CHAPTER VI :

PRICING OF ELECTRICITY

1. PRINCIPLES OF ELECTRICITY TARIFF FIXING

Need for a separate analysis :

One has to analyse pricing of electricity as a special problem in itself because of the typical nature of the industry. Price determination under a perfectly competitive market situation results in the most efficient allocation of resources. But for a public utility industry like electricity this situation cannot be allowed to operate. This is so for the simple reason that, though such a market structure results in the most efficient resource allocation, it also results in sharp fluctuations in prices on account of variations in demand and supply. This is not desirable in the case of electricity, for the simple reason that it is one of the most important inputs for industries. In order to have long term planning for industries we must have a rather stable level of prices for electricity. Also electricity industry is best organized as a regulated monopoly, and not on competitive basis. Another reason for not depending on the market forces to determine the price of electricity is that it is a public utility. On account of its being a public utility electricity is to be supplied to anybody who asks for its services at a reasonable price.

Other problems associated with pricing of electricity arise due to the fact that it is a joint product industry. The quality of the electricity supplied to different consumers is remarkably different though purely as far as its production is concerned there is not much of a difference. The electricity generated for domestic consumers is from the same plant as that for industrial consumers. However in terms of timing, continuity and volume there are marked differences in demand for electricity for different purposes. On account of this it becomes very difficult to identify the cost incurred for supplying different consumers.This problem of allocating costs to different consumers makes it very difficult to price electricity.

Further, it is rightly observed that "A fundamental feature of electricity supply is that an enterprise provides each of its consumers with two services: (a) the actual energy he consumes (as measured in Kilowatt-hours); and (b) readiness to supply the energy he wants whenever he wants it. The latter service is or should be, continuous day and night; it costs money to provide it even if no energy is actually consumed."[1]

An electricity tariff has to reflect both these components of costs viz., a variable component of cost and a fixed component of cost. Thus, there emerged a system of electricity tariffs with different principles guiding the authorities in fixing the tariff for electricity. While evolving a tariff structure one has to accept the fact that "Different classes of consumers have different load characteristics and any resulting tariff structure can hardly be simple and standardized."[2] Thus any tariff structure tries to take into consideration the three types of costs: viz., consumer costs, variable (or unit) costs and Maximum Demand costs. So before discussing the tariff structure we digress

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1 United Nations.Dept. of Economic & Social Affairs: Electricity Costs & Tariffs: A General Study. New York, 1972, p.8.

2 Crew M. : "Electricity Tariff", in Ralph Turney (ed.): Public Enterprise, Penguin Modern Economic Readings, p.263.

and discuss the types of tariffs and the costs of electricity. This will help us in understanding the fact that a reasonably good tariff structure has to combine more than one type of tariff.

Types of Tariffs :

(i) Flat Rate : The simplest and the most non-scientific types of tariff is the flat rate tariff. It is a non-scientific form of tariff because it does not take into consideration the multipart nature of costs. Thus, the total cost of supplying electricity may be made up of two components; one, the cost of readiness to supply and secondly the cost of energy actually supplied. A flat rate Tariff fails to take into consideration the consumer component of costs. Though this form of tariff is non-scientific, under certain conditions it can be applied. It can be applied when the load factors of different consumers are not remarkably different and where consumer component is of not much significance. Quite often it is not possible to measure, either directly or indirectly, the maximum demands of each individual consumer. Under these circumstances also flat rate tariff can be applied. Flat rate tariff can be made less non-scientific by introducing a minimum fixed charge even for a very small consumer.

This rate is most suitable for domestic and commercial consumers. This is so because the load factors of different consumers in these classes are not very divergent. On account of flat rate being unscientific, Dr. John Hopkinson suggested, in 1882, two-part - costing for electricity. His suggestion was to have two components of costs; one the variable component and the other the fixed component of costs. This brings us to the discussion of the second form of tariff, viz., two-part rates.

(ii) Two-part rates :

(a) Hopkinson rates: This form of tariff is more scientific than the flat rate tariff. One part of the tariff which is based on a charge per month (or quarter, week, year etc.) per kilowatt of maximum demand takes care of the fixed component of costs. The other part of the tariff is based on the kwh consumed and takes care of the variable component of costs. Quite often it has been made obligatory, by the government, for the enterprise to offer flat rate as an alternative to Hopkinson rate. For small consumers flat rates are more advantageous and for big consumers, like industries, it is the Hopkinson rate that is more suitable. This is so because under the Hopkinson rate a small variable charge proves to be an incentive for small consumers to improve their load factor. For big industries the proportion of consumer-component is so small that they would prefer the Hopkinson rate to the flat rate.

Sometimes the Hopkinson rate is slightly changed and we come across a situation where the consumers are overcharged for the consumer component of costs and are offered a block of free kilowatt hours before charging for the variable component of costs. The size of the block of free kwh will be directly proportional to the maximum demand. This variation of the Hopkinson rate is not very rational for the simple reason that the profit or the loss under this rate depends on the load factor of the consumer.

Under the Hopkinson rate it becomes essential to measure the maximum demand of the consumer. Thus, it becomes necessary to install some device to measure the maximum demand of consumers. This will be possible only in the case of those consumers for whom fixed component of costs is very small. So, the Hopkinson rate is more suitable for medium and large-sized industrial consumers. Under this rate the consumers are encouraged to improve their load factor. The disadvantage of this form of tariff is that the benefits derived by improving the load factor may be wiped out because of a reduction in internal diversity that is, concentration of demand in a few working hours. This disadvantage can be substantially reduced if somehow the large industrial consumers are persuaded to improve their load factor by lengthening their working hours.

(b) All-in-rates : Hopkinson rate, as already seen earlier, is not suitable for domestic and commercial consumers. It is the flat rate that is more appropriate for this category of consumers. But this flat rate also does not prove to be most efficient for domestic & commercial consumers. As far as domestic and commercial consumers demand for lighting is concerned flat rate may be quite appropriate because of the uniformity of their load factor. But in the case of their demand for heating and power the load factor tends to be non-uniform. Under this condition flat rate cannot be justified. At the same time Hopkinson rate also cannot be applied for the small size of the consumer does not warrant the installation of costly defices for measuring the maximum demand. Under this condition we apply the all-in-rate. All-in-rate "is a two part rate with a low variable charge per kilowatt-hour, but in order to avoid the need for installing costly equipment to measure the maximum demand of each consumer, the fixed component of the rate is charged according to some indirect parameter which is believed to have some rather vague empirical relationship with the consumer's maximum demand".[3] The indirect parameters usually selected for this purpose are either dependent on the size of the house or the quality of the house. For measuring the size of the house one can adopt any criterion like the number of rooms, floor area etc. The quality of the house is normally decided by considering the locality of the house or by the taxable rating of the house. We consider either the size or the quality of the house in order to decide upon the fixed component of the rate for the reason that there is a general belief that a bigger house or a house in a posh locality, normally has a higher load factor than a smaller house or a houses in a poor locality. This belief normally holds good because a bigger or a better quality house quite often goes in fo~~u~~r higher waltage lamps

3 Ibid, p.146.

and more use of electrical appliances.

The biggest advantage of this rate is that the parameters discussed above can be easily measured and are only to be measured once. This fixed charge can be changed from month to month or from season to season. The all-in rate is more beneficial to the bigger domestic and commercial consumers. Whereas, for the small domestic and commercial consumers it is the flat rate that is more advantageous. All-in-rate is most appropriate for domestic and commercial consumers because though it is simple and it encourages an improvement in the load factor at the same time it does make it possible to recover the consumer component of costs.

(c) Special Service Rates : Quite often the consumers are to be provided with special services along with the supply of electricity. The classic example of this is the case of street lighting where the corporation has not only to supply electricity but has also to replace the lamps and colour the poles. A part of such costs can be expressed as an additional variable cost, like replacement of burnt out lamps. The other part may be expressed either as maximum demand or as consumer costs which ever is more convenient. The most appropriate method of charging for street lights would be to have a two-part tariff. The fixed element would include the consumer component and the maximum demand component as well as the costs of repairs, maintenance and attendance. Whereas the variable component would include the system variable costs along with the cost of lamp replacement. The benefit of this system of rate fixing is that it encourages the corporations to improve the quality of the street lighting, by installing higher waltage lamps, as well as to improve their load factor.

(iii) Block Rates :

(a) Simple Block Rates : A simple block rate is a combination of flat rate and a two-part rate. It imposes a very high rate per kwh in a certain block and when the consumption exceeds this block the rates charged are very low, almost as low as to cover the variable component only. The consumption in excess of the expensive block is not only charged at a lower rate but it is also charged at a flat rate per kwh consumed. The demerit of this simple block rate is that it does not take into consideration the maximum demand or the load factor of the consumers.

(b) Block Grading of Fixed Charges : Under this system instead of blocking the variable component we block the fixed component of charges in the Hopkinson rate. The first block of the maximum demand may be charged at a higher rate than the subsequent blocks of maximum demand. The idea behind imposing a very high rate for the first block of maximum demand is to recover the consumer component. But this rate could be applied only to the consumers of moderate size, for them the consumer component is not very much important. This form of tariff has some merit in that it provides an opportunity to consumers to benefit from the economies of scale.

(c) Complex Block Rates : In this case we block the rates charged per kilowatt hour. Under this tariff the blocking is done on the basis of maximum demand. Thus each size of the block varies with the demand and does not remain fixed as in the case of simple block rate. Under this method of charging it becomes essential either to measure or to assess the consumer's maximum demand. Thus, we note that the same effects can be achieved more easily by adopting the Hopkinson rate instead of going in for complex block rates.

(d) Spread Fixed Charge : Under the all-in-rate we have a separate charge for the fixed component. The same result could be obtained by spreading this fixed charge over certain blocks of kwh. Under this system it is the small consumer that benefits.

(e) Quantity discounts : With a view to encourage the consumers to increase their consumption, quite often discounts are offered to flat rate consumers. Not very infrequently we come across a situation where discounts are offered on block rates as well. When discounts are offered on block rates we observe a discontinuity at the beginning of each block. This discontinuity creates a problem since under this system it is possible to consume larger number of kwh at a lower total cost. All the same, such discounts are sometimes used in practice.

(f) Inverted Block Rates : Under this form of tariff the price per kwh increases with each block as the consumption of electricity increases. This is an unusual type of tariff because normally the average cost of producing electricity falls as the output increases. As a result of this falling average cost we normally have a tariff system that encourages consumers to increase their consumption and thereby make it possible to reap the economies of scale. Thus almost all the forms of tariff try to encourage consumption by offering a lower price per kwh to large consumers. Under Inverted Block Rates a higher price per kwh is charged to large consumers as their consumption increases. The underlying reasoning behind the inverted block rate is that in the initial stages when industries are not making large profits electricity should be supplied at a subsidised rate. Later on when these industries start earning profits they should be ready to share their profits, with electricity industry, by paying a higher price for electricity. Based on this reasoning, "inverted block tariff" is alternatively also called as a "profit sharing and subsidy rate".[4] The inverted block rate may either be applied to the fixed component of Hopkinson rate or to the variable component. It is simpler to apply it to the variable component, and therefore, it is usually applied to the variable component only. This form of rate is not decided upon by cost considerations, but, "it offers a means of subsidizing a struggling new industry and of sharing in its profits when the industry

4 Ibid, p.152.

becomes well established. Such activities are not generally regarded as the proper concern of electricity enterprises, but there could be occasions where they might be felt to be justified as a feature of long-term policy."[5]

The weakness of this method of pricing electricity is that it encourages a large consumer to split into small uncoordinated organizations, and disguise its own identity, and thereby benefit from the low rate.

(iv) <u>Off-peak rates</u> : Since electricity cannot be stored we have to install capacity on the basis of maximum demand. That is to say a capacity has to be installed to meet the highest demand that might be made on it during a given short time unit during day, week, month or year. A capacity has to remain in readiness to serve at any time. But this maximum demand is not sustained for the whole day. As a result of this for a long time the capacity of the industry remains idle. At the same time if any consumer wants to increase his consumption at a time when the capacity is fully utilised his demand cannot be satisfied without creating a new capacity ~~is~~ in the industry. With a view to

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5 <u>Ibid</u>, p.152.

encourage consumers to demand electricity at a time when the plants are lying idle the industry offers concessional rates to consumers who take supply at any time other than the system peak. Thus offering attractive rates at off-peak times improves the system load factor. Hopkinson rate encourages a consumer to improve his load factor but in case his maximum demand coincides with the system peak load then the system load factor will fail to register an improvement. Block rates and all in rates, though they encourage consumers to increase their consumption, do not guide the consumers about the time of incidence of the additional consumption. On account of the failure of other rates to improve the system load factor, we go in for some attractive off-peak rates.

To implement the off peak rates there has to be some device that would either register the off-peak demand separately or would disconnect a consumer if he consumes during peak load hours. A complete disconnection of a consumer during peak load hours is not very advisable, because such a practice is not quite conducive to growth. In certain cases this practice is justifiable, e.g. in the case of water pumping. It is probable that installation of time switches for individual consumers may prove to be extremely expensive. As an alternative to the installation of time switches an enterprise may go in for some form of centralized control that may be cheaper than the time-switches.

While offering attractive rates to off-peak consumers one has to be careful in deciding the differentials between off peak rates and on peak rates. It is quite conceivable that if the differentials between off-peak rates and on-peak rates are very wide then it may result in a shifting of the peak itself. Normally the flat rates are combined with time switches to offer off peak rates. Block rates are not much suitable for offering lower prices to off-peak consumers of electricity.

(v) <u>Current limiters</u> : The current limiters are mainly installed to limit the maximum demand of a consumer and not to measure it. The intention behind installing current limiters is to prevent misuse resulting from unauthorised connections by small consumers. The charges are normally determined on the basis of the current passed for an assumed number of hours of daily use. These are most suitable for very small lighting loads. The charges for these consumers are usually determined on the basis of hours of darkness in a day. Current limiters are an obstacle in the extensive use of electricity. They discourage small consumers from increasing their consumption of electricity.

(vi) Bulk Supply Rates : These are special rates decided upon on the basis of an agreement between a large consumer and the electricity producing industry. The consumer in this case is normally a licensed distributor of electricity or he may be a large industrial consumer. The rates fixed under the agreement are such that they encourage new consumer to buy electricity in bulk and at the same time the rates have tobe such that the enterprise is able to supply the electricity to all the bulk consumers at the same rate. The bulk supply rates are based on the Hopkinson rate; with special meters for off-peak and on-peak demands. The consumer, under the agreement, has to guarantee a certain minimum revenue to the enterprise. And the enterprise, in its turn, has to guarantee an uninterrupted supply of electricity. In case of interruption of supply the enterprise is liable to heavy penalties.

(vii) Power Factor Penalties or Discounts : Under this system a consumer is offered a bonus for improving his power factor or is penalised for decreasing his power factor. "Power factor may be defined as the ratio of kilowatts (KW) to the kilovatt-amperes (KVA)."[6] The costing allowance for a consumer is made on the basis of "KVA correction factor, or KCF, may be regarded as a direct measure of the responsibility of a consumer class for incurring MD costs due to power factor alone."[7] Of course, using this method of penalising or giving a bonus to a consumer on the basis of power factor is rather arbitrary. This is so because the capital costs of electrical equipment need not be proportional to the KVA ratings; as the MD costs need not be directly proportional to the KW ratings.

(viii) Fuel Cost Variations : When the price of fuel increases then the electricity industry may suffer from losses. The thermal power stations would be more sensitive to variations in fuel prices. It is not advisable to change the price of electricity for all the consumer whenever the fuel prices undergo a change. Minor changes in fuel prices

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6 Ibid, p.55.

7 Ibid, p.56.

the industry should be able to absorb without changing the price of electricity. But for major variations in fuel prices some arrangement has to be made whereby the electricity industry can pass on these changes to the consumers. It may not always be possible to change the price of electricity for each and every small consumer. Therefore, normally the enterprise incorporates a power clause in its agreement with the bulk consumers. These adjustments about the fuel prices are applied to the variable component of the rate under a Hopkinson rate.

(ix) Service Charges and Minimum Revenue Guarantee : Whenever a new consumer is given a connection from the public main line a "service" is said to be rendered by the enterprise. Thus the cost of wiring a consumer's residence from the main line has to be borne by the consumer. There are three alternative ways of collecting these charges, from the consumer, by the enterprise. (1) One of the ways is to combine the costs of all services and add the capital charges to them. Then these can be treated as a recurring cost and added to the consumer component. (2) The other alternative is to combine the costs of all services and the capital charges and then charge a capital connection fee which is an average non-recurring charge. Or (3) alternatively each consumer is separately charged according to the services provided to him by the enterprise.

The first alternative may not be very practical for those consumers who are not settled permanently at a particular place. The usual practice is to provide certain minimum service to the consumers free of charge. The consumers then will pay, the enterprise, for the balance. The free allowance then is to be treated as a part of the consumer component for the whole system.

It is quite conceivable that we may come across certain cases where the consumer is not in a position to pay as a lumpsum for the services. Under these conditions the enterprise bears the cost of connecting a consumer on the basis of guaranteed revenue. This system of connecting outlying consumers on the basis of guaranteed revenue has the advantage of encouraging growth of the enterprise. This is so, because, "..... the consumer, for fear of not getting his money's worth, will tend to consume ~~r~~ at least enough electricity to ensure that its price is no less than the guaranteed payment."[18]

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8 Ibid, p.160.

The above discussed are different forms of tariff for electricity. Since the price to be charged is not independent of the costs incurred by the industry in producing, transmitting and distributing electricity, a digression on costs may not be out of place.

Types of Costs

The analysis of costs is important because the knowledge about the cost behaviour is useful in order to have rational resource allocation. The analysis of the costs of producing, transmitting and distributing electricity is a rather difficult task. This is so because, as observed by I.M.D. Little, "..... electricity costs vary not merely with the amount of output supplied, but also with the time of day, month and year, at which it is supplied, and to whom it is supplied. A classification of electricity costs is required according to the manner in which they vary."[9]

The first eategory of costs is the "energy" costs. These costs vary with the amount of electricity sold. These costs include cost of fuel, labour charges, and a fraction of

9 Little, I.M.D., "The Price of Fuel". Oxford at the Clarendon Press, 1955, p.54.

depreciation, general establishment and management expenses etc.

The second category of costs is known as the "capacity" costs. The capacity costs do not vary with the amount of electricity sold but they rather change according to the maximum rate at which the electricity is sold. "If this maximum rate increases, even though total annual output does not increase, costs will increase because greater productive capacity is needed (and also distributive capacity - thicker cables etc.) and, of course, increased managerial costs."[10] The capacity costs increase, even though annual output does not increase, because the electricity cannot be stored and the cables used for transporting electricity cannot be used for transporting anything else. Similarly, power stations installed for the production of electricity cannot be used for producing anything else. Since electricity cannot be stored the enterprise has to satisfy a higher maximum demand by installing more capacity in the industry. Thus, an enterprise will have to increase its installed capacity, if a higher maximum demand is to be met, inspite of the fact that a part of the existing capacity is

10 Ibid, p.55.

already lying idle. This is so because the enterprise has to supply the required output at the place desired by the consumer and at the time indicated by the consumer.

Third category consists of "consumer" costs. These costs, by definition vary with the number of consumers, given the maximum rate of demand and total sales of electricity. The costs of distributing electricity vary with the number of consumers.This is so because with an increase in the number of consumers the costs of the distribution network also increase. Over and above these there are some direct costs, like costs of metering, billing etc., which are involved in installing electricity and selling it to households etc. The consumer cost element in the total bill of a consumer would be substantial for a smaller consumer like a household or a shop, but it will be of negligible importance for a large consumer like big industries.

The fourth category of costs includes those costs that vary with location. All the three above mentioned costs also vary with location. The cost of supplying electricity to rural areas would be higher than the urban areas. The cost of generating and transmitting electricity would be different for different areas on account of all areas not being suitable for generation of electricity. If an area is not suitable for generating electricity then it has to import it from other areas, and thus has to incur the additional costs of installing transmission lines, as well as some electricity will be lost in the process of transmission itself.

Lastly, there are some costs that do not vary either with the amount of electricity sold or with the maximum rate at which it is sold; e.g. manager's salary.

This is one of the ways of classifying electricity costs, of course, this is not the only way of classifying electricity costs. One may classify costs as production costs, transmission costs, distribution costs and consumers servicing. This is the classification that we find in the Revenue Accounts published in the Public Electricity Supply - All India Statistics.

On account of different costs varying according to different elements we observe that the cost at the 'peak' time will be remarkably different from the cost at the 'off-peak" time. This is so because the capacity costs, which are very heavy in comparison to running costs, vary directly with the maximum time-rate of demand. Whereas the energy costs vary with the average rate. The rate of demand in itself varies not only with the time of day but also with the time of the year, being influenced largely by seasonal factors. On account of the variability of weather itself we cannot know the costs of supplying electricity, at different times, with any certainty.

Adopting a broader classification of costs, we can classify costs into two categories viz., Fixed costs and variable costs. This broader classification is the basis for the three-part costing theory."The basis of three-part costing theory is that each consumer incurs costs which can be analysed into three parts - the variable component, the maximum demand component, (usually abbreviated to the MD component); and the consumer component. The last two together form the fixed component."[11] The variable component of cost is affected by the amount of electricity supplied. Whereas only a part of fixed cost is influenced by the MD component.

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11. UNO: Electricity Costs & Tariffs: A General Study, p.13.

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The price structure of electricity is influenced by a number of technical factors. The consumer of electricity has the freedom of demand in the amount of electricity, that he decides to buy, at the location of his choice. Not only this, but he expects the services to be uninterrupted and regulated as to the voltage.The amount of electricity that a consumer decides to buy determines the generation and distribution capacities to be created by the industry. Again, "The customer's requirements that load be supplied at any time makes it necessary for the utility to provide facilities for his maximum requirements, since storage is not possible. The electricity utility cannot make the customer await his turn."[12] Thus, a customer is to be intantly provided with the full amount of electricity that he demands. The demands of many customers quite often coincide with each other as to the time, which creates "peaks" and "valleys" in the output curve of the industry. Thus, at the time of the "peak" the capacity is almost fully utilized, and during the time of the valleys a sizeable capacity may be remaining idle.

The consumer requires the service to be provided at a place that he desires. This requirement decides the

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12 Caywood, Russell E.: Electricity Utility Rate Economics. McGraw-Hill Book Co.Inc., New York,1956, p.23.

distribution network to be developed by the utility.

The customers demand for the service to be uninterrupted further decides the amount of reserve capacity that the utility will have to create.

On account of these technical factors associated with seasonal factors the tariff structure that emerges has to be rather complex.

Having seen the factors that influence the tariff structure of electricity we go over to the discussion of the objectives that a tariff structure is meant to achieve. There are two basic features of the market for electricity which make the pricing of electricity a special problem. One of the features is that electricity cannot be stored and therefore the capital investment is determined by the maximum demand and not the average demand for the utility. The second feature is the impossibility of reselling electricity by the consumers. This feature associated with the monopoly, in production, transmission and distribution of electricity of a public authority makes it possible to have price discrimination amongst different consumers. Thus, as rightly observed by Houthakker, "This makes it possible (though not necessarily advisable) to discriminate between buyers and (.....) to levy charges which are not proportional to actual consumption."[13] This possibility of price discrimination makes it easier for the authorities to achieve the stated objectives by evolving a suitable tariff structure.

OBJECTIVES

Boiteux,[14] while recommending that the unit price of electricity should be equal to the short run marginal cost of supplying that unit, had the basic welfare objective in mind. Thus, for him the optimum pricing policy would result in the optimal use of the existing plant capacity. Associated with this optimal pricing policy he has an optimal investment policy that produces a given level of output at the minimum average cost. If this happens then the price would be equal to both short run as well as the long run marginal cost. The welfare objective is rather a very general objective. Coming to more specific objectives, we can say that the electricity tariff is mainly to achieve three basic objectives. (1) The first objective, of course, is the objective of generating

13 Houthakker, H.S.: "Electricity Tariffs in Theory and Practice", in Economic Journal, March 1951, p.2.

14 Boiteux Marcel, "Peak-Load Pricing", in Marginal Cost Pricing in Practice, (Ed. James R.Nelson), Englewood Cliffs, N.J.,1964.

sufficient revenue for the utility; (2) secondly, we can say that the electricity rate structure can aim at the most efficient allocation of scarce resources; and lastly, (3) to allocate the costs of producing, transmitting and distributing electricity among different consumers. This distribution of costs has to be as fair as is possible.

Pricing Principles :

The most popular and rather more scientific principle underlying the pricing of electricity is the marginal cost pricing. The marginal cost pricing, which makes the price of a commodity equal to the cost of producing one additional unit of that commodity, is supposed to achieve the objective of efficient resource allocation. In the case of electricity the marginal cost of supplying one additional kwh would be different for different periods of time. Thus, we have to have two different rates, one rate for peak hour and another rate at the off-peak hour. Thus, as has been rightly observed by S.W.Tewari, "In referring to fixed, variable, incremental or marginal costs, it is always essential to specify the relevant time frame. Fixed costs, for instance, are constant in the short run but they become variable in the longrun..."[15]

15 Tewari, S.W.: "Electricity Tariff Designing Issues", in The Economic Times, March 15, 1977, p.5.

Depending on the time of the day at which the consumer decides to buy electricity we will have different rates, higher at the peak load and lower at off-peak load. This is known as "peak-load pricing". In the case of U.S.A. it is the marginal cost pricing principle that has become more and more popular and has substantially replaced average cost pricing of electricity. France and Sweden, as observed by S.W.Tewari, have completely gone for marginal cost pricing.

The marginal cost principle helps us in deciding about, firstly, how to use the existing capacity in the most intensive manner; and secondly, when to create new capacity in the industry. When new consumers are given the connection or the existing consumers decide to increase their consumption at the peak hours the enterprise has to decide about an addition to the existing plant capacity. "The concept of Long-Run Marginal Cost (LRMC) enables the power supply managements to measure the effects which these consumer decisions have upon the power supply undertaking and thus enable them to design electricity tariffs which reflect the consequences of these decisions."[16]

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16 Tewari, S.W.: "Marginal Cost Pricing and Electricity Tariffs", in the Economic Times, March 14, 1977, p.5.

Whether the marginal cost pricing would be able to achieve the objective of generating sufficient revenue for the electricity authorities depends on whether the LRMC is higher than the historic average cost or not. The revenue requirements are based on the calculations of the historic average cost. Thus, if the LRMC is higher than the historic average cost then there would be excess revenue. This is likely to happen when the costs have a generally rising trend. When LRMC is equal to historic average cost then the rates should be fixed at the LRMC. This rate would generate neither an excess nor a short-fall in revenue. Under the condition of LRMC being lower than the average cost the rate for the more price sensitive consumers should be fixed at the LRMC. This would lead to an increase in consumption by the price sensitive consumers and thereby there would be a reduction in the average cost. Here, LRMC provides a floor for the electricity tariff. If the LRMC is higher than the historic average cost then the enterprise can follow the inverse electricity rule for designing electricity tariff. In this case fixing the tariff at the LRMC would generate an excess revenue. "..... the inverse elasticity rule provides a mechanism for minimising departures from allocative efficiency."[17]

17 Tewari, S.W.: "Electricity Tariffs: Allocation of Marginal Costs", in The Economic Times, March 17, 1977, p.6.

Thus, according to inverse elasticity rule the more price sensitive consumers like industrial consumers will pay the price at the LRMC whereas the less price sensitive consumers like domestic consumers benefit from this rule. In this case the LRMC rates would be the ceiling rates.

2. ELECTRICITY PRICING IN INDIA

Having discussed the objectives and the principle of electricity pricing in a rather general way, we may go over to the discussion of the experience of India in electricity pricing.

Objectives

In the case of India, it appears that the most important objective in the minds of authorities seems to have been the generation of adequate revenue for the State electricity boards, Though this is an important objective it has not been the only objective underlying pricing of electricity. This is clearly reflected in the Draft Fifth Plan where it is mentioned that, "A proper tariff situation would, apart from yielding considerable additional revenues, promote better use of electricity and eliminate its wasteful consumption."[18] At the same time, as one observes the tariff structure one fails to see any objective being reflected in it. This observation is made by P.D. Henderson, when he states that, "In the electricity supply industry, it would appear that the rationale of existing tariff structures needs to be critically reviewed. At present there is little reason to believe that the charges made to different classes of consumer bear any consistent relation to the costs of supply."[19] Thus, in the case of India we do not have a clear cut policy objective while designing the electricity tariff structure.

All the same, one can definitely make some observations about the general characteristics of the Indian electricity tariff. There are four characteristics of Indian tariff structure that one can notice. The first, is that the rate per unit tends to fall as the consumption increases. Secondly, rates are based on the principle of no profit and no loss. Or rather very moderate profits. Thirdly, industrial tariffs are two-part tariffs - viz., demand charges as well as per

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18 Govt. of India: Planning Commission: Draft Fifth Five Year Plan, Vol.I, p.61.

19 Henderson, P.D.: India: The Energy Sector. Oxford University Press, 1975, p. 155

unit charges. Lastly, we come across a situation of block tariffs also; with some elements of peak-load pricing. At the same time tariffs for bulk consumers and agriculture are characterised by a minimum charge.

Thus, for the most important consumer, viz., industrial consumer, we follow a two-part tariff, and for most other categories of consumers we have a system of flat rates. Sometimes under the flat rates we come across a situation where there is a provision for a reduction in the rate as the consumption increases, with a provision for a minimum total charge. Again quoting from Henderson, we observe that, "Actual practice seems to vary a good deal as between different state Electricity Boards (SEBs), and special concessional and incentive rates are found. It seems probable that a good deal of cross-subsidization takes place, but there appear to be no estimates of its extent or of the probable amounts involved within different supplying utilities."[20] Thus, we notice a rather unfortunate absence of a clear cut policy for rate fixing of electricity"... the entire tariff structure seems to be the result of historical development, with little effort to see whether the assumptions behind the

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20 Ibid ~~op. cit.~~, p. 85

tariff required any modification."[21] Thus, under the present conditions of serious shortage of electricity one fails to understand the rationale underlying the practice of lower rates for slabs of increasing consumption without any time differentiation. At the same time the rates have proved to be insufficient for covering up the costs of services rendered. Similar observation was made by the World Bank Mission in 1962, where it noticed that the average price of electricity in India was lower than the average cost of producing, transmitting and distributing energy. In comparison to other countries also the average price of electricity in India turns out to be on the lower side. In the case of big industries the cost of power is not a major cost element and therefore, they would be willing to pay a higher price and receive an uninterrupted service. In India on account of severe power shortage power cuts have become quite frequent. Under these conditions industries would rather prefer to pay a higher price for electricity than to pay a lower price and face the dangers of power cuts. Thus the conclusion that in India below-cost or very near-cost pricing of electricity takes place seems to be a rather valid conclusion. In recent

21 Venkataraman, K.: Power Development in India: The Financial Aspects. New Delhi, Wiley Eastern Pvt.Ltd., 1972, pp.59-60.

years the rates have been increased but at the same time the costs have also been increasing; mainly on account of higher fuel prices, labour charges, machinery prices etc.

In India the rates do not take into consideration the time of the day when consumer decides to demand electricity. At the same time the tariff structure does not take into consideration the seasonal factors. Unlike Western countries, in India the peaks are during summer and not in winter. Like most of the other Western countries India can also adopt differential rates for different seasons. Under Indian climate we would have higher rates for summer and lower for winter.

Further, the present method of average cost pricing cannot be justified. This is so because, "The average cost method currently used for tariff formulation has basic deficiencies in that it focuses on historical rather than current costs and fails to identify the marginal costs of providing generation, transmission and distribution facilities - the appropriate basis for designing economically efficient tariffs."[22] Thus, the average cost method is "backward looking", in that it is based on historical

22 Tewari, S.W.: op.cit., p.8.

behaviour of average cost. In short, we can say that the tariff structure in India does not reflect the cost of services rendered by the utility.

Price Discrimination in Electricity in India :

As observed earlier, we know that the determination of cost in electricity utility is an extremely difficult task. At the same time we also know that the cost of supplying electricity to different consumers is not uniform. Based on this fact of non-uniformity of costs, as among different consumers, is the principle of charging different prices to different consumers. Therefore, in this study we make an attempt to see whether price discrimination among different consumers of electricity has taken place in India or not. We intend to observe the existence or otherwise of price discrimination by comparing the average cost differentials and the average revenue differentials among different consumers.

For the analysis of price discrimination we have classified the consumers, as earlier, in three categories: These categories are -

I. Domestic Light and Small Power; Commercial Light and Small Power; Public Lighting and Miscellaneous.

II. Industrial Power - Low and Medium Voltage, High Voltage; Traction, and, public Water Works and Sewage Pumping.

III. Agriculture.

Operating Expenses of Electricity Utility :

We study price discrimination for 1970-71, the latest year for which the financial data are available. The financial data give operating Expenses under eight headings: (1)Generation, (2) Transmission, (3) Distribution, (4) Consumer Servicing, (5) General Establishment Charges; (6) Management Expenses, (7) Administration, and (8) Depreciation.

In Generation Expenses we have not included Purchase of Energy. This is so because the energy purchased from other non-utilities (66.33 million kwh) comes to be only 0.12% of total energy generated (55827.64 million kwh) in 1970-71. Thus, the expenses on generation are exclusive of purchase of energy.We have lumped together the General Establishment Charges, Management Expenses and Administration expenses.

Therefore, we have five types of expenses. Table VI.1 gives the information about these expenses. We have to have the different types of expenses shown separately because these expenses vary according to different factors and are not influenced by the same factors and to the same extent.

Allocation of Costs to Different Consumers :

How do we allocate the various elements in costs to different types of consumers? As mentioned in earlier chapters a kwh sold to one type of consumers is not the same thing as a kwh sold to another type of consumer. The various elements in costs, such as those presented in VI.1 can be allocated on the basis of three different considerations or a combination of them. The costs may be allocated on the basis of kwh consumed or kw connected or the number of consumers served. Thus for instance, the cost of fuel, labour and repairs for electricity generation varies directly with the electricity consumed. The cost of billing etc. does not vary with the kwh consumed or kw connected. It remains more or less the same for a large or a small consumer.The electricity has to remain in readiness to serve the consumer any time he demands energy. The cost of transmission and distribution very much varies

Table VI.1

Operating Costs by Types of Costs - For Electricity Utilities in India, 1970-71 (Rs. lakhs)

Particulars	Operating Cost (Rs.lakhs)
1. Generation	14684
2. Transmission	1002
3. Distribution	6512
4. Consumer Servicing	1565
5. General Establishment and Management Expenses	6418
6. Depreciation	9295
Total	39476

Source: Public Electricity Supply, op.cit., 1971-72.

Note: Generation costs exclude the expenses on purchase of energy. The expenses on purchase of energy given in Public Electricity Supply, are intra-industry item, representing the payments made by one electricity unit to another unit. The purchases made from outside the utility system are negligible.

with kw connected. Whichever way we allocate the different components of cost to different types of consumers, these have to be ultimately expressed in terms of cost per kwh. Therefore when the cost is allocated on the basis of kw connected or per consumer, we have to take one more step of dividing the cost so allocated by the kwh consumed per 1 kw connected load or by the kwh consumed per consumer, so that we get the cost per kwh. Where the cost is allocated on kwh basis, this further intermediate step is not needed.

Thus, for allocating different types of expenses to different categories of consumers we need the data pertaining to total kwh sold, kwh sold per consumer and kwh sold per connected load. This information is given in Table VI.2. Generation costs, as seen above, are allocated according to the kwh generated and sold. Therefore, we have first calculated the average generation cost per kwh sold. Since the generation costs are allocated on the basis of kwh sold average cost of generation per kwh sold will remain the same for all the categories of consumers.

Transmission costs are more sensitive to kw connected rather than to kwh sold. Therefore, we have first estimated the transmission cost per kw connected; for all the consumers taken together. Then, we have allocated the transmission cost per kwh sold to different categories of consumers. This is done by dividing the average transmission cost per kw connected by kwh sold per kw connected, for each category of consumers given in Table VI.2. Thus even though, transmission cost per kw connected would be the same for all the consumers, the transmission costs per kwh consumed would vary considerably as the kwh consumed per kw connected vary widely among different category of consumers.

The distribution costs are also allocated on the basis of kw connected and then expressed as distribution cost per kwh sold to different categories of consumers.

Expenses on consumer services are independent of kwh sold or kw connected. The expenses on consumer services are dependent on the number of consumers to be served by the electricity utility. Therefore, first we calculate the cost of consumer services per consumer. Then, divide this average cost by kwh sold per consumer and arrive at the figure of consumer cost per kwh sold for each and every category of consumer.

General Establishment, Management and administration expenses depend on the total business of the industry. In electricity this depends partly on number of consumers, partly on kw connected and partly on kwh sold to final consumers. Therefore, we have divided these costs in three equal parts and then estimated the establishment etc. expenses per consumer; establishment expenses per kw connected and establishment expenses per kwh sold.

Table VI.2

Number of Consumers, Connected Load, KWH Sold, KWH sold per KW Connected, and KWH sold per Consumer, in Electricity in India, 1970-71

Category of Consumers	No.of consumers	KW connected (MW)	KWH sold (Mil.)	KWH sold per KW connected	KWH sold per consumer
I. Domestic & Commercial Light & small Power; Public Lighting and Miscellaneous.	12541481	8374	7294	871	582
II. Industrial Power- L,M and HV; Traction, Public Water Works & Sewage Pumping.	552569	11632	31045	2669	56183
III. Agriculture	1570928	6225	4470	718	2845
Total	14664978	26230	42809	1632	2919

Source: Public Electricity Supply, op.cit. 1971-72.

That is, we have taken the view that one third of the general establishment and administration expenses vary with the kwh consumed, one third vary with kw connected and one-third vary with the number of consumers. This is arbitrary. But it is probably less arbitrary than allocating these costs on the basis of one single criteria.

Having calculated the average establishment expenses per consumer, we allocate them to different categories of consumers by applying the ratio of kwh sold to total number of consumers in each category. That part of general establishment expenses which is segregated on the basis of kw connected load is, in similar way, expressed as average cost per kwh sold by dividing it by kwh sold per kw connected. The last portion of establishment expenses is allocated on the basis of kwh sold. Therefore, this portion of average cost of establishment will remain the same for all the consumers.

The last type of operating expenses is the depreciation of capital assets. The depreciation of capital is independent of number of consumers to be served. However, it is influenced by the other two factors, viz., kw connected and kwh sold. An electricity generation, transmission and distribution plant has to remain in readiness to serve the consumers. Therefore, at first sight it may appear logical to apportion the entire depreciation on the basis of kw connected. However, depreciation depends not only on time but also on wear and tear which depends on the rate of utilization. Therefore, we divided depreciation into two equal parts. The first part of depreciation is calculated on the basis of kw connected, which gives us depreciation per kw connected. Dividing this figure by kwh sold per kw connected (taken from Table VI.2) we get depreciation per unit of kwh sold. The other half of the depreciation is allocated on the basis of kwh sold and, therefore, it will be the same for all the consumers.

Thus, we have selected three criteria for allocating costs of generating, transmistting and distributing electricity to final consumers. Generating costs are allocated on the basis of kwh sold, Transmission and Distribution costs on the basis of kw connected; and consumer servicing on the basis of number of consumers to be served. All these three criteria are applied to General Establishment, Management and Administration expenses. As against this, depreciation is allocated on the basis of kw connected and kwh sold.Though, there are three different criteria for apportioning different costs to different consumers, all the average costs are expressed as the average cost per kwh. This is done by applying the ratio of kwh sold to kw connected wherever allocation of costs is on the basis of kw connected. Wherever allocation of costs is based on the number of consumers we apply the ratio of kwh sold to number of consumers in each category of consumers.

Table VI.3

Category-wise Cost Per KWH, for Electricity Utilities in India, 1970-71 (in paise per kwh)

Type of cost	Category of Consumers I	II	III	Total
1	2	3	4	5
1. Generation Cost (Ps/kwh)	3.43	3.43	3.43	3.43
2. Transmission cost (Ps/kwh)	0.44	0.14	0.53	0.23
3. Distribution cost (Ps/kwh)	2.85	0.93	3.46	1.52
4. Consumer Servicing (Ps/kwh)	1.83	0.02	0.38	0.37
5. General Establishment & Management Expenses(Ps/kwh)				
(a) Based on No.of consumer	2.51	0.03	0.51	0.50
(b) Based on kw connected	0.94	0.31	1.14	0.50
(c) Based on kwh sold	0.50	0.50	0.50	0.50
6. Depreciation(Ps/kwh)				
(a) Based on kw connected	2.03	0.66	2.47	1.09
(b) Based on kwh sold	1.09	1.09	1.09	1.09
A.C./kwh	15.62	7.11	13.01	9.23
A.R./kwh	22.92	9.55	14.12	12.05
A.R.(inclusive of electricity duties/kwh	25.90	10.79	15.96	13.62

Notes:
1. Category I includes, (i) Domestic Light & Small Power, (ii) Commercial Light & Small Power, (iii) Public Lighting & Miscellaneous.
2. Category II includes (i) Industrial Power - L & MV, (ii) Industrial Power - HV, (iii) Traction, (iv) Public Water Works and Sewage Pumping.
3. Category III is the Agriculture.
4. A.C. = Average Cost, and A.R. = Average Revenue.
5. For (a), (b) and (c) see text.
6. 1 paise = .01 Rupee.

Table IV.3 gives the average cost according to different types of costs for each category of consumers and for the total of all consumers taken together.

Relative Costs and Relative Prices

Observing Table VI.3, we note that the highest average cost per kwh sold is the cost of serving domestic and commercial consumers. The lowest average cost is accounted for by industrial consumers, including traction and public water works, and sewage pumping. At the same time it is the domestic consumers (inclusive of commercial consumers and public lighting) that pays the highest price and the lowest price is paid by industrial consumers. Apparently it would appear that there is no price discrimination among consumers because the consumers that have the highest cost also pay the highest price and vice-versa.

Before comparing the average cost and average price of electricity paid by different consumers, an explanation regarding the average price is necessary. The average revenue per kwh sold to different categories of consumers is the ratio of revenue derived from the sale of electricity to the kwh sold to a given category of consumers.

This is not the price that the consumer actually pays because the consumer, along with this price, also pays the electricity duties. However, all the consumers are not subject to taxes. The consumers that pay the duties are domestic and commercial consumers, industrial consumers, public water works and sewage pumping, agriculture and traction. Therefore, in our total revenue figure we do not include the revenue derived from the sale of electricity to consumers in bulk and for public lighting. In 1970-71 the electricity duties formed 13.02% of total revenue (exclusive of bulk consumers and public lighting). Assuming this percentage to remain the same for categories of consumers, we have raised the average price for all consumers by 13.02 per cent; and thus, we get the average price (revenue), inclusive of electricity duties, per kwh sold.

The following figures show the cost differentials and the revenue differentials among different consumers :

$$\frac{A.C._1}{A.C._2} = 2.20, \qquad \frac{A.R._1}{A.R._2} = 2.40 \qquad \frac{A.R._1}{A.C._1} = 1.66$$

$$\frac{AC_1}{AC_3} = 1.20, \qquad \frac{A.R._1}{A.R._3} = 1.62 \qquad \frac{AR_2}{AC_2} = 1.56$$

$$\frac{A.C._2}{A.C._3} = 0.55, \qquad \frac{A.R._2}{A.R._3} = 0.68 \qquad \frac{AR_3}{AC_3} = 1.23$$

In the above information A.C. and A.R. stand for average cost and average revenue respectively. The subscripts 1, 2 and 3 indicate the category of consumers. Comparing the cost differentials between 1st category and 2nd category of consumers we see that this differential is as high as 2.2. As against this the average revenue differential between these two categories of consumers turns out to be still larger, viz., 2.4. This indicates that, though the domestic consumers (i.e. Ist category) have a higher cost as compared to industrial consumers,(i.e. 2nd category) it is the domestic consumer that is discriminated against as compared to industrial consumers. The same is the case if we compare domestic consumers with agricultural consumers. In this case also the average revenue differential between domestic and agricultural consumer is larger than the cost differential, indicating discrimination against domestic consumers.

Comparing industrial consumers with agricultural consumers we observe that the average revenue differential is larger than the cost differential, indicating discrimination against 2nd category of consumers as compared to the 3rd category of consumers. Thus, we notice that the agricultural consumers are favoured as compared to the other two categories of consumers. In short, we observe the existence of discrimination, either in favour of or against a given category of consumers, by comparing the price spread between two consumers with their cost differential.

Comparing the ratio of average cost of supplying electricity to a given category of consumers with the average price that this group of consumers pays, we notice, again, that it is the domestic (i.e. 1st category) consumer that pays the highest price as compared to the cost of supplying electricity to it. The lowest average price, as compared to its own cost, is paid by agricultural consumers. It must be admitted that these are very crude estimates. We have no data about peak-loads etc. which would have provided basis for a more ~~resigned~~ scientific analysis.

Profitability and Adequacy of Tariffs :

Since all the consumers pay a higher average price, as compared to the average cost of supplying electricity to them, the electricity industry is bound to make a profit. For getting some idea about the profitability of this industry we calculate the net profit rate of this industry.

Net profit is defined as the ratio of balance carried over to the financial investment of this industry. Balance carried over is nothing else but the difference between total Operating Revenue and Total Operating Costs. Total Operating Revenue of Public Electricity Utility in 1970-71 was Rs.76,404 lakhs. As against this, the total operating expenses (including depreciation) were Rs.53,481 lakhs, giving us a balance of Rs.22,923 lakhs for 1970-71. Total financial investment of Public Electricity in 1970-71 consisted of[23]-

	Rs.lakhs
Net Block	2,56,062
Capital works in progress	90,694
Sundry debtors for Electricity Supplied [illegible]	13,304
Other debtors	19,879
Accounts receivable	14,990
Balance at Bank-current account and at Call	3,406
Cash in hand	922
Total Financial Investment	3,99,257

Thus, as against the total financial investment of Rs.3,99,257 lakhs, the public electricity earns a net profit of only Rs.22,923. This gives us a rate of net profit of

23 Source: Public Electricity Supply, op.cit.

only 5.74%. Even if we include Rs.6720 lakhs of electricity duty collected, the rate of profit comes to only 7.42%. This is too a low a rate of profit considering the fact that this is one of the fastest growing industries, with a sizeable amount of investment, of our country. This low rate of profit indicates that electricity has been heavily underpriced in India. Generally it is considered desirable that the public enterprises should earn a rate of profit of 12%. Not only that the obtained rate of profit is considerably below the desired rate of 12%, it is even lower than 8.5% to 9% prime lending rates of term lending institutions such as the Industrial Development Bank of India, obtaining in 1970-71.