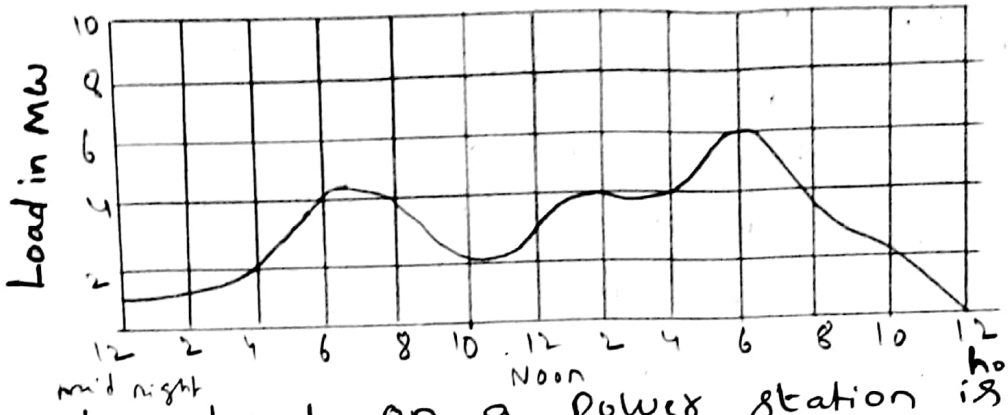
VI. Economic Aspects of Power Generation & Tariff.

⇒ **Load Curve:** The Curve showing the Variation of Load on the power station with respect to time is known as a Load Curve.



* The Load on a power station is never constant it varies from time to time. These load variations during the whole day (i.e 24 hrs) are recorded half-hourly or hourly and are plotted against time on the graph. The curve thus obtained is known as daily load curve. fig (a) shows a typical daily load curve of a power station.

monthly load curve: it can be obtained from the daily load curves of that month. For this purpose average values of power over a month at different times of the day are calculated and then plotted on the graph.

yearly load curve: It is obtained by considering the monthly load curves of that particular year. the yearly load curve is generally

Used to determine the annual load factor.

Importance: The daily load curves have attained a great importance in generation they have

* The daily load curve shows the variations of load on the power station during different hrs of the day.
* The Area under the daily load curve gives the no of units generated in the day.
* The highest point on the daily load curve represents the maximum demand on the station on that day.
* The Area under the daily load curve divided by the total no of hours gives the average load on the station in the day.

$$\text{Average load} = \frac{\text{Area (in kwh) under daily load curve}}{24 \text{ hrs}}$$

⇒ Important terms and factors:

i) Connected load: It is the sum of Continuous rating of all the equipments Connected to supply system.

* A Power station supplies load to thousands of Consumers. Each Consumer has certain equipment installed in his premises. The sum of the Continuous ratings of all the equipments in the Consumer's premises is the Connected load of the Consumer.

ii) maximum demand: It is the greatest demand of load on the power station during a given period.

* The load on the power station varies from time to time. The maximum of all the demands that have occurred during a given period is the maximum demand.

iii) Demand factor: It is the ratio of maximum demand on the power station to its connected load

$$\text{Demand factor} = \frac{\text{maximum demand}}{\text{connected load}}$$

* The value of demand factor is usually less than 1. It is expected because maximum demand on the power station is generally less than the connected load.

If the maximum demand on the power station is 80 mw and connected load is 100 mw, then demand factor = $80/100 = 0.8$

iv) Average load: The average of loads occuring on the power station in a given period (day or month or year) is known as average load or average demand.

$$\text{Daily average load} = \frac{\text{No of units(kwh) generated in a day}}{24 \text{ hrs}}$$

$$\text{monthly average load} = \frac{\text{No of units(kwh) generated in a month}}{\text{No of hrs in a month}}$$

$$\text{yearly average load} = \frac{\text{No of units(kwh) generated in a year}}{8760 \text{ hrs}}$$

v) Load factor: The ratio of average load to the maximum demand during a given period is known as load factor.

$$\text{Load factor} = \frac{\text{Average load}}{\text{max demand}}$$

If the plant is in operation for T hrs

$$\text{Load factor} = \frac{\text{Average load} \times T}{\text{Max. demand} \times T}$$

$$= \frac{\text{Units generated in T hrs}}{\text{max. demand} \times T \text{ hrs}}$$

Load factor is always less than 1 because average load is smaller than the maximum demand.

vi) Diversity factor: The ratio of the sum of individual maximum demands to the maximum demand on power station is known as diversity factor.

$$\text{Diversity factor} = \frac{\text{Sum of individual max. demands}}{\text{max demand on Power station.}}$$

The Diversity factor will be always greater than one. The greater the diversity factor, the lesser is the cost of generation of power.

vii) plant Capacity factor: It is the ratio of actual energy produced to the maximum possible energy that could have been produced during a given period.

$$\text{plant Capacity factor} = \frac{\text{Actual energy produced}}{\text{max. energy that could have been produced.}}$$

$$= \frac{\text{Average demand} \times T}{\text{plant capacity} \times T}$$

$$= \frac{\text{Average demand}}{\text{plant capacity.}}$$

Thus If the considered period is one year.

$$\text{Annual plant capacity factor} = \frac{\text{Annual kwh o/p}}{\text{plant capacity} \times 8760}$$

viii) Plant use factor: It is ratio of kwh generated to the product of plant capacity and the no of hours for which the plant was in operation.

$$\text{plant use factor} = \frac{\text{station o/p in kwh}}{\text{plant capacity} \times \text{Hrs of use.}}$$

Suppose a plant having installed capacity of 20mw produces annual output of 7.35×10^6 kwh and remain in operation for 2190 hrs in a year. then

$$\text{plant use factor} = \frac{7.35 \times 10^6}{(20 \times 10^3) \times 2190} = 0.167 = 16.7\%$$

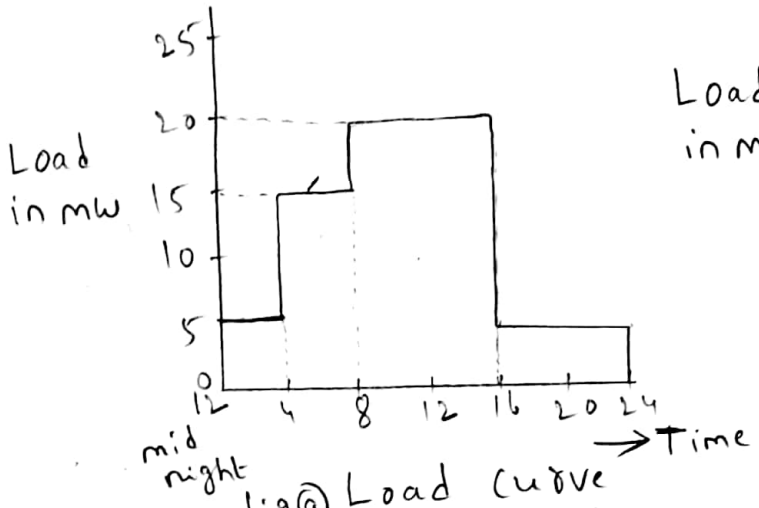
⇒ Load duration curve:

When the load elements of a load curve are arranged in the order of descending magnitudes the curve thus obtained is called a load duration curve

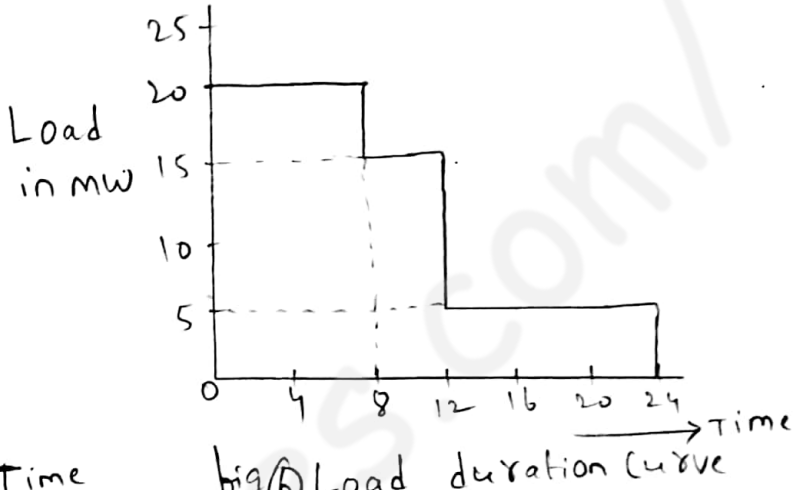
* The Load duration curve is obtained from the same data as the load curve but the ordinates are arranged in order of descending magnitudes.

The maximum load is represented to the left and decreasing loads are represented to the right in the descending order.

* Hence the area under load duration curve and the area under the load curve are equal.



big ⓐ Load curve

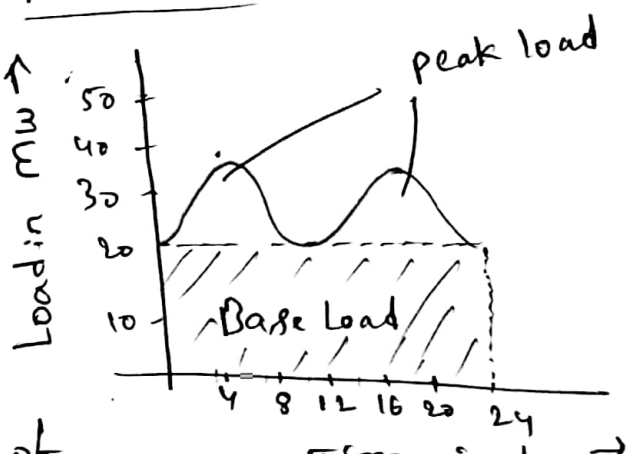


big ⓑ Load duration curve

From the above bigs 20mw for 8 hrs, 15mw for 4 hrs and 5 mw for 12 hrs. plotting these loads in order of descending magnitude we get the daily load duration curve.

⇒ Base Load (&) Peak Load

Base load:
The unvarying load which occurs almost the whole day on the station is known as base load



from this big. 20mw of load has to be supplied by the station at all times of day and night i.e throughout 24 hrs.
20 mw is the base load of the station.
As base load on the station is almst of constant.

Peak Load: The various peak demands of load over and above the base load of the station is known as peak load.

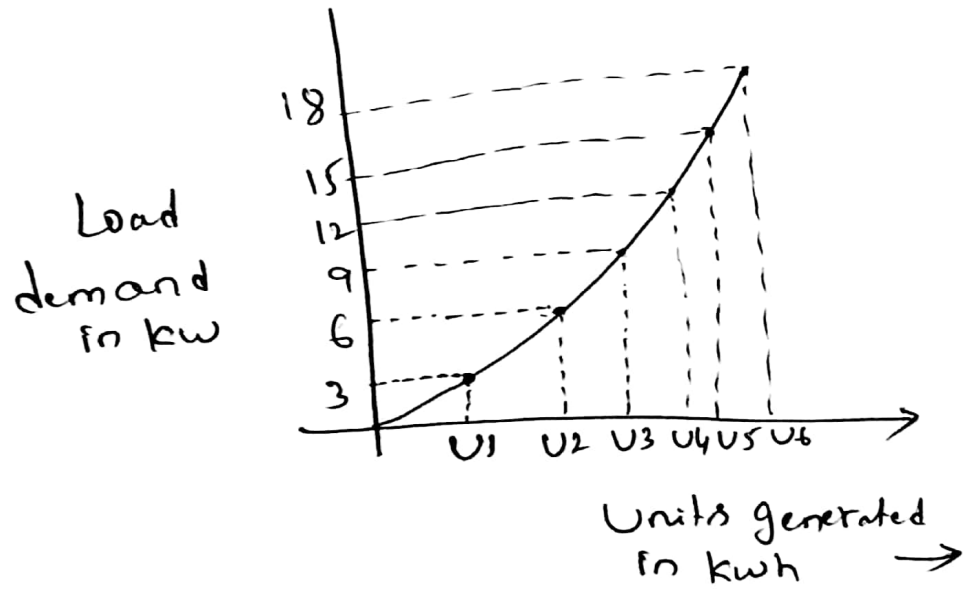
From the above fig. there are peak demands of load excluding base load. these peak demand of the station generally form a small part of the total load and may occur throughout the day.

⇒ **Integrated Load duration curve:**

A plot of number of units generated (kwh) for a given demand (kw) is called Integration Load duration curve.

On Y-axis Load demand in kw or MW is plotted while X-axis corresponding no of units generated are obtained.

The Integrated Load duration curve is shown in fig@



The curve is obtained from Load duration curve. Let the load demand be 3 kW from the load duration curve in section 1. The no of units generated corresponding to this demand will be area under section 1 which is shown as U_1 in integrated load duration curve.

Similarly the other points are also obtained to get a total curve.

⇒ Explain the various costs of electrical energy.

Sol: The determination of production cost of an electrical energy per unit is known as economics of power generation. (5)

During designing and installation of a power station the economy plays a key role.

Depending upon generation, maintenance and distribution of electrical energy it's cost are classified into three types. They are,

i) fixed cost
ii) Semi fixed cost
iii) Running or operating cost.

i) fixed cost: It is the cost which is independent of maximum demand and units generated The fixed cost is due to the annual cost of Central organisation, interest on Capital cost of Land and Salaries of high officials.

ii) Semi fixed cost: It is the cost which depends upon maximum demand but is independent of units generated

The Semi fixed cost is directly proportional to the maximum demand on power station and account of annual interest and depreciation on capital investment of building and equipment, taxes, Salaries of management and clerical staff.

iii) Running cost: It is the cost which depends only upon the no of units generated.

The running cost is on account of annual Cost of fuel, lubricating oil, maintenance,

repairs and Salaries of operating staff.

⇒ Tariff: The rate at which electrical energy is supplied to a consumer is known as tariff. Although tariff should include the total cost of producing and supplying electrical energy plus the profit, yet it can not be the same for all types of consumers.

Objectives of tariff:

a tariff should include the following items:

* Recovery of cost of producing electrical energy at the power station.
* Recovery of cost on the capital investment in transmission and distribution systems
* Recovery of cost of operation and maintenance of supply of electrical energy e.g metering equipments, building etc.
* A suitable profit on the capital investment.

⇒ Desirable characteristics of a Tariff:

A tariff must have the following desirable characteristics.

i) Proper return: The tariff ensures the proper return from each consumer. In other words, the total receipts from the consumers must be equal to the cost of producing and supplying electrical energy plus reasonable profit.

ii) Attractive: The tariff should be attractive so that a large no of consumers are encouraged to use electrical energy.

iii) Fairness: The tariff must be fair so that different types of consumers are satisfied with the rate of charge of electrical energy. Thus a big consumer should be charged at a lower rate than a small consumer. (6)

iv) Simplicity: The tariff should be simple so that an ordinary consumer can easily understand it. A complicated tariff may cause an opposition from the public which is generally distrustful of supply companies.

v) Reasonable profit: The profit element in the tariff should be reasonable. An electric supply company is a public utility company. the investment is relatively safe due to non competition in the market.

⇒ Types of Tariff:

There are several types of tariff. However the following are the commonly used types of tariff.

1. Simple tariff: When there is a fixed rate per unit of energy consumed. it is called a simple tariff or uniform rate tariff.

* In this type of tariff, the price charged per unit is constant i.e it does not vary with increase or decrease in number of units consumed.

Advantages: i) This is the simplest of all tariffs

ii) it is readily understood by the consumers

Disadvantages:

* there is no discrimination between different types of consumers since every consumer has to pay equitably for the fixed charges.
* The cost per unit delivered is high.

2. Flat rate tariff: When different types of consumers are charged at different uniform per unit rates it is called flat rate tariff.

The rate for each type of consumer is arrived at by taking its load factor, diversity factors into account. The bill will be total units consumed x rate/unit

consumers using electricity for agricultural purposes such as irrigation, trashing etc.

Advantages: it is more fair to different types of consumers and is quite simple in calculations.

Disadvantages: If the consumer has got two types of loads i.e i) Lighting load ii) Power load then two meters are installed at his premises. i.e for different types of power supply, Separate meters are required.

3. Block rate tariff: when a given block of energy is charged at a specified rate and the succeeding blocks of energy are charged at progressively reduced rates it is called block rate tariff.

* If the number of units generated increases then the cost of generation per unit automatically decreases. For ex, the first 30 units may be charged at the rate of 60 Paise per unit; the next 25 units at the rate of 55 paise per unit and the remaining additional units may be charged at the rate of 30 paise per unit.

* This type of tariff is being used for majority of residential and small commercial consumers.

Advantage: If the consumer has large demand of no of units then he has to pay less amount only.

Disadvantage: It lacks a measure of the consumers demand.

4. Two part tariff: When the rate of electrical energy is charged on the basis of maximum demand of the consumer and the units consumed, it is called a two part tariff.

* In two part tariff, the total charge to be made from the consumer is split into two components i.e fixed charges and running charges. The fixed charges depends upon the maximum demand of the consumer while the running charges depend upon the no of units consumed by the consumer.

Total charges = Rs (b × kw + C × kwh

b = charge per kw of maximum demand

C = Charge per kwh of energy consumed.

This type of tariff is mostly applicable to industrial consumers.

Advantages: It is easily understood by the consumers

* It recovers the fixed charges which depend upon the maximum demand of the consumer but are independent of the units consumed.

Disadvantages: There is always error in assessing the maximum demand of the consumer.

5. maximum demand tariff: It is similar to two part tariff with the only difference that the maximum demand is actually measured by installing maximum demand meter in the premises of the consumer.

* this type of tariff is mostly applied to big consumer; as a separate maximum demand meter is required.

6. three part tariff: when the total charge to be made from the consumer split into three parts i.e fixed charge, Semi fixed charge and Running charge. it is known as three part tariff.

total charge = Rs $(a + b \times kw + c \times kwh)$

a = fixed charge made during each billing period

b = charge per kw of maximum demand.

c = Charge per kwh of energy consumed

By adding fixed charge to two part tariff, it becomes three part tariff
this type of tariff is generally applied to big consumers. (8)

Advantage: this type of tariff is suitable for bulk consumers

Disadvantages: It has complex calculations when compared with two part tariff method
* it is not recommended for residential consumers.

7. Power factor tariff: The tariff in which power factor of the consumer's load is taken into consideration is known as power factor tariff
The following are the important types of power factor tariff.

i) KVA maximum demand tariff: It is a modified form of two part tariff. the fixed charges are made on the basis of maximum demand in KVA and not in kw. As KVA is inversely proportional to power factor, a consumer having low power factor has to contribute more towards the fixed charge.

ii) Sliding scale tariff: this is also known as average P.f tariff. In this case, an average power factor say 0.8 lagging is taken as reference.

* If the P.f of the consumer falls below this factor, suitable additional charges are made. If the P.f is above the referance, a discount is allowed to the consumer.

iii) KW and KVAR tariff:

In this type, both active power (kw) and reactive power (KVAR) supplied are charged separately. A consumer having low P.f will draw more reactive power and hence shall have to pay more charges.