IQRA National University, Peshawar
Department of Electrical Engineering
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Power Generation
Assignment 1

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Question No 1 *(CLO -1)* ***20***

A. What is meant by electricity tariff, explain different classes of tariff with examples?
B. Define Load Factor, Diversity Factor, Plant Capacity Factor and Plant Use Factor?

Question No 2 *(CLO-2)* ***10***

A. A power station has to supply load as follows:

Timings	KW
11 pm to 5 am	500
5 am to 6 am	750
6 am to 7 am	1000
7 am to 9 am	2000
9 am to 12 noon	2500
12 Noon to 1 pm	1500
1 pm to 5 pm	2500
5 pm to 7 pm	2000
7 pm to 9 pm	2500
9 pm to 11 pm	1000

For the given data above draw the load curve. Select the number and size of generator units to supply this load. Find the reserve capacity of the plant required. Calculate the plant capacity factor. Determine the operating schedule of the units in the station. Calculate the plant factor?

Q.(A) What is meant by electricity tariff, explain different classes of tariff with examples?

Electricity Tariffs:

Definition: The amount of money frame by the supplier for the supply of electrical energy to various types of consumers in known as an electricity tariff. In other words, the tariff is the methods of charging a consumer for consuming electric power. The tariff covers the total cost of producing and supplying electric energy plus a reasonable cost.

The actual tariffs that the customer pay depends on the consumption of the electricity. The consumer bill varies according to their requirements. The industrial consumers pay more tariffs because they use more power for long times than the domestic consumers. The electricity tariffs depends on the following factors

- Type of load
- Time at which load is required.
- The power factor of the load.
- The amount of energy used.

Various types of electricity tariff

1. Simple tariff

In this type of tariff, a fixed rate is applied for each unit of the energy consumed. It is also known as a uniform tariff. The **rate per unit of energy does not depend upon the quantity** of energy used by a consumer. The price per unit (1 kWh) of energy is constant. This energy consumed by the consumer is recorded by the energy meters.
Graphically, it can be represented as follows:

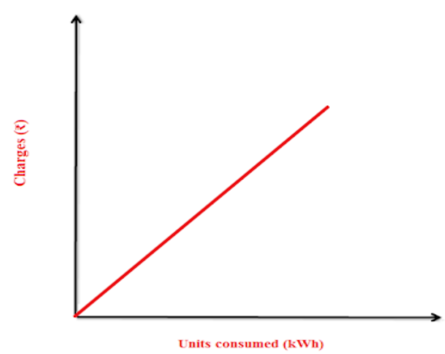


Figure : Simple Tariff

Advantages:

- Simplest method
- Easily understandable and easy to apply
- Each consumer has to pay according to his utilization

Disadvantages :

- There is no discrimination according to the different types of consumers.
- The cost per unit is high.
- There are no incentives (an attractive feature that makes the consumers use more electricity.)

- If a consumer does not consume any energy in a particular month, the supplier cannot charge any money even though the connection provided to the consumer has its own costs.
- **Application** : Generally applied to tube wells used for irrigation purposes.

2. Flat rate tariff

In this tariff, different types of consumers are charged at different rates of cost per unit (1kWh) of electrical energy consumed. Different consumers are grouped under different categories. Then, each category is charged money at a fixed rate similar to Simple Tariff. The different rates are decided according to the consumers, their loads and load factors.

Graphically, it can be represented as follows:

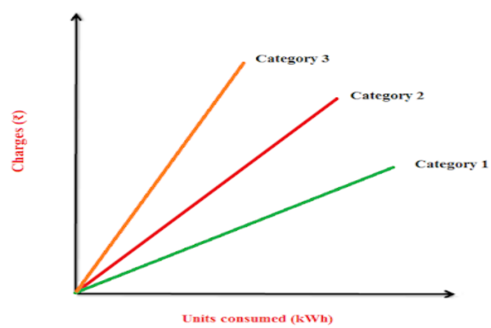


Figure : : Flat Rate Tariff

Advantages

- More fair to different consumers.
- Simple calculations.

Disadvantages

- A particular consumer is charged at a particular rate. But there are no incentives for the consumer.
- Since different rates are decided according to different loads, separate meters need to be installed for different loads such as light loads, power loads, etc. This makes the whole arrangement complicated and expensive.
- All the consumers in a particular “category” are charged at the same rates. However, it is fairer if the consumers that utilize more energy be charged at lower fixed rates.

Application

- Generally applied to domestic consumers.

3. Block rate tariff

In this tariff, the first block of the energy consumed (consisting of a fixed number of units) is charged at a given rate and the succeeding blocks of energy (each with a predetermined number of units) are charged at progressively reduced rates. The rate per unit in each block is fixed.

For example, the first 50 units (1st block) may be charged at 3 rupees per unit; the next 30 units (2nd block) at 2.50 rupees per unit and the next 30 units (3rd block) at 2 rupees per unit.

Graphically, it can be represented as follows:

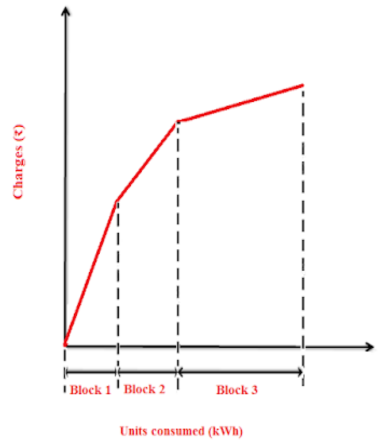


Figure : Block Rate Tariff

Advantages

- Only 1 energy meter is required.
- Incentives are provided for the consumers due to reduced rates. Hence consumers use more energy. This improves load factor and reduces cost of generation.

Disadvantages

- If a consumer does not consume any energy in a particular month, the supplier does not charge any money even though the connection provided to the consumer has its own costs.

Application

- Generally applied to residential and small commercial consumers.

4. Two part tariff

In this tariff scheme, the total costs charged to the consumers consist of two components: fixed charges and running charges. It can be expressed as:

Total Cost = [A (kW) + B (kWh)] Rs.

Where, A = charge per kW of max demand (i.e. A is a constant which when multiplied with max demand (kW) gives the total fixed costs.)

B = charge per kWh of energy consumed (i.e. B is a constant which when multiplied with units consumed (kWh), gives total running charges.)

The fixed charges will depend upon maximum demand of the consumer and the running charge will depend upon the energy (units) consumed. The fixed charges are due to the interest and depreciation on the capital cost of building and equipment, taxes and a part of operating cost which is independent of energy generated. On the other hand, the running charges are due to the operating cost which varies with variation in generated (or supplied) energy.

Advantages

- If a consumer does not consume any energy in a particular month, the supplier will get the return equal to the fixed charges.

Disadvantages

- Even if a consumer does not use any electricity, he has to pay the fixed charges regularly.
- The maximum demand of the consumer is not determined. Hence, there is error of assessment of max demand and hence conflict between the supplier and the consumer.

Application

- Generally applied to industrial consumers with appreciable max demand.

5. Maximum demand tariff: In this tariff, the energy consumed is charged on the basis of maximum demand. The units (energy) consumed by him is called maximum demand. The max demand is calculated by a maximum demand meter. This removes any conflict between the supplier and the consumer as it were the two part tariff. It is similar to two-part tariff.

Application

- Generally applied to large industrial consumers.

6. Power factor tariff

In this tariff scheme, the power factor of the consumer's load is also considered. We know that power factor is an important parameter in power system. For optimal operation, the pf must be high. Low pf will cause more losses and imbalance on the system. Hence the consumers which have low pf loads will be charged more. It can be further divided into the following types:

(I) kVA Maximum Demand tariff

In this type of tariff, the fixed charges are made on the basis of maximum demand in kVA instead of KW.
We know that power factor = kW / kVA
Hence, the pf is inversely proportional to kVA demand. Hence, a consumer having low power factor load will have to pay more fixed charges. This gives the incentive to the consumers to operate their load at high power factor. Generally, the suppliers ask the consumers to install power factor correction equipment.

(II) kW and kVAR tariff

In this tariff scheme, the active power (kW) consumption and the reactive power (kVAR) consumption is measured separately. Of course, a consumer having low power factor load will have to pay more fixed charges.

(III) Sliding Scale Tariff

In this type of tariff scheme, an average power factor (generally 0.8 lagging) is taken as reference. Now, if the power factor of the consumer's loads is lower than the reference, he is penalized accordingly. Hence, a consumer having low power factor load will have to pay more fixed charges. Also, if the pf of the consumer's load is greater than the reference, he is awarded with a discount. This gives incentives to the consumers. It is usually applied to large industrial consumers.

7. Three part tariff

In this scheme, the total costs are divided into 3 sections: Fixed costs, semi-fixed costs and running costs.
Total Charges = [A + B (kW) + C (kWh)]
Where, A = fixed charges,
B = charge per kW of max demand (i.e. B is a constant which when multiplied with max demand (kW) gives the total fixed costs.)
C = charge per kWh of energy consumed (i.e. C is a constant which when multiplied with units consumed (kWh), gives total running charges.)

Application

- This type of tariff is generally applied to big consumers.

B. Define Load Factor, Diversity Factor, Plant Capacity Factor and Plant Use Factor?

a).Load factor: Definition: Load factor is defined as the ratio of the average load over a given period to the maximum demand (peak load) occurring in that period. In other words, the load factor is the ratio of energy consumed in a given period of the times of hours to the peak load which has occurred during that particular period.

$$Load\ factor = \frac{average\ load}{peak\ load}$$

Load factor means how efficiently we use energy. It is the measure of the utilisation of electrical energy during a given period to the maximum energy which would have been utilised in that period. The load factor plays an important role in the cost of generation per unit (kWh). The higher the load factor the smaller will be the generation cost for the same maximum demands. Load factor regarding energy,

$$Load\ factor = \frac{average\ load \times T}{peak\ load \times T}$$

Depending on the number of hours in days, weeks, months, or years we define different load factors. For daily load factor, period T is taken as 24 hours; similarly, for weeks, months and years the different value of T is taken.

Mathematically,

$$Daily\ load\ factor = \frac{Total\ kwh\ during\ 24\ h\ of\ the\ day}{(peak\ load\ in\ kW)\ \times 24\ h}$$

$$Annual\ load\ factor = \frac{total\ kWh\ during\ the\ year}{(peak\ load\ in\ kW) \times (8760\ hours)}$$

For calculating load factor, the following information is required;

Actual kilowatt hours used (kWh)

Peak kilowatt demand (kW)

Number of days

b).Diversity <u>Factor</u> :<u>Definition:</u> Diversity factor is defined as the ratio of the sum of the maximum demands of the various part of a system to the coincident maximum demand of the whole system. The maximum demands of the individual consumers of a group do not occur simultaneously. Thus, there is a diversity in the occurrence of the load. Due to this diverse nature of the load, full load power supply to all the consumers at the same time is not required.

$$Diversity\ factor = \frac{(sum\ of\ individual\ maximum\ demands)}{(coincident\ maximum\ demand\ of\ the\ whole\ system)}$$

Mathematically, diversity factor is expressed as:

$$F_D = \frac{D_1 + D_2 \dots\dots\dots\dots\dots + D_n}{D_g}$$

or

$$F_D = \frac{\sum_{i=1}^{n} D_i}{D_g}$$

Where,

FD – diversity factor

Di – maximum demand of the load I, irrespective of the time of occurrence.

Dg = D(1+2+3…….n) – maximum coincident demands of a group of n load.

Diversity factors can be defined for loads, substations, feeders, and generating stations. Usually, the maximum demands of the consumers do not occur at the same time. The diversity factor can be equal or greater than 1.

If the value of the diversity factor is greater than 1, then it is a good diversity factor, and 1.0 represents a poor diversity factor. A high diversity factor has the effect of reducing the maximum demand. It is obtained by using electrical energy at night load or light load periods.

c).Plant Capacity Factor: The plant capacity factor is defined as the ratio of the total actual energy produced or supply over a definite period, to the energy that would have been produced if the plant (generating unit) had operated continuously at the maximum rating. The capacity factor mainly depends on the type of the fuel used in the circuit.

$$Capacity\ factor = \frac{(actual\ energy\ produced\ or\ supplied\ in\ time\ T)}{maximum\ plant\ rating \times T}$$

The capacity factor is computed by dividing the total energy producing by the full load capacity of the plant. Capacity factor is mostly used in generation studies. The annual capacity factor is expressed as

$$Annual\ capacity\ factor = \frac{actual\ annual\ energy\ generation}{maximum\ plant\ rating\ \times 8760}$$

Capacity factor indicates the extent of the use of the generating station. If the power generation unit is always running at its rated capacity, then their capacity factor is 100% or 1. It is also expressed regarding peak load and load factor.

$$Capacity\ factor = \frac{peak\ load}{plant\ capacity} \times load\ factor$$

The power plant always has some reserve capacity for the future expansion like an increase in load and maintenance. If the rate plant capacity is equal to the peak load, then the capacity factor and load factor become identical, i.e. in the absence of reverse capacity.

Capacity factor = load factor

d).Plant Use Factor:

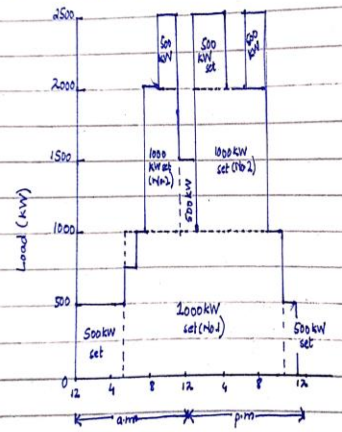
it is defined as the ratio of energy produced in agiven time to the maximum possible energy that could have been produced during the actual number of hours the plant was in operation.

Plant use factor= annual energy produced ÷ capacity of plant × no of hours plant is in operation during year

QUESTION NO 2:

Question No 2 :-

Sol :- ① Load curve :-



⇒ Plant capacity factor = $\frac{\text{Energy Produced during 24h (kWh)}}{\text{Installed capacity (kW)} \times 24h}$

$= \frac{38,750}{3500 \times 24} = 0.46$ or 46%

⇒ The operating schedule is fixed, the energy that could have been generated by the capacity of plant actually running for the scheduled time would be

$(500 \times 6) + (1000 \times 2) + (2000 \times 2) + (2500 \times 3) + (1500 \times 1) + (2500 \times 4) + (2000 \times 2) + (2500 \times 2) + (1000 \times 2) = 39,000$ kWh

Energy actually produced = 38,750 kWh

⇒ Plant use factor = $\frac{\text{Energy produced (kWh)}}{\text{capacity of plant (kW)} \times \text{no of hrs plant has been in operation}}$

$= \frac{38,750}{39,000} = 0.994$ or 99.4%

⇒ Maximum demand = 2500 kW

⇒ Energy generated during 24 hours

$$= (500 \times 5) + (750 \times 1) + (1000 \times 1) + (2000 \times 2)$$
$$+ (2500 \times 3) + (1500 \times 1) + (2500 \times 4) + (2000 \times 2)$$
$$+ (2500 \times 2) + (1000 + 2) + (500 \times 1)$$
$$= 38750 \text{ kWh}$$

⇒ Load factor = $\frac{\text{Energy generated during 24 hours}}{\text{max demand} \times \text{24 hours}} = \frac{38750}{2500 \times 24}$

$$= 64.7\%$$

⇒ From the nature of load curve, it will be seen that this is the load of a small industrial town, will distributed during day and night. From the load curve it will also be seen that three generator sets will suffice with the following ratings:

- ↳ Two sets each of 1000 kW capacity
- ↳ one set of 500 kW capacity.

⇒ The reserve capacity required will correspond to the largest size of the units in the station. In this case, a set of 1000 kW will have to be bought and kept as reserve. the total installed capacity of the station will therefore be 1000 + 1000 + 500 + 1000 (reserve), i.e, 3500 kW