USAID / SOUTH ASIA REGIONAL INITIATIVE FOR ENERGY (SARI/ENERGY)

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Central Institute for Rural Electrification of Rural Electrification Corporation Ltd (A Govt. of India)

Hyderabad, Andhra Pradesh, India

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DISTRIBUTION SYSTEM PLANNING

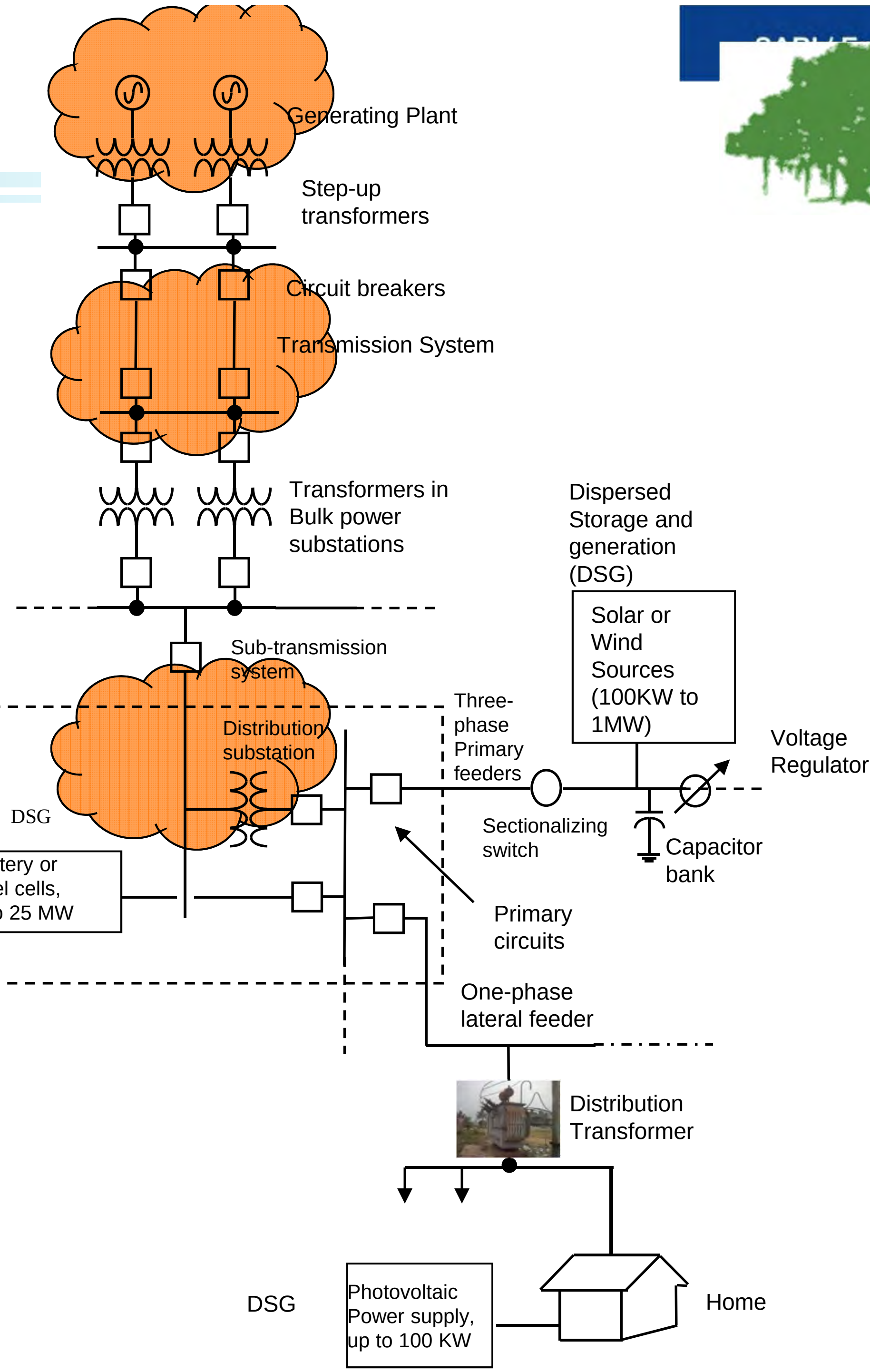
Typical Power System

Generation System

Transmission System

Distribution System

- substations
- transformers
- circuit breakers
- feeders
- sectionalizing switches
- capacitor banks
- voltage regulators
- DSGs
- customers
  - HT customers
  - LT customers



Power System connectivity

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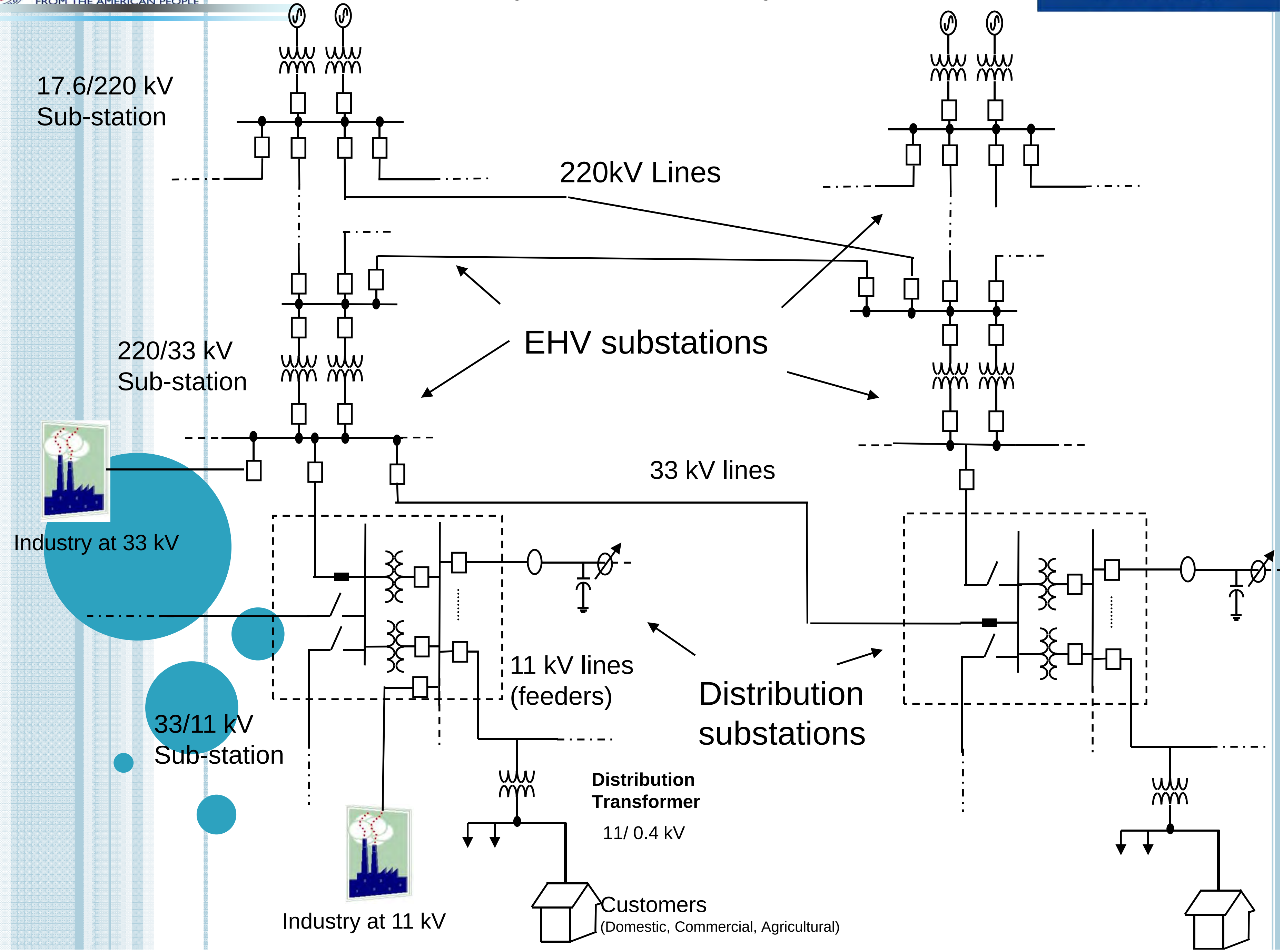

STRUCTURE OF POWER SYSTEM

Power System Components:

- Grid substation(GSS): The power from Transmission network is delivered to Sub-Transmission network after stepping down the voltage to 66 kV or 33kV through220/110/66/33 kV Grid substation
- Sub-transmission Network: Power is carried at 66 kV or 33 kV by Overhead lines or Underground cables
- Primary Substation(PSS): Power is stepped down by 66/11 kV or 33/11 kV transformersto11kv.In some cases power is stepped down from 132/110 kV to11kV

STRUCTURE OF POWER SYSTEM (CONTD…)

- Primary Distribution Feeders: Power is delivered from PSS through primary feeders mainly at 11kV to Various Distribution Transformers
- Distribution Substation(DSS): Power is further stepped down by Distribution Transformers to utilisation Voltage 400 V
- Secondary Distribution network:It carries power from DSS at 400V(230V single phase) to various consumers through overhead lines/UGcables/service wires

Planning Objectives

- Planning and design of distribution system to meet load growth and to ensure
  - Voltage conditions to be within permissible levels
  - Optimum energy losses
  - Least overall cost system
- Improvement in reliability/security of power supply
- Improvement in quality of power supply
- Safety of operation
- Evolving a scientific automation and load management system
- Better customer service

Planning Philosophy

- The approach for planning of distribution system should be based on the following
  - Delivering bulk supply of electricity as near to the load centres as possible
  - Consumers affected due to outage to be few in the area, if at all it becomes inevitable
  - Formation of ring circuit and radial circuit or combination of both depending on the technical and economic requirement of the system to enhance reliability of power supply.

PLANNING PROCESS

STRATEGY

- Short Term Plan
- Long Term Plan

SHORT TERM PLAN

- In the prevailing situation of mounting losses, priority attention to be given to reduction of losses- technical & commercial
- Short term plan shall cover the measures required for immediate improvements and reduction of losses
- Works identified as short term shall be completed within1-2 years period

WORKS UNDERSHORT TERM PLAN

- Network reconfiguration
- Network Reconductoring
- Installation of LT & 11 kV Capacitors
- Installation of Voltage Boosters
- Additional DTRs(DSS)
- Shifting DTRs to Load Centres
- Load Balancing ON ALL Three Phases
- Improvement of joints in the network
- Refurbishment/replacement of old/obsolete Equipment

LONG TERM PLAN

-Area for planning purposes may be circle or district

- <u>Steps involved in preparation of the plan:</u>

1. Data collection/compilation of existing system.

- Category wise number of consumers and connected load
- Peak demand MW/VAR- simultaneous and non simultaneous
- Annual energy consumption
- Geographical map of the area depicting T&D system(GIS Mapping)

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Data collection/compilation of Existing system.(contd..)

- Sub-transmission system
- Distribution system
- Operational parameters
- Electrical network details
- Single line diagrams and equipment parameter data
- Load Data
- System load factor and Loss load factor(LF&LLF)
- Data validation

LONG TERM PLANNING (CONTD…)

2. **Analysis of existing Transmission, sub-transmission and Distribution systems**

- Voltage variation
  - Voltage at each node/bus section
  - % voltage variation w.r. t rated input voltage
  - Whether Voltage variation within permissible limit
- Peak power loss/Energy loss of each system element for arriving at total technical losses in the circle

LONG TERM PLANNING **(CONTD...)**

- Computation of commercial losses
- Assessment of inadequacies of the existing ST& D system along with the identification of
  - Overloading of transformers
  - Overloading of lines
  - Requirement of reactive compensation
- Inadequacy of the back up transmission system
- Security and reliability of power supply

LONG TERM PLANNING **(CONTD…)**

3. Existing T&D Losses:

The technical losses are obtained from the simulation and analysis of the network element wise. From the total losses obtained from the energy balance sheet, technical losses obtained above will be subtracted to find the commercial losses of the area under study.

LONG TERM PLAN (CONTD…)

4. Load Forecast

- As the long term plan caters to the load growth of 5-7 years, The important step in the planning process is LOAD FORECAST.
- The Distribution System planning Involves siting of substations, routing of feeders and many other decisions relating to both locations and amounts of capacity additions
- Therefore Distribution Load forecast refers to forecast of geographical locations as well as quantum of future load growth.

LOAD FORECAST(CONTD….)

- The Distribution Load forecast of urban areas is relatively more complex due to:
  - high density
  - high growth rates
  - Variation in density in a small geographical area
  - Rapid transition of suburban area from Rural to urban Characteristics

LOAD FORECAST(CONTD….)

- Three step procedure involved in entireload Forecast are:

  -Analysis of past trends of growth in Electricity Demand and Energy Consumption

  - System load Forecast for the entire study area

  - Spatial or small area load forecas viz.,

Divide the utility service area into sufficiently large number of small areas and forecast for each small area

LOAD FORECAST(CONTD….)

Trend Analysis

Data Required:

- Category wise number of services
- Connected Load
- Energy consumption for the last 5-10 Yrs

LOAD FORECAST(CONTD….)

Trend Parameters Evaluated from analysis of load growth:

- Growth rate **of energy** year wise and cumulative growth rate of energy for the period
- Share of electrical energy consumption among different sectors year wise and the average for the period
- Energy consumption per service year wise and the average for the period

LOAD FORECAST(CONTD….)

- Growth rate of service connections year wise and the cumulative growth rate for the period
- Connected load per service connection year wise and the average during the period

LOAD FORECAT (CONTD…)

- **System Load Forecast Techniques**
- Techniques Based on Extrapolation

  This technique involves fitting a trend curve to the basic historical data, using method of least squares
- Techniques Based on Co-relation

  This technique relates the system demand to various demographic and economic factors such as population, value added, net domestic product, etc
- `

LOAD FORECAT (CONTD…)

- Enduse Method

  In this method the demand of each category of consumer is assessed and summed up to arrive at the total consumption

Power utility may adopt end-use technique to compute the demand projection of each distribution circle for horizon year(say 5 years). The demand for energy is estimated for each category of consumption taking into account relevant parameters such as

LOAD FORECAT (CONTD…)

number of consumers, connected load, annual rate of energy consumption per consumer or per kW of connected load, past trends etc. The peak demand is worked out from the total consumption adopting appropriate annual load factors keeping in view the nature and composition of loads and also considering the loss figures.

LOAD FORECAT (CONTD…)

Estimation of Agricultural consumption/Rural load :

The agricultural consumers are largely unmetered and a correct assessment of energy consumption is difficult. The agricultural consumption depends on three factors:-

- Number of pump sets
- Capacity of pump
- Number of working hours in a day

LOAD FORECAT (CONTD…)

Methods used to assess the agricultural consumption:

- **Sampling:**

  Average consumption per H.P. is calculated from sampling techniques

- **Annual consumption:**

  Average load factorX total connected kW of pump sets X8760 units

- **Consumption/irrigation/hectare as per studies by independent agencies:**
- Total consumption per year=Consumption for one irrigation per Hectare X number of irrigations per

  year X total land under irrigation in hectares

  Total consumption per year = Consumption for one irrigation per hectare x number of irrigations per year x total land under irrigation in hectares.

LOAD FORECAT (CONTD…)

Spatial load forecast:

- The forecast of loads and their locations, known as spatial or small area load forecast, is very important for Distribution system planning. For optimal sitting of new substation/augmentation of capacity of existing S/S and economical reinforcement of existing networks, the spatial load forecast has to be adopted
- For this purpose, the total area is divided into a number of small areas and the loads in each area are forecasted. How these small areas are

LOAD FORECAT (CONTD…)

Constituted, is very important because it forms the basis for codification of customer and distribution system equipment like transformers, capacitors, boosters for the purpose of proper operation and maintenance of records.

- One of the widely used method is to divide the area into squares of 0.5 or 1 km size, known as grid co-ordinate system. The main advantage of this method is that application of optimization techniques for distribution system planning is relatively simple, as the area of cell is constant

LOAD FORECAT (CONTD…)

The disadvantage of this method is that the areas do not coincide with administrative units of government agency and collection of economic and general data is difficult

- The other method is known as random area method where each small area constitutes an administrative unit of Government agencies. Hence, the economic and general data for the small area will be readily available from data records maintained and collected by Government. The main advantage of this method is that each area is clearly identified and

LOAD FORECAT (CONTD…)

with administrative unit of Government. The disadvantage of the method is the application of optimization techniques is complex. Considering the data availability etc., it is suggested to adopt uniform area model for urban areas and random area model for suburban or rural area around the town.

- The small area forecasting can be broadly classified as trend, multivariate and land use based simulation methods. The objective of spatial load forecast is to allocate among the small areas the growth of demand or

LOAD FORECAT (CONTD…)

energy consumption/the number of customers computed in system forecast for the total area. The load forecasts made for small areas have to be adjusted taking into account the specific growth rates and other characteristics of each small area.

5.PLANNING CRITERIA

1. The voltage variations in 33 kV and 11kV feeders should not exceed the following limits at the farthest end under peak load conditions and normal system operation regime.

Above 33kV	(-) 12.5% to (+) 10%
Up to 33kV	(-)9.0% to (+)6.0%
Low voltage	(-)6.0% to (+) 6.0%

In case it is difficult to achieve the desired voltage especially in Rural areas, then 11/0.433kV distribution transformers(in place of normal 11/0.4kV DT's) may be used in these areas

PLANNING CRITERIA (CONTD…)

Adequate power supply at normal voltage shall be available at main grid sub-stations to meet the system demand. The transformation capacity at the Grid-substations shall be such that the system demand shall be met even with the outage of the largest capacity transformer.

2. Every primary Receiving sub-station, subject to space constraints shall be provided with at least two transformers having either sufficient cyclic loading capacity to supply the sub-station maximum demand or sufficient 11kV system inter-connections to enable the maximum demand in the area to be met in the event of outage of single largest capacity transformer.

PLANNING CRITERIA (CONTD…)

3. Every 33/11 kV substation should preferably have at least two incoming feeders from two different sources from reliability considerations. If both the 33kV incoming feeders to 33/11 kV sub station(s/s) emanate from the same source(sub-station) then each feeder should supply independent sections of 33/11 kV s/s, the two sections being isolated from each other by bus coupler or isolators. This results in increased reliability. However, if one of 33kV feeders has much longer route, the shorter feeder may normally feed the 33/11 kV s/s and the other one may be called upon to supply in emergency

PLANNING CRITERIA (CONTD…)

4. The sitting of primary substation i.e. 33/11 kV substation should be on the basis of spatial load forecast, demographic factors, space availability, right of way considerations, existing network configuration etc.
5. Power transformers: The preferred transformer capacities for Primary sub-stations(i.e. 66/11 kV or 33/11 kV) should be of 6.3,8,10,16 MVA for urban areas and 1.6,3.15,5 MVA for rural areas

PLANNING CRITERIA (CONTD…)

6. Distribution transformers: The distribution transformers to be installed in the circle should preferably have standard rating of 25,50,63,100,250,315,400,500 and 630 kVA. The higher capacity(i.e. larger than 250 kVA) shall be used for concentrated load or area with high load density and lower capacity(less than 100 kVA) may be used for Rural areas. In high rise building having concentrated loads, higher capacity distribution transformers such as 1000kVA may be use. 33/0.415 kV distribution transformer of appropriate ratin-630kVA,1000kVA,2000kVA,may also be used based on techno-economic considerations. Lower ratings could be used for rural areas/far flung urban areas. Standardization of ratings would help in achieving reduction in inventory for purposes of procurement & maintenance and reduction in price on account of bulk purchases.

PLANNING CRITERIA (CONTD…)

The distribution transformers in urban areas should operate at an initial capacity factor of about 65%-75% of their rated capacity and would have to be augmented when the maximum demand on the transformer is near its rating. In case of Rural areas, a higher loading based on the assessment of load growth could be considered for adoption.

7. Choice of conductor: Standard conductor sizes should be adopted for 66kV,33kV,11kV and LT (400 V)

PLANNING CRITERIA (CONTD…)

lines. ACSR and AAC conductors for overhead lines and XLPE and PVC/PILC cables can be used. Most power utilities use ACSR on account of price considerations although AAAC conductors are lighter in weight, have a longer life on account of higher resistance to corrosion. The characteristics of conductors/cables being used in distribution systems are detailed. As a guideline the sizes of conductors/cables indicated below could be preferred:

Rated System Voltage	Conductor Type
33 Kv	ACSR panther, wolf, Dog or equivalent AAC, 3 core XLPE cables of 150,185,240,300 and 400 sq.mm
11kV	ACSR Dog, Racoon, Rabit or equivalent AAC, Equivalent aerial Bunched cables(ABC)3-core XLPE cables of sizes 120,150,185,240 & 300 sq.mm
LT	ACSR Dog, Racoon, Rabbit AAC, ant, Grass hopper, wasp or equivalent AAAC.Equivalent aerial Bunched cales(ABC) 3 ½ core or 4-core PVC cables of 95,120,150,185,240 & 300 sq.mm

In the choice of conductor size, the parameters to be considered are the thermal limit, voltage regulation and economic loading based on capitalized cost of losses. The first two parameters are technical requirements and have to be ensured. The loading of the lines should preferably be kept as near to the economic loading level of the conductor as feasible. This approach could lead to requirement of huge capital cost. Therefore optimization of conductor size after ensuring voltage regulation and Thermal limits has to be done considering the cost of decremental losses vis-a the incremental cost involved.

Till computer software facilities are established in the circle, KVA-km concept may be used to decide the size of conductor and length of feeder. However, it would be desirable to limit length of LT feeder to a minimum.

Based on the experience and condition prevailing, the length of LT feeder should not exceed about 400 meters. For higher voltage levels, feeder length should be decided based on studies.

8. The 11kV feeders shall generally not be long under normal conditions and shall as far as possible feed only local areas. The 11 kV feeders shall be so planned that wherever the size of the conductor is inadequate or the voltage drop exceed the prescribed limit, the existing conductors shall either be replaced by higher size conductor or load on the feeder shall be reduced by addition of new feeders. Existing.. Lines should be utilized to the maximum extent.

9. Selection of voltage vis a vis size of conductor: Most of the power utilities use 0.4kV,11kV and 33kV as distribution voltages depending upon quantum and location of load. The higher the voltage more expensive is the system in terms of investment cost. However, it would be less in terms of total owning cost by way of capitalization of losses. The most economic voltage level would have to be determined through tech-economic studies from voltage regulation considerations, loading limit of conductor, cost of losses and investment cost consideration.

In order to avoid proliferation of 66kV or 33kV sub-stations, overloading of network, poor voltage regulation etc. the following criteria is suggested for releasing new bulk loads.

However, the same can be modified by the concerned utility as per the loading condition in the network.

- Maximum Demand of upto 70kVA to be supplied at low voltage.
- Maximum Demand of between 70 kVA and 1500 kVA to be supplied at 11kV

- Maximum Demand between 1.5 MVA and 5 MVA to be supplied at 33kV
- Maximum Demand of more than 5 MVA to be supplied at 66kV(or higher voltage)

  Separate 33kV/11 kV feeders shall be laid for major industrial consumers, In case or rural areas, separate feeders, as far as possible, shall be provided

11. Customer Substation:- A large customer (generally over 5MW) may request special service for his needs. In such a case.

    a) one source feed and the standard substation design(not including switch gear) shall be provided

Enhanced power options should be at customers expense. These include alternate feeds and any additional equipment, such as CBs/switches, additional redundant transformers etc. These options require a contract that must be coordinated with both Distribution Services and Electric planning

12. The power factor of the system would preferably be not less than 0.95 at 11 kV level.

13. The level of security of supply to be provided is a matter of subjective judgment for the power utility. Higher the level of security, higher would be the cost. The highest degree of security is obtained when a sub-transmission system is operated in closed ring but this method requires an expensive protection system. Operation is more complicated and this system should be restricted to very densely loaded city centres or VIP areas where security of supply is essential. More common arrangement requiring less of investment would be an open ring system.

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For industrial consumers, it may be appropriate to provide an alternatives source of supply by using an open ring circuit for 66/33kV and 11kV consumers with the least possible restoration time. In case of important low voltage consumers, it may be proposed to provide alternate source of supply from adjacent Distribution transformer.

14 Technical loss levels: Acceptable technical loss levels are subject to the economic factors such as costs of power and energy, cost of equipment and discount rates rather than purely on technical factors.

However target levels and maximum tolerable loss levels for each voltage level on the system with a view to meet the economic loss performance may be taken as shown below.

System components	Level for peak power losses Target level %	Maximum tolerable %
(i) Step up transformer and EHV transmission system	0.50	1.00
(ii) Transformation to inter- mediate voltage level, transmission system & step down to sub-transmission voltage level.	1.50	3.00
(iii) sub-transmission system and step-down to distribution voltage level	2.25	4.50
(iv) Distribution lines and service connection	4.00	7.00
Total power losses	**8.25**	**15.50**

15. Maximum fault levels: The three phase fault levels may not exceed the following except where the system is nearer to the generating source where actual short circuit value may be used to decide switchgear specifications:

   i) 33kV systems 750MVA
   ii) 11kV system 350 MVA(urban areas)
   250 MVA(rural areas)

16. Harmonic distortion: Harmonic distortion is cause principally by non-linear loads such as rectifiers and arc furnaces and can effect the operation of a supply system and can cause overloading of equipments such as capacitors, or even resonance with the system leading to overstressing(excessive voltage& current).Other effects are interference with telephone circuits and broadcasting, metering errors overheating of rotating machines due to increased iron losses(eddy current effects),

overheating of rotating machines due to increased iron losses(eddy current effects), overheating of delta connected winding of transformer due to excessive third harmonics or excessive exciting current.

The suggested total harmonic voltage distortion and individual harmonic voltage distortion at point of common coupling are

Total Harmonic Distortion(THD) =

9% in 0.4 ≤45kV

4% in 45<U ≤ 220kV

3% in U>220kV

17. Sub-station layout: Before deciding the rating of the equipment in a sub-station it is necessary to prepare a schematic/lay out diagram of the substation. There are a number of arrangements dependent upon system voltage, position of the sub-station in the system, flexibility, reliability of supply and cost. The factors to be considered while deciding the layout are

- It shall be possible to carry out equipment maintenance without interrupting the entire supply
- As far as possible there should be alternate arrangements in the event of outage of any one important item of equipment
- The layout should be economical and should not hinder future expansion.

single bus bar, single bus bar with bus sectionalizer, double busbar. Double bus bar with double breaker scheme and mesh scheme and mesh scheme are the various types of layouts being adopted. A layout which is most economical, satisfies technical requirements as per actual site conditions may be adopted. Generally 33/11 kV s/s with single busbsr and sectionalizer in between on the 33 kV as well as 11kV sides is being adopted.

18. To improve the operational flexibility, minimize restoration time of power supply and to prevent overloading of lines and transformers in real time mode, modern features such as Distribution Automation may be incorporated.

19. A mobile substation could be used as backup of distribution substation in the event of a transformer failure. Where a mobile substation cannot be provided to feed the total normal load of the failed transformer, there must be adequate tie capacity available to serve the remainder of the transformers normal load form other sources. The service by back up means must be capable of maintaining normal voltage levels at the load for indefinite lengths of time
20. The overall planned system subject to meeting the technical requirement for supplying quality and reliable power supply to the consumers should be the least cost(considering the capital cost of proposed works and capitalizing the cost of losses over the life of the equipment out of the various alternatives considered.

6. UPGRADATION/STRENGHENING OF THE SUB-TRANSMISSION AND DISTRIBUTION SYSTEMS

With substantial increase in load demand expected in the plan period, the system would need strengthening and augmentation to ensure delivery of power to the consumers at proper voltage and for reduction of losses to a reasonable level. For the development of the system, the spatial load demand are worked out and imposed on the existing system to assess the inadequacy of the system for meeting the demand in the horizon year. This system augmentation/strengthening is then worked out to cover the inadequacy of the existing system to meet the proposed demand as well as to identify the constraints in the back up system.

Transmission (back up system)

The existing distribution network is supplied by 220,132,66 and 33 KV substations. For Sub-transmission & Distribution study, it may be considered that adequate power supply at normal voltage shall be available form main Grid sub-stations to meet the system demand. Further, transformation capacity at the Grid sub-station shall be such that the system demand shall be met even with the outage of one of largest capacity transformers. However, if there are any constraints/inadequacy in back up transmission system, the same may be clearly identified in the Project report.

Sub –Transmission:

The sub –transmission and Distribution system would have to be expanded to meet the growth in demand. The following options for expansion of sub-transmission system would have to be considered:-

Sub –Transmission (CONTD…)

i. Augmentation of the transformation capacity at the existing 66 or 33/11 kV substation., rearranging/reconfiguring the 66/33 kV feeders by using higher size conductors and or increasing the number of feeders.

ii. Establishing new 66/11 kv or 33/11 kV sub-stations nearer to the load centres and redistribution the loads between existing and new sub-stations and feeder strengthening.

iii. Augmenting the transformer capacities at some of the existing sub-stations and establishing new sub-stations so as to have an even distribution of load on the substations and corresponding strengthening and addition of feeders.

Sub –Transmission (CONTD…)

The location for augmentation/new substations have to be worked out on the basis of assessment of the area wise power demand potential. In theory the area supplied by individual Power sub-station varies as a function of distribution system voltage and load density

Once the radius of operation of the sub-station has been determined from these two factors, new sub-station have to be planned to cater to the loads not covered by the existing sub-stations. The proposed locations of the new primary sub-station have to be chosen considering the proximity to the load centre and availability of suitable and adequate site. In the case of augmentation of existing sub-stations, the availability of land and feasibility of adding

Sub –Transmission (CONTD...)

new transformer/additional lines have to kept in view.

planning for sitting of S/S and 11kV trunk and spur feeder in Rural area should be based on the load survey, and load centres in the village. The geographical maps of village/Taluka showing the location of well, village streets, clusters, existing diesel based on industry/cold storage etc. would have to be plotted ultimately for optimal planning of network for the rural area.

The various options for the sub-transmission system are evaluated on techno-economic considerations to decide on the final alternative.

Sub –Transmission (CONTD…)

The load flow studies would give the losses for the various alternatives and total cost of each alternative would then be worked out on the basis of capital cost of each alternative and the cost of losses.

Evaluation of Various Alternatives

The study of each alternative should be analysed under normal condition as well as outage condition. It should be ensured that the network does not experience overloading and the voltage variation in all the alternatives is within permissible limit as indicated in the planning criteria.

Evaluation of Various Alternatives (CONTD…)

To evolve the least cost alternative, subject to their meeting the technical requirements, the total owning cost of the various alternatives should be estimated.

After identifying the scope of works and estimation of losses under various alternatives for Sub-Transmission system, the least cost optimal solution may be worked out considering the capital cost of proposed works and net present worth of peak & energy losses over the expected life of the equipment.

Evaluation of Various Alternatives (CONTD...)

- Transmission and sub-Transmission system Requirement

  The proposed system details would be indicated as below:

- Back up Transmission system
  a) Augmentation of EHV sub-stations
  b) New EHV sub-station
  c) Transmission lines
  d) Reconductoring of EHV lines

Evaluation of Various Alternatives (CONTD…)

- Sub-Transmission system requirement
  a) Augmentation of sub-station
  b) New Sub-station
  c) Sub-transmission line(new)
  d) Reconductoring of sub-transmission lines

Distribution System

Once the sub-transmission system has been finalized, the upgradation requirements of distribution system have to be identified. The peak demand at 66 or 33/11 kV sub-station would have to be disaggregated to work out the peak demand in each feeder and the allocation of demand on the distribution transformers would be made on the basis of actual load connected to the distribution transformer.

The voltage regulation and power losses along each feeder section up to Distribution transformer would have to be worked out. Based on the results of studies(using the software),

Distribution System (CONTD…)

The feeder section requiring reconductoring /addition of new feeder and its conductor size may be Decided. It may be ensured that the voltage is within the limit at each node/distribution transformer.

In addition some new transformers would be required and some would have to be augmented. Attempts should be made to locate the distribution transformer as near to the load centre as possible. It may not possible to determine the actual locations where these are to be installed. However, for the purpose of the scheme expected load growth indications would have to be considered of determining the number and location of the distribution transformers.

Distribution System requirement

The proposed distribution system details shall cover the following

i) Augmentation of distribution sub-stations
ii) New 11 kV lines
iii) Reconductoring 11kV lines
iv) New Distribution Sub-stations
v) Reconductoring of LT feeders
vi) New LT lines

The requirement of LT line may be worked out on the basis of detailed study network emanating from various distribution transformers. However, in the begin the requirement of LT lines may be worked out on the basis of extrapolation results from studies of typical distribution transformers

Installation of capacitors

Shunt capacitors are the simplest and cheapest way of managing the reactive power Agricultural pump sets & LT motive load are operating at very low power factor (0.6 to 0.7) causing reactive power management and voltage profile problems in the Systems and thereby increasing system losses. It has been realized that the installation of LT capacitors close to the consumer load would-(i) reduce load current in the LT feeders(ii) reduce overloading of distribution transformers and 11 kV lines& Backup system.

Installation of capacitors (CONTD...)

It is therefore recommended to install:

- LT fixed capacitors on Lt side of distribution transformer
- Pole mounted 11 kV of suitable rating(auto switchable) capacitors

The requirement of additional switched reactive compensation at 220/ 132/66/33/11 kV may be decided on system studies

Analysis of proposed system

The proposed system would have to be analyzed for meeting the load demand in horizon year so that:

i) Voltages are within permissible limit
ii) Adequacy of system is established
iii) Losses are within limits
iv) Choice of least cost alternatives

For the analysis of the system, the entire system in horizon year would have to be detailed with load transfers and load sharing so that peak loading of each elements is known

Evaluation of technical losses(for proposed systems)

The studies by simulation of the proposed system would facilitate in identifying the element wise losses in the system. The total technical annual average energy losses of the proposed system would be computed using appropriate load factors at different voltages in the system and corresponding load loss factors

7. Reliability Analysis

In order to demonstrate the improvement in quality and reliability of supply with the implementation of project, reliability indices of power supply in the circle shall be estimated before and after 'implementation of the project'. These reliability indices can be assessed as under

- Customer Interruption Frequency Index=

$$\frac{\text{Total number of Customer Interruptions}}{\text{Total number of customers served}}$$

Reliability Analysis (CONTD…)

Total number of customer interruption = Sum of no. of customers having no power supply in each interruption

- Customer Interruption Duration Index=

  $$\frac{\text{Sum of customer Interruption Duration}}{\text{Total no. of customers served}}$$

Sum of customer interruption Duration = sum of No. of customers not having power supply duration of interruption

8. Technological Options

Long term proposal should be based on latest technology such as:

- Adoption of High voltage Distribution system
- Standardization of construction practices and operation and maintenance of procedures
- Adoption of Distribution Automation techniques, so as to improve the reliability and security of power supply
- Adoption of Demand side Management measures
- Use of modern and effective equipments like electronic meters with remote meter reading systems, prepayment meters etc..

Technological options (CONTD…)

- Use of all aluminum alloy conductors, Aerial bunched/partial insulted LT lines in theft prone area, XLPE cables
- Low loss transformers viz amorphous core transformers, Hi-B steel core transformers completely self protected transformers, cast resin transformers dry type transformers etc..
- Ring main units, Automatic sectionaliser, autoreclosers, load break switches etc.
- Adoption of management Information systems, Customer relation ship management system etc..

9. Scope of works and cost estimates

- The various works as evolved from system studies as per the planning criteria as detailed above, which constitute the long term plan, should be formed up and summarized.
- Detailed Cost estimates should be prepared based on the prevailing market rates both for the material and labour.
- Abstract of cost estimates covering each item of work may be prepared
- The works have to be phased year-wise as per the capability of the utility to execute the works and the finance available.
- The phasing of works shall be decided on the priority accorded to a various sub-works depending on the benefits form each sub-work

10. Financial Analysis

- The design and sustainability of projects is to take into account the level of incentive for undertaking and maintaining a project investment. The financial incentive takes the form of the increased income the investment generates with the executive of project.
- The following methods are adopted to check the financial viability of the projects/schemes
- Benefit cost Ratio: The method is based on life cycle(25-30 years period) cost benefits.
- The financial analysis is usually done for the lifetime of the project considering the year-wise costs including

FINANCIAL ANALYSIS (CONTD…)

- interest, depreciation, operation and maintenance charges, and the expenditure on additional sale of energy ant the year-wise gross benefits including the revenue from additional energy, and cost saving due to saving in losses. The year-wise net present value of the net benefits is calculated an the cumulative net present value of the net benefits is evaluated.
- Internal Rate of Return(IRR): This method calculates the rate of interest needed for the present value of the returns to be the same as the present value of the investment needed. i.e net present value to be zero. This is the point at which the project breaks even. REC specifies the IRR as 15 percent while sanctioning short-term(seven-year repayment) loan scheme

Financial Analysis (CONTD…)

- Pay back period: It is the ratio of the investment to the monetary value of benefits expected due to the execution of project. This method does not consider the time value of money and the life of investment after the pay back period but this measure used as an indication of the amount of investment's risk. Acceptable payback period for power utility projects range from 1-5 years.

11. Implementation of the Projects under Long Term Plan

- The project reports prepared for implementation for long term plans should clearly bring out the various preliminary investigation carried out including route survey, land acquisition, etc.,
- The works proposed under project may be notified as per the statutory requirement.
- The bar/per-chart for each activity/work involved for timely implementation of project may be furnished
- The availability/tie-up of funds for implementation of report may be given.

THANK 'U'