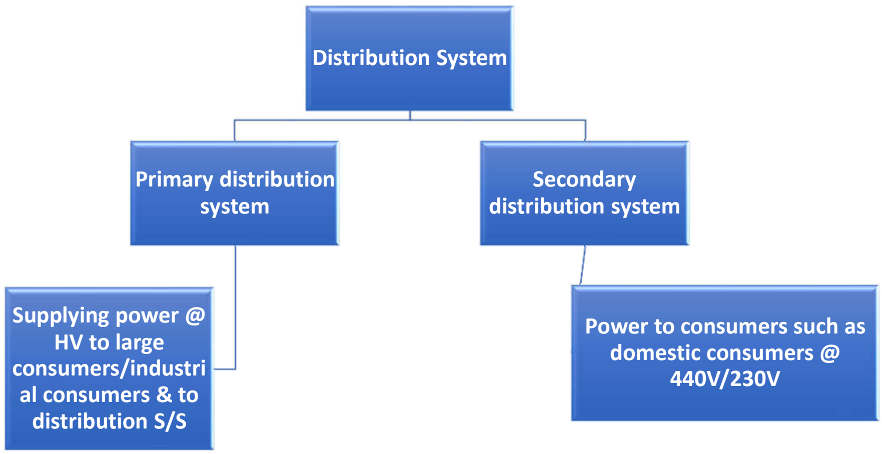
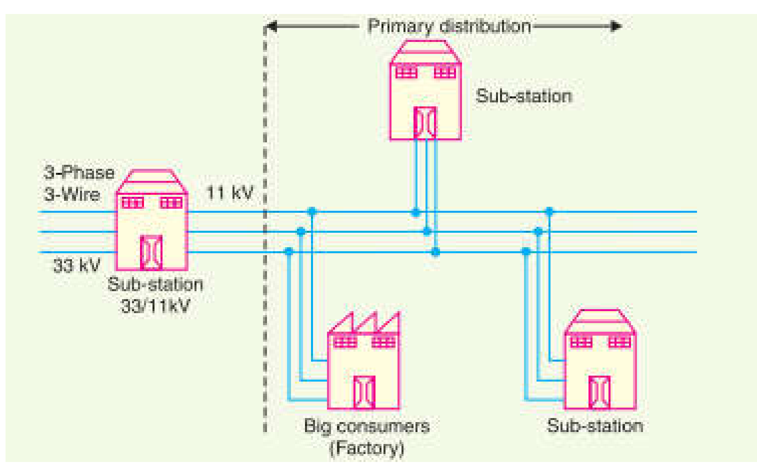
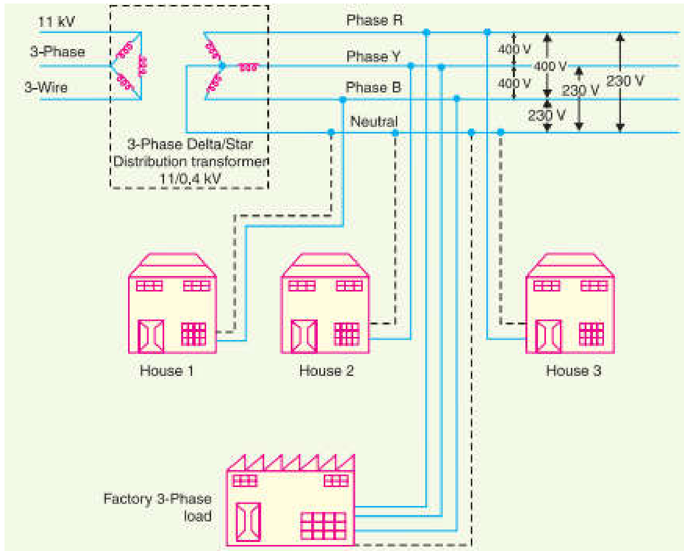
Types of Distribution System Arrangements



Primary Distribution



Secondary Distribution



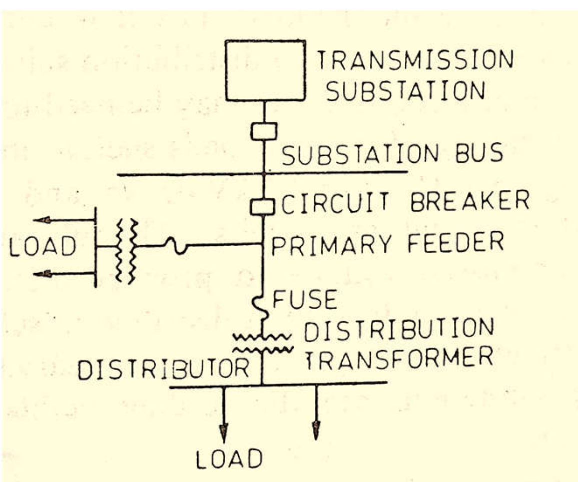
Distribution Systems

- **Distribution Systems**
  - **Radial Systems**
  - **Parallel or Loop system**
  - **Network of grid system of distribution**

Distribution Systems: Parts

- Sub transmission circuits
- Distribution substations
- Primary feeders
- Distribution transformers
- Secondary distribution circuits
- Consumers' service connections

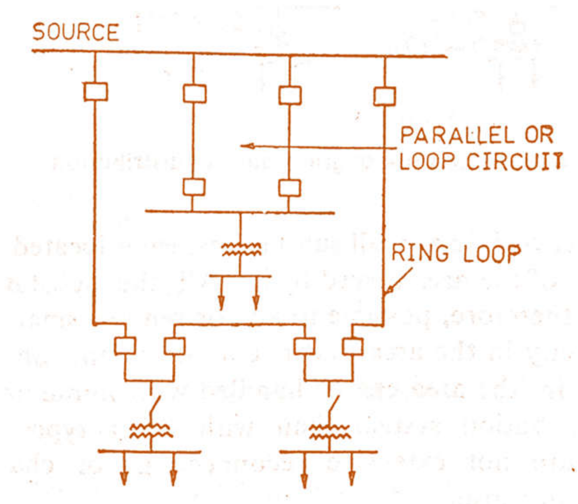
Radial Systems



- **Primary Feeder Voltages: 11 kV, 3.3 kV**
- **Secondary distribution voltage 415/230 V 3-phase-4 wire**

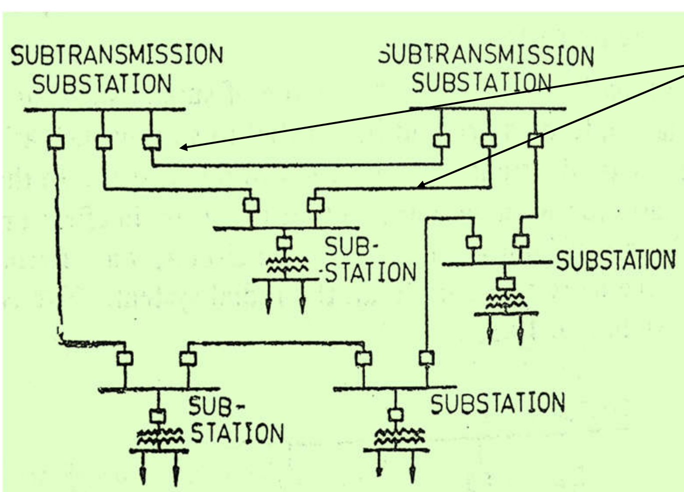
Courtesy: Electrical Power System Design, MV Deshpande

Parallel or loop distribution system



- **The circuit returns to the same point, one feeding point ONLY.**
- **More reliable in case of fault occurrences/maintenance.**

Grid Connected system



Interconnected primary feeders supplied by two or more sub transmission circuits

Advantages:

- ❑ Flexibility
- ❑ Reliability
- ❑ Continuity
- ❑ Diversity of loads
- ❑ Better voltage regulation

Selection and size of feeders

- Factors to account……

- Current carrying capacity
- Permissible heating limits for allowable temperature rise
- Cables of suitable thermal characteristics
- Voltage drop & regulation

Kelvin's Law for cable selection

- $Annual\ Charge\ on\ the\ cost\ of\ cable,$
  $circuits\ for\ distribution = P1 + P_2\,A$

Where A is cross sectional area

Further, considering Power Losses (P_3) in kWh during the year…

The cost of the energy loss is proportional to kWh loss during year.

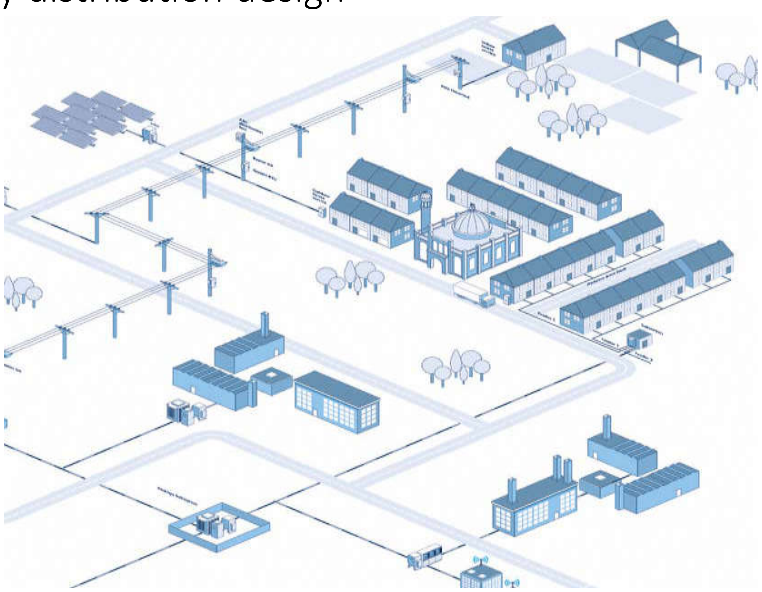
Therefore,

$$Annual\ Charge = P1 + P12 + \frac{P_3}{A}$$

Limitations of the Kelvin's Law

- The energy costs as well as depreciation and sinking fund charges of two similar cable systems may different in different locations.
- The cost of copper conductors is not the only variable cost
- The load factor at the station or of the system and the load factor of the losses differ and this causes error in calculation.

Secondary distribution design



Secondary distribution design: Factors to consider

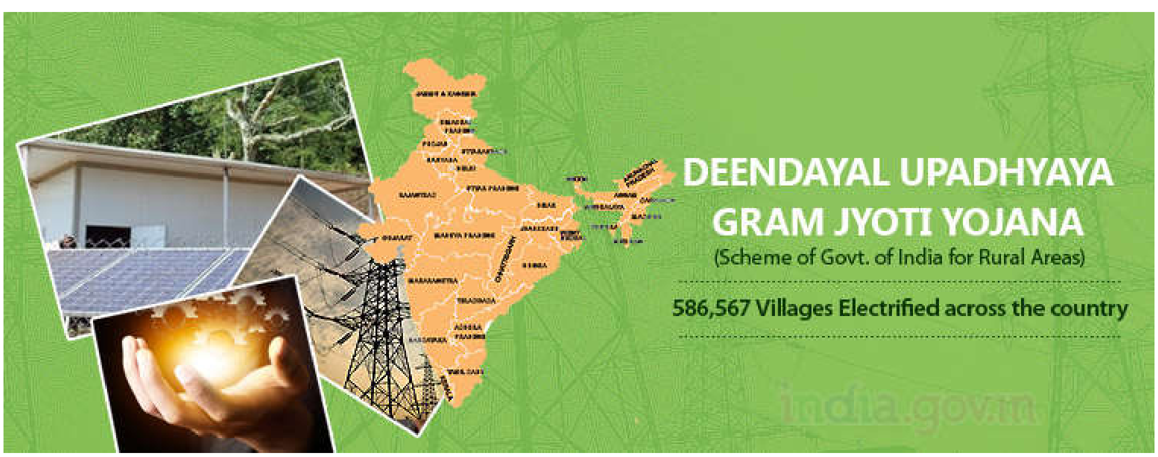
- Choice of voltage
- Conductor size: permissible voltage drop, current capacity
- Types of secondary distribution system

Individual transformer for each customer with direct secondary connection
A common secondary distributor fed by one transformer supplying a group of customers -radial system
A common continuous secondary distributor fed by several transformers, all of which are connected to the same primary feeder
A common continuous secondary distributor fed by several transformers divided among two or more primary feeders for their source of supple, i.e., ac low voltage network or secondary network.

Secondary banks: Purpose

- In case one transformer fails, its load can be carried by adjacent transformers.
- There is better load distribution on a number of transformers instead of one only.
- There is better average voltage conditions.
- A general increase in the load may be effected by increasing the size of a part of the transformers in the bank.

Planning of Design of Town- electrification schemes



Courtesy: Ministry of Power, India.
Rural Electrification Corporation Limited (REC) will be the nodal agency for implementation of the scheme.

Definition: Rural electrification

- As per the DEENDAYAL UPADHYAYA GRAM JYOTI YOJANA

if :

- Basic infrastructure such as Distribution Transformer and Distribution lines are provided in the inhabited locality as well as the Dalit Basti hamlet where it exists.
- Electricity is provided to public places like Schools, Panchayat Office, Health-Centers, Dispensaries, Community centers etc.
- The number of households electrified should be at least 10% of the total number of households in the village.

Issued by MOP, vide their letter No. 42/1/2001-D(RE) dated 5th February 2004 and its corrigendum vide letter no. 42/1/2001-D(RE) dated 17th February 2004.)

Planning of Design of Town- electrification schemes

A village would be declared as electrified, if :

- Basic infrastructure such as Distribution Transformer and Distribution lines are provided in the inhabited locality as well as the Dalit Basti hamlet where it exists.
- Electricity is provided to public places like Schools, Panchayat Office, Health Centers, Dispensaries, Community centers etc.
- The number of households electrified should be at least 10% of the total number of households in the village.

Source: Ministry of Power, India

Planning of Design of Town- electrification schemes: Step-by-step

1. Survey the area to be supplied
2. Load estimation with regard to magnitude, time of occurrence, maximum demand and location.
3. Category of load: industrial, residential, commercial, municipal, agricultural etc.
4. Work out load density.

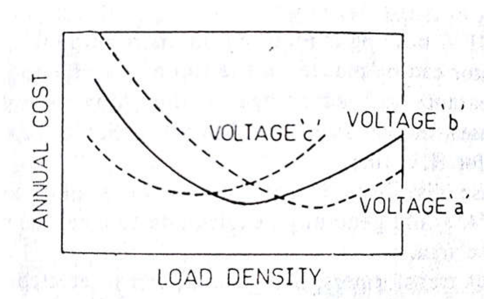


Fig. Annual cost versus load density

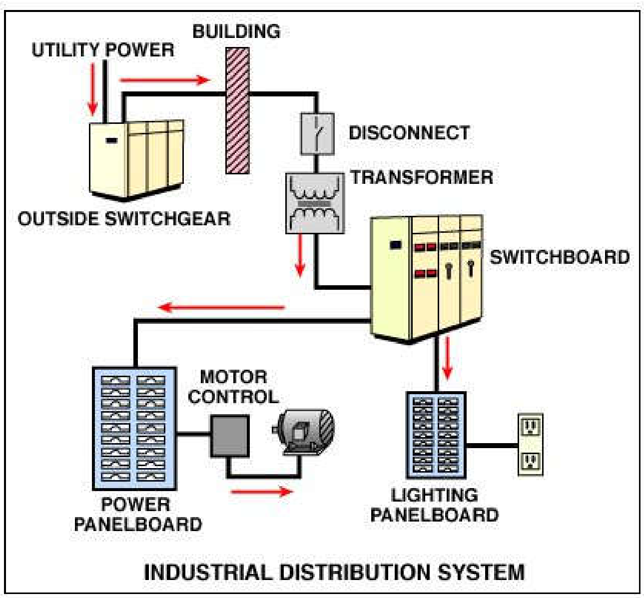
Planning of Design of Town- electrification schemes: Step-by-step

6. Availability of power supply nearby.
7. Fix the location of transmission s/s and select the voltage of sub transmission.
8. Locate the main distribution s/s preferably separate for each type of load.
9. Find the total load of each type in the separate areas, and using the demand factor, diversity, and calculate maximum demand.
10. Design primary-distribution system (radial/loop/grid type).
11. Choose the size of conductors, calculate voltage drops

Planning of Design of Town- electrification schemes: Step-by-step

12. Estimate the load centers (gravity of load), choose the size of transformers.
13. Prepare secondary distribution systems.
14. Keep provision for easy addition or expansion of the distribution systems.
15. Analyze the requirement of reactive power requirement.
16. Avoid lamp flicker within the limit of 2-2.5% .
17. Check the initial cost of equipment, lines, primary/secondary distribution lines.
18. Estimate the loses in the distribution system and work out the cost/kWh as per the tariff structure.

Industrial distribution system



Industrial distribution system: Facts & Figures

- Load structure: special characteristics

✓ Industrial sectors take about 70% of the net energy transmitted.
✓Special characteristics: high specific-load density
✓Load density: 1-6 W/sq. Meter for low voltage networks
✓ Load density- 50- 600 W/sq. meter for high current networks
✓Peak-load duration-4000-5000 hours per annum

Load groups and power demand

Uniformly distributed load

Large groups with point loads

Large single loads

Load groups and power demand

Uniformly distributed load

Power consuming equipment distributed uniformly over an area or in space in which the equipment represents constant loading over periods of time.

Load density: 50-100 W/sq. mt.
P.f. – 0.7 without corrective measures

Source: SRI Krishna Spinning & Weaving Mill, Bangalore

Load groups and power demand

Large groups with point loads

Type of load	Average load densities (W/m²)	Power factor (estimated)
Manufacture of machine tools	70-100	0.6
Punching and pressing	100-300	0.5
Mechanical workshops	170-300	0.6
Welding shops	200-600	0.5
Hardening shops	200-600	0.9

Load groups and power demand

Large single loads

A few examples/applications:

- Large furnaces
- Mining machineries
- Steel works
- Rolling mills
- Chemical industries e.g., rectifiers for electrolytic process

Mining/tippler machineries

Electric Furnace

Steel Works Industries

Rolling Mills

Electrolysis Process Industry-
Extracting Copper (Cu)

Economics of distribution systems

Why?

- To save the capital and running cost of the distribution systems
- To generate higher revenue
- To ensure reliability of the electrical supply

Economics of distribution systems: Factors to consider

- Voltage class
- Type of construction
- Sub transmission circuits
- Primary feeder circuits
- Load density
- Working conditions
- Anticipated (estimated-future) load growth
- Total cost of the system

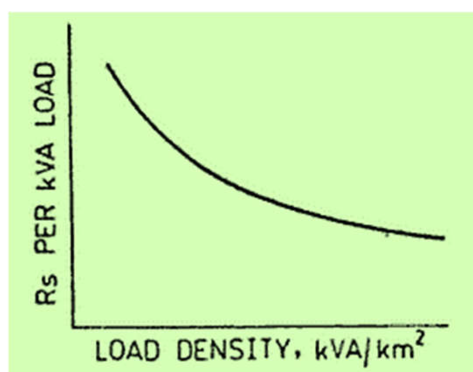
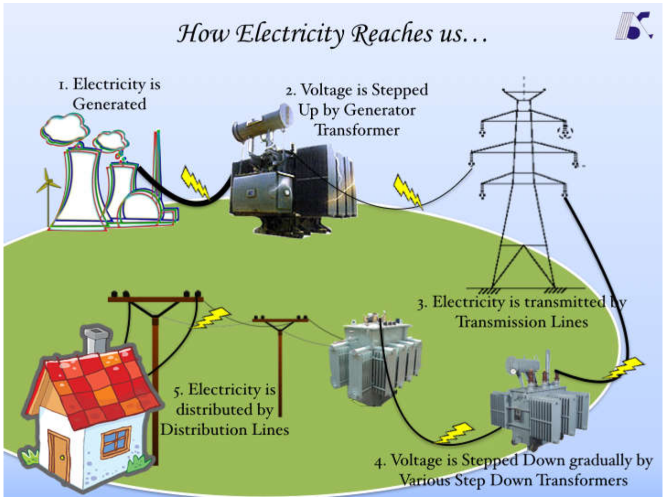


Fig. Cost per kVA versus load density kVA/km^2

Transmission and distribution (T & D) costs



T & D components & requirements

- Transmission lines (in structure kilometers)
- Transmission substations (in kVA capacity)
- Primary distribution lines (in circuit kilometers)
- Distribution substations (in kVA capacity)
- Line transformers (in kVA capacity)
- Energy meters (in numbers)

T & D- Total cost components

The costs of HV transmission lines

The costs of distribution lines

The operation and maintenance cost of T & D systems

80 % of total cost of T & D

Operation and Maintenance expenses of transmission

Transmission network

Transmission or substation equipment & load dispatching services

Supervising and engineering expenses

Operation and Maintenance expenses of distribution

Energy losses in a distribution system

- Line losses on phase conductors
- Line losses on ground wires and ground
- Transformer core and leakage losses
- Excess losses due to lack of coordination of VAR elements
- Excess losses due to load characteristics
- Excess losses due to load imbalance on the phases

Type of load as per load nature & tariff structure/category

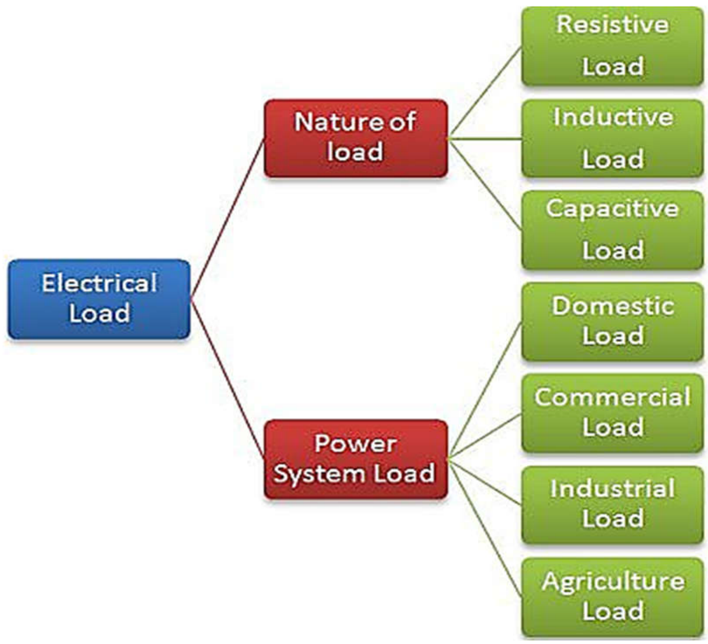


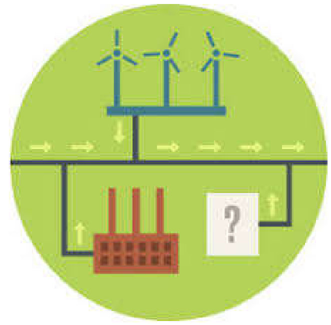
Table: Type of Motor load

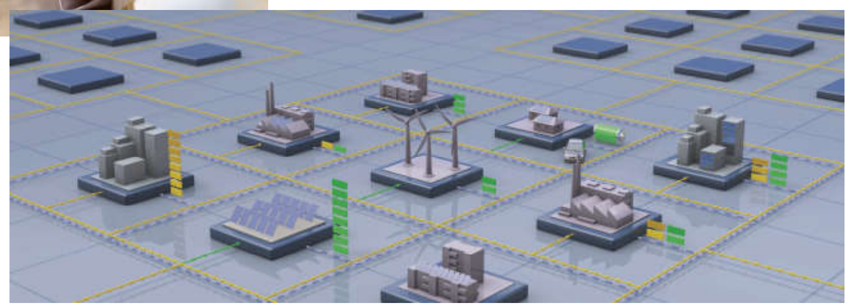
Electric Motors

Three types of Motor Load

Motor loads	Description	Examples
Constant torque loads	Output power varies but torque is constant	Conveyors, rotary kilns, constant-displacement pumps
Variable torque loads	Torque varies with square of operation speed	Centrifugal pumps, fans
Constant power loads	Torque changes inversely with speed	Machine tools

Power System Planning





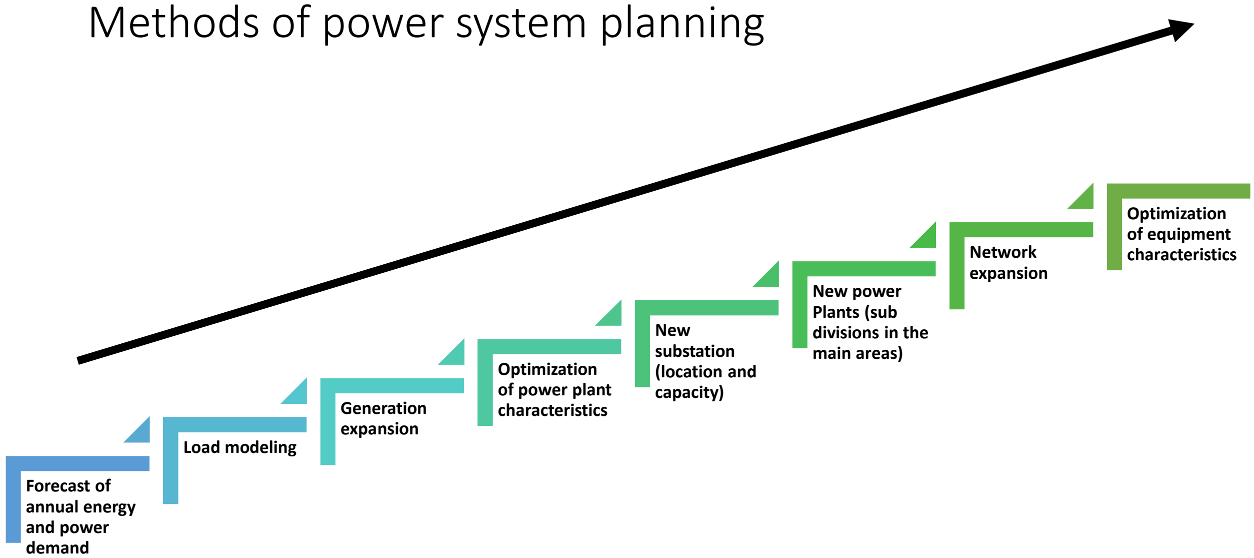
Power System Planning: Why?

- Technical Performance
- Economic Performance

Consider.......

Stability +
Reliability of the system

Methods of power system planning



Power System Improvement: Why?

- Low Power Factor of the consumer installations
- Long and overhead LT lines
- Distribution transformers’ centers located away from load centers
- Long and overhead 11 kV and sub transmission lines
- Poor voltage regulation on 11 kV and LT lines, voltage drops being extended beyond permissible limits
- Underloading of distribution transformers
- Absence of shut compensation

Objectives of power system improvement

- To reduce T & D losses
- To improve voltage regulation
- To improve continuity of supply
- To improve power factor in all segments of power system
- To get optimum utilization of generators and T & D systems

Methods of power system improvement

- Improvement on LT system
- Improvement of the existing 11 kV system
- Shunt compensation
- Augmentation of power transformer capacity
- Augmentation of sub transmission lines
- New sub transmission line and substations

Financial aspects of the power system improvement scheme

Financial aspects of the power system improvement scheme

- Savings on account of reduction in system losses
- Revenue from the sale of additional energy on account of load growth
- Shunt compensation at the HT substation
- Capital gains without load growth

Reducing MVAR loading on generator

Release in transmission capacity and reduction in losses

Improvement in power factor and reduction in current