Chapter9 Types of tariff

Tariff : *The rate at which electrical energy is supplied to a consumer is known as* **tariff**.

Objectives of tariff. Like other commodities, electrical energy is also sold at such a rate so that it not only returns the cost but also earns reasonable profit. Therefore, 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 equipment, billing etc.
- A suitable profit on the capital investment.

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

In this type of tariff, the consumers are grouped into different classes and each class of consumers is charged at a different uniform rate. For instance, the flat rate per kWh for lighting load may be 60 paise, whereas it may be slightly less† (say 55 paise per kWh) for power load. The different classes of consumers are made taking into account their diversity and load factors. The advantage of such a tariff is that it is more fair to different types of consumers and is quite simple in calculations.

Disadvantages

Since the flat rate tariff varies according to the way the supply is used, separate meters are required for lighting load, power load etc. This makes the application of such a tariff expen- sive and complicated.

A particular class of consumers is charged at the same rate irrespective of the magnitude of energy consumed. However, a big consumer should be charged at a lower rate as in his case the fixed charges per unit are reduced.

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 *viz.*, fixed charges and running charges. The fixed charges depend upon the maximum demand of the consumer while the running charges depend upon the number of units consumed by the consumer. Thus, the consumer is charged at a certain amount per kW of maximum demand plus a certain amount per kWh of energy consumed *i.e.*,

Total charges = Rs ($b \times$ kW + $c \times$ kWh)

where, b = charge per kW of maximum demand

c = charge per kWh of energy consumed

This type of tariff is mostly applicable to industrial consumers who have appreciable maximum demand.

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

- The consumer has to pay the fixed charges irrespective of the fact whether he has consumed or not consumed the electrical energy.

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

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 a* **block rate tariff**.

In block rate tariff, the energy consumption is divided into blocks and the price per unit is fixed in each block. The price per unit in the first block is the highest** and it is progressively reduced for the succeeding blocks of energy. For example, 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.

- The advantage of such a tariff is that the consumer gets an incentive to consume more electrical energy. This increases the load factor of the system and hence the cost of generation is reduced. However, its principal defect is that it lacks a measure of the consumer's demand. This type of tariff is being used for majority of residential and small commercial consumers.

Problems:

Example *A consumer has a maximum demand of 200 kW at 40% load factor. If the tariff is Rs. 100 per kW of maximum demand plus 10 paise per kWh, find the overall cost per kWh.*

Solution.

$$\text{Units consumed/year} = \text{Max. demand} \times \text{L.F.} \times \text{Hours in a year}$$
$$= (200) \times (0{\cdot}4) \times 8760 = 7{,}00{,}800 \text{ kWh}$$
$$\text{Annual charges} = \text{Annual M.D. charges} + \text{Annual energy charges}$$
$$= \text{Rs}\,(100 \times 200 + 0{\cdot}1 \times 7{,}00{,}800)$$
$$= \text{Rs}\,90{,}080$$
$$\therefore \quad \text{Overall cost/kWh} = \text{Rs}\,\frac{90{,}080}{7{,}00{,}800} = \text{Re}\,0{\cdot}1285 = 12{\cdot}85 \text{ paise}$$

Example *The maximum demand of a consumer is 20 A at 220 V and his total energy consumption is 8760 kWh. If the energy is charged at the rate of 20 paise per unit for 500 hours use of the maximum demand per annum plus 10 paise per unit for additional units, calculate : (i) annual bill (ii) equivalent flat rate.*

Solution.

Assume the load factor and power factor to be unity.

$$\therefore \quad \text{Maximum demand} = \frac{220 \times 20 \times 1}{1000} = 4{\cdot}4 \text{ kW}$$
$$(i) \quad \text{Units consumed in 500 hrs} = 4{\cdot}4 \times 500 = 2200 \text{ kWh}$$
$$\text{Charges for 2200 kWh} = \text{Rs}\ 0{\cdot}2 \times 2200 = \text{Rs}\,440$$
$$\text{Remaining units} = 8760 - 2200 = 6560 \text{ kWh}$$

Charges for 6560 kWh = Rs 0·1 × 6560 = Rs 656

$\therefore$ Total annual bill = Rs (440 + 656) = Rs. 1096

(*ii*) Equivalent flat rate = Rs $\frac{1096}{8760}$ = Re 0·125 = 12.5 paise

Example *The following two tariffs are offered :*

(*a*) *Rs 100 plus 15 paise per unit ;*

(*b*) *A flat rate of 30 paise per unit ;*

At what consumption is first tariff economical ?

Solution.

Let x be the number of units at which charges due to both tariffs become equal. Then,

$$100 + 0{\cdot}15x = 0{\cdot}3x$$

or $$0{\cdot}15x = 100$$

$\therefore$ $$x = 100/0{\cdot}15 = 666{\cdot}67 \text{ units}$$

Therefore, tariff (*a*) is economical if consumption is more than 666·67 units.

Example *A supply is offered on the basis of fixed charges of Rs 30 per annum plus 3 paise per unit or alternatively, at the rate of 6 paise per unit for the first 400 units per annum and 5 paise per unit for all the additional units. Find the number of units taken per annum for which the cost under the two tariffs becomes the same.*

Solution. Let x (> 400) be the number of units taken per annum for which the annual charges due to both tariffs become equal.

Annual charges due to first tariff = Rs $(30 + 0{\cdot}03x)$

Annual charges due to second tariff = Rs $[(0{\cdot}06 \times 400) + (x - 400) \times 0{\cdot}05]$

= Rs $(4 + 0{\cdot}05x)$

As the charges in both cases are equal,

$\therefore$ $$30 + 0{\cdot}03x = 4 + 0{\cdot}05x$$

or $$x = \frac{30 - 4}{0{\cdot}05 - 0{\cdot}03} = 1300 \text{ kWh}$$

Example *An electric supply company having a maximum load of 50 MW generates 18×10^7 units per annum and the supply consumers have an aggregate demand of 75 MW. The annual expenses including capital charges are :*

For fuel = Rs 90 lakhs

Fixed charges concerning generation = Rs 28 lakhs

Fixed charges concerning transmission and distribution = Rs 32 lakhs

Assuming 90% of the fuel cost is essential to running charges and the loss in transmission and distribution as 15% of kWh generated, deduce a two part tariff to find the actual cost of supply to the consumers.

Solution.

Annual fixed charges

For generation = Rs 28×10^5

For transmission and distribution = Rs 32×10^5

For fuel (10% only) = Rs $0{\cdot}1 \times 90 \times 10^5$ = Rs 9×10^5

Total annual fixed charge = Rs $(28 + 32 + 9) \times 10^5$ = Rs 69×10^5

This cost has to be spread over the aggregate maximum demand of all the consumers *i.e.*, 75 MW.

$$\therefore \quad \text{Cost per kW of maximum demand} = \text{Rs}\,\frac{69\times10^5}{75\times10^3} = \textbf{Rs. 92}$$

Annual running charges.

$$\text{Cost of fuel (90\%)} = \text{Rs}\,0{\cdot}9\times90\times10^5 = \text{Rs}\,81\times10^5$$

$$\text{Units delivered to consumers} = 85\%\text{ of units generated}$$

$$= 0{\cdot}85\times18\times10^7 = 15{\cdot}3\times10^7\ \text{kWh}$$

This cost is to be spread over the units delivered to the consumers.

$$\therefore \quad \text{Cost/kWh} = \text{Rs}\,\frac{81\times10^5}{15{\cdot}3\times10^7} = \text{Re}\,0{\cdot}053 = \textbf{5.3 paise}$$

$\therefore$ Tariff is Rs 92 per kW of maximum demand plus 5·3 paise per kWh.

Example *A generating station has a maximum demand of 75 MW and a yearly load factor of 40%. Generating costs inclusive of station capital costs are Rs. 60 per annum per kW demand plus 4 paise per kWh transmitted. The annual capital charges for transmission system are Rs 20,00,000 and for distribution system Rs 15,00,000 ; the respective diversity factors being 1·2 and 1·25. The efficiency of transmission system is 90% and that of the distribution system inclusive of substation losses is 85%. Find the yearly cost per kW demand and cost per kWh supplied :*

(*i*) *at the substation* (*ii*) *at the consumers premises.*

Solution.

$$\text{Maximum demand} = 75\,\text{MW} = 75{,}000\,\text{kW}$$

$$\text{Annual load factor} = 40\% = 0{\cdot}4$$

(*i*) **Cost at substation.** The cost per kW of maximum demand is to be determined from the total annual fixed charges associated with the supply of energy at the substation. The cost per kWh shall be determined from the running charges.

(*a*) **Annual fixed charges**

$$\text{Generation cost} = \text{Rs}\,60\times75\times10^3 = \text{Rs}\,4{\cdot}5\times10^6$$

$$\text{Transmission cost} = \text{Rs}\,2\times10^6$$

Total annual fixed charges at the substation

$$= \text{Rs}\,(4{\cdot}5+2)\times10^6 = \text{Rs}\,6{\cdot}5\times10^6$$

Aggregate of all maximum demands by the various substations

$$= \text{Max. demand on generating station} \times \text{Diversity factor}$$

$$= (75\times10^3)\times1{\cdot}2 = 90\times10^3\,\text{kW}$$

The total annual fixed charges have to be spread over the aggregate maximum demands by various substations *i.e.*, 90×10^3 kW.

Annual cost per kW of maximum demand

$$= \text{Rs}\,\frac{6{\cdot}5\times10^6}{90\times10^3} = \textbf{Rs. 72.22}$$

(*b*) **Running Charges.** It is given that cost of 1 kWh transmitted to substation is 4 paise. As the transmission efficiency is 90%, therefore, for every kWh transmitted, 0·9 kWh reaches the sub-station.

$\therefore$ Cost/kWh at substation = 4/0·9 = **4·45 paise**

Hence at sub-station, the cost is **Rs 72·22** per annum per kW maximum demand plus **4·45 paise** per kWh.

(*ii*) Cost at consumer's premises. The total annual fixed charges at consumer's premises is the sum of annual fixed charges at substation (*i.e.* Rs $6{\cdot}5\times10^6$) and annual fixed charge for distribution (*i.e.*, Rs $1{\cdot}5\times10^6$).

∴ Total annual fixed charges at consumer's premises

$$= \text{Rs}\,(6{\cdot}5+1{\cdot}5)\times10^6 = \text{Rs}\,8\times10^6$$

Aggregate of maximum demands of all consumers

$$= \text{Max. demand on Substation} \times \text{Diversity factor}$$
$$= (90\times10^3)\times1{\cdot}25 = 112{\cdot}5\times10^3\ \text{kW}$$

∴ Annual cost per kW of maximum demand

$$= \text{Rs}\,\frac{8\times10^6}{112{\cdot}5\times10^3} = \textbf{Rs. 71.11}$$

As the distribution efficiency is 85%, therefore, for each kWh delivered from substation, only 0·85 kWh reaches the consumer's premises.

∴ Cost per kWh at consumer's premises

$$= \frac{\text{Cost per kWh at substation}}{0{\cdot}85} = \frac{4{\cdot}45}{0{\cdot}85} = \textbf{:5.23 paise}$$

Hence at consumer's premises, the cost is **Rs. 71·11** per annum per kW maximum demand plus **5·23 paise** per kWh.

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