>Primary Substations 33 kV/11 kV or 132 kV/11 kV</i></b>				
Metropolitan	33 kV and 132 kV	Up to 60MVA	Immediately	Where more than one transformer is available.
Urban	-do-	-do-	-do-	-do-
Rural	-do-	-do-	-do-	-do-