**(5) Two Part Tariff (Hopkinson Demand Rate).** In this tariff the total charges are based on the maximum demand and energy consumed. It is expressed as

$$Y = D \times X + EZ$$

A separate meter is required to record the maximum demand. This tariff is used for industrial loads.

**(6) Three-Part Tariff (Doherty Rate).** According to this tariff the customer pays some fixed amount in addition to the charges for maximum demand and energy consumed. The fixed amount to be charged depends upon the occasional increase in fuel price, rise in wages of labour etc. It is expressed by the expression

$$Y = DX + EZ + C.$$

## Load Distribution Parameters

**1. Load Factor**

It is defined as the ratio of the average load to the peak load during a certain prescribed period of time. The load factor of a power plant should be high so that the total capacity of the plant is utilized for the maximum period that will result in lower cost of the electricity being generated. It is always less than unity.

High load factor is a desirable quality. Higher load factor means greater average load, resulting in greater number of power units generated for a given maximum demand. Thus, the fixed cost, which is proportional to the maximum demand, can be distributed over a greater number of units (kWh) supplied. This will lower the overall cost of the supply of electric energy.

**2. Utility Factor**

It is the ratio of the units of electricity generated per year to the capacity of the plant installed in the station. It can also be defined as the ratio of maximum demand of a plant to the rated capacity of the plant. Supposing the rated capacity of a plant is 200 MW. The maximum load on the plant is 100 MW at load factor of 80 per cent, and then the utility will be

$$= \frac{100 \times 0.8}{200} = 40\%$$

**3. Plant Operating Factor**

It is the ratio of the duration during which the plant is in actual service, to the total duration of the period of time considered.

**4. Plant Capacity Factor**

It is the ratio of the average loads on a machine or equipment to the rating of the machine or equipment, for a certain period of time considered.

Since the load and diversity factors are not involved with 'reserve capacity' of the power plant, a factor is needed which will measure the reserve, likewise the degree of utilization of the installed equipment. For this, the factor "Plant factor, Capacity factor or Plant Capacity factor" is defined as,

$$\textbf{Plant Capacity Factor} = \frac{\text{Actual kWh Produced}}{\text{Maximum Possible Energy that might have produced during the same period}}$$

Thus the annual plant capacity factor will be,

$$= \frac{\text{Actual kWh Produced}}{\text{Plant capacity (kW)} \times \text{hours of the year}}$$

The difference between load and capacity factors is an indication of reserve capacity.

**5. Demand Factor**

The actual maximum demand of a consumer is always less than his connected load since all the appliances in his residence will not be in operation at the same time or to their fullest extent. This ratio of' the maximum demand of a system to its connected load is termed as demand factor. It is always less than unity.

**6. Diversity Factor**

Supposing there is a group of consumers. It is known from experience that the maximum demands of the individual consumers will not occur at one time. The ratio of the sum of the individual maximum demands to the maximum demand of the total group is known as diversity factor. It is always greater than unity.

High diversity factor (which is always greater than unity) is also a desirable quality. With a given number of consumers, higher the value of diversity factor, lower will be the maximum demand on the plant, since,

$$\text{Diversity factor} = \frac{\text{Sum of the individual maximum Demands}}{\text{Maximum demand of the total group}}$$

So, the capacity of the plant will be smaller, resulting in fixed charges.

7. **Load Curve**

   It is a curve showing the variation of power with time. It shows the value of a specific load for each unit of the period covered. The unit of time considered may be hour, days, weeks, months or years.

8. **Load Duration Curve**

   It is the curve for a plant showing the total time within a specified period, during which the load equaled or exceeded the values shown.

9. **Plant Use Factor**

   This is a modification of Plant Capacity factor in that only the actual number of hours that the plant was in operation is used. Thus Annual Plant Use factor is,

$$\text{Diversity factor} = \frac{\text{Annual kWh produced}}{\text{Plant capacity (kW)} \times \text{ number of hours of plant operation}}$$

## Load Curves

The load demand on a power system is governed by the consumers and for a system supplying industrial and domestic consumers, it varies within wide limits. This variation of load can be considered as daily, weekly, monthly or yearly. Typical load curves for a large power system are shown in Fig. A.

These curves are for a day and for a year and these show the load demanded by the consumers at any particular time. Such load curves are termed as “Chronological load Curves”. If the ordinates of the chronological load curves are arranged in the descending order of magnitude with the highest ordinates on left, a new type of load curve known as “load duration curve” is obtained. Fig. A, shows such a curve. If any point is taken on this curve then the abscissa of this point will show the number of hours per year during which the load exceeds the value denoted by its ordinate. Another type of curve is known as “energy load curve” or the “integrated duration curve”. This curve is plotted between the load in kW or MW and the total energy generated in kWh. If any point is taken on this curve, abscissa of this point show the total energy in kWh generated at or below the load given by the ordinate of this point. Such a curve is shown in Fig. A. In Fig. B, the lower part of the curve consisting of the loads which are to be supplied for almost the whole number of hours in a year, represents the "Base Load", while the upper part, comprising loads which are required for relatively few hours per year, represents the "Peak Load".

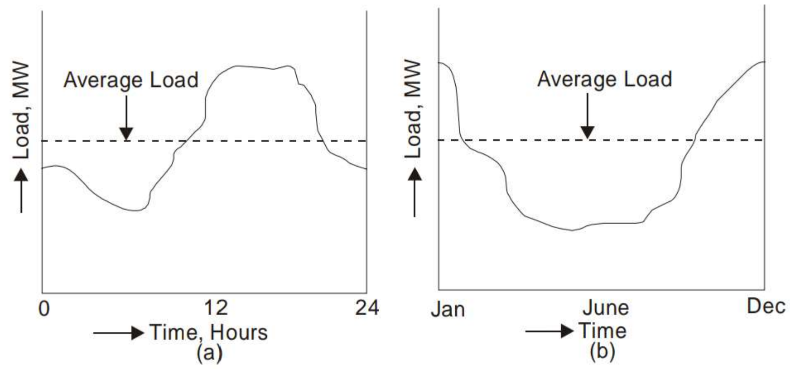


**Fig.** Chronological Load Curves (a) Daily Load Curve (b) Yearly Load Curve.

## Effect of Power Plant Type on Costs

The cost of a power plant depends upon, when a new power plant is to set up or an existing plant is to be replaced or plant to be extended. The cost analysis includes

### 1. Fixed Cost

It includes Initial cost of the plant, Rate of interest, Depreciation cost, Taxes, and Insurance.

### 2. Operational Cost

It includes Fuel cost, Operating labour cost, Maintenance cost, Supplies, Supervision, Operating taxes.

## 1. Fixed Cost

### Initial Cost

The initial cost of a power station includes the following:

1. Land cost
2. Building cost
3. Equipment cost
4. Installation cost

5. Overhead charges, which will include the transportation cost, stores and storekeeping charges, interest during construction etc.

To reduce the cost of building, it is desirable to eliminate the superstructure over the boiler house and as far as possible on turbine house also.

Adopting unit system where one boiler is used for one turbo-generator can reduce the cost on equipment. Also by simplifying the piping system and elimination of duplicate system such as steam headers and boiler feed headers. Eliminating duplicate or stand-by auxiliaries can further reduce the cost.

When the power plant is not situated in the proximity to the load served, the cost of a primary distribution system will be a part of the initial investment.

**Rate of Interest**

All enterprises need investment of money and this money may be obtained as loan, through bonds and shares or from owners of personal funds. Interest is the difference between money borrowed and money returned. It may be charged at a simple rate expressed as % per annum or may be compounded, in which case the interest is reinvested and adds to the principal, thereby earning more interest in subsequent years. Even if the owner invests his own capital the charge of interest is necessary to cover the income that he would have derived from it through an alternative investment or fixed deposit with a bank.

**Depreciation**

Depreciation accounts for the deterioration of the equipment and decrease in its value due to corrosion, weathering and wear and tear with use. It also covers the decrease in value of equipment due to obsolescence. With rapid improvements in design and construction of plants, obsolescence factor is of enormous importance. Availability of better models with lesser overall cost of generation makes it imperative to replace the old equipment earlier than its useful life is spent. The actual life span of the plant has, therefore, to be taken as shorter than what would be normally expected out of it.

The following methods are used to calculate the depreciation cost:

(1) Straight line method

(2) Percentage method

(3) Sinking fund method

(4) Unit method.

**Straight Line Method.** It is the simplest and commonly used method. The life of the equipment or the enterprise is first assessed as also the residual or salvage value of the same after the estimated life span. This salvage value is deducted from the initial capital cost and the balance is divided by the life as assessed in years. Thus, the annual value of decrease in cost of equipment is found and is set aside as depreciation annually from the income. Thus, the rate of depreciation is uniform throughout the life of the equipment. By the time the equipment has lived out its useful life, an amount equivalent to its net cost is accumulated which can be utilized for replacement of the plant.

**Percentage Method.** In this method the deterioration in value of equipment from year to year is taken into account and the amount of depreciation calculated upon actual residual value for each year. It thus, reduces for successive years.

**Sinking Fund Method.** This method is based on the conception that the annual uniform deduction from income for depreciation will accumulate to the capital value of the plant at the end of life of the plant or equipment. In this method, the amount set aside per year consists of annual installments and the interest earned on all the installments.

**Unit Method.** In this method some factor is taken as a standard one and, depreciation is measured by that standard. In place of years equipment will last, the number of hours that equipment will last is calculated. This total number of hours is then divided by the capital value of the equipment. This constant is then multiplied by the number of actual working hours each year to get the value of depreciation for that year. In place of number of hours, the number of units of production is taken as the measuring standard.

## 2. Operational Costs

The elements that make up the operating expenditure of a power plant include the following

(1) Cost of fuels.

(2) Labour cost.

(3) Cost of maintenance and repairs.

(4) Cost of stores (other than fuel).

(5) Supervision.

(6) Taxes.

**Cost of Fuels**

In a thermal station fuel is the heaviest item of operating cost. The selection of the fuel and the maximum economy in its use are, therefore, very important considerations in thermal plant design. It is desirable to achieve the highest thermal efficiency for the plant so that fuel charges are reduced. The cost of fuel includes not only its price at the site of purchase but its transportation and handling costs also. In the hydro plants the absence of fuel factor in cost is responsible for lowering the operating cost. Plant heat rate can be improved by the use of better quality of fuel or by employing better thermodynamic conditions in the plant design.

The cost of fuel varies with the following:

(i) Unit price of the fuel.

(ii) Amount of energy produced.

(iii) Efficiency of the plant.

**Labour Cost**

For plant operation labour cost is another item of operating cost. Maximum labour is needed in a thermal power plant using coal as a fuel. A hydraulic power plant or a diesel power plant of equal capacity requires a lesser number of persons. In case of automatic power station the cost of labour is reduced to a great extent. However labour cost cannot be completely eliminated even with fully automatic station, as they will still require some manpower for periodic inspection etc.

**Cost of Maintenance and Repairs**

In order to avoid plant breakdowns maintenance is necessary. Maintenance includes periodic cleaning, greasing, adjustments and overhauling of equipment. The material used for maintenance is also charged under this head. Sometimes an arbitrary percentage is assumed as maintenance cost. A good plan of maintenance would keep the sets in dependable condition and avoid the necessity of too many stand-by plants.

Repairs are necessitated when the plant breaks down or stops due to faults developing in the mechanism. The repairs may be minor, major or periodic overhauls and are charged to the depreciation fund of the equipment. This item of cost is higher for thermal plants than for hydro-plants due to complex nature of principal equipment and auxiliaries in the former.

**Cost of Stores**

The items of consumable stores other than fuel include such articles as lubricating oil and greases, cotton waste, small tools, chemicals, paints and such other things. The incidence of this cost is also higher in thermal stations than in hydro-electric power stations.

**Supervision**

In this head the salary of supervising staff is included. A good supervision is reflected in lesser breakdowns and extended plant life. The supervising staff includes the station superintendent, chief engineer, chemist, engineers, supervisors, stores in-charges, purchase officer and other establishment. Again, thermal stations, particularly coal fed, have a greater incidence of this cost than the hydro-electric power stations.

**Taxes**

The taxes under operating head include the following:

(i) Income tax

(ii) Sales tax

(iii) Social security and employee's security etc.