SUBMISSION TO THE:

COMMISSION OF ENQUIRY INTO THE SUPPLY OF ELECTRICITY IN SOUTH AFRICA

1. General Submission - November 1983
2. Submission on Nuclear Power in South Africa - January 1985

R K Dutkiewicz
March 1985.

IN057/C
This report discusses Escom's role in the supply of electricity. It highlights the role of planning in the provision of electricity at the lowest possible cost and discusses the role of reliability in such a planning process.

The report shows that the real price of electricity has been steadily decreasing except for a period between 1975 and 1977. It is also shown that the cost of electricity in South Africa is amongst the cheapest in the world, ranking together with large hydro-plant suppliers such as New Zealand and Canada.

It is considered that the tariff structure is satisfactory in its attempts to apportion capital and operating costs in such a way as to adequately recover costs in both categories. It is shown that the demand curve for electricity is relatively price inelastic and that adjustments to tariffs are not expected to have adverse effects on total revenue.

It is considered that Escom's public image is very poor, due to Escom's inability to understand how the average person views it. It is also considered that Escom is not doing sufficient in the area of improving science and education in South Africa.
INTRODUCTION

During the last quarter century Escom has grown by an average of 8.7% in installed capacity and 8.4% in electricity sales. This has required Escom to change from a small utility to a large utility, and from a loose arrangement of separate undertakings to an integrated generation and distribution pool. Such changes have brought about growing pains. Since Escom has become a virtual monopoly in the supply of electricity in South Africa - accounting for 93.6% of electricity sales in South Africa in 1982 - it is pertinent to examine whether the growing pains experienced are natural or whether they are an indication of a deeper malaise.

As with all monopoly situations it is difficult to determine whether Escom's efficiency and productivity are adequate or whether a private enterprise utility would achieve lower costs. The problems of supplying power on the scale required in South Africa preclude the formation of an independent electricity supply utility in competition with Escom; the country could not stand the financial implications. Thus the most direct method of determining cost - the relevant selling costs in a free market economy - are denied to us, and other methods of determining internal efficiency must be adopted.

There are two main ways of determining whether an organisation such as Escom is efficient. The first is to determine whether within Escom itself the situation, as represented by various indicators, is improving or is deteriorating. Secondly it is possible to compare performance indicators for Escom with those of other countries - taking into account the variations in operating conditions between different utilities.
In a utility, planning is the most important function. In the case of electricity supply the correct mix of power generation and the required transmission system is all important. Once a power station is built there is not much that can be done with it other than to operate it at the designed efficiency. The operation function is then, apart from fault conditions, a simple system of station loading. The planning function will therefore be discussed first.

PLANNING

In its planning function Escom is mainly influenced by economic growth factors provided by others, such as private industry - the consumer - and by government in its economic growth forecasts. The relationship between economic growth and electricity demand is fairly well understood. Figure 1 illustrates the yearly change in Gross Domestic Product and in electricity consumption over the period 1950 to 1982. It is evident that there is a strong correlation in the pattern of the two curves. The average growth rate in Gross Domestic Product over this period was 4,6 % whilst that of electricity consumption was 8,6 % pa. The absolute values of electricity consumption are, however, affected by two factors, the wealth factor and the population growth factor. Population growth in South Africa has been running at an average of 3,3 % (1960 - 1970 figures). The per capita consumption of electricity has, in turn, also been rising due to the well substantiated relationship between wealth (GDP/capita) and electricity consumption (kWh/capita). The increase of electricity consumption in South Africa has been rising by an average of 5,1 % as shown in Figure 2. Thus the population growth and the consumption-wealth relationship led to the combined growth rate of over 8 % determined earlier. Thus in the medium term Escom's
planning is influenced purely by National Economics and by an assessment of the relatively insensitive wealth effect. In the short to medium term the forecasts of individual consumers, or potential consumers, must be aggregated. It must be remembered, however, that each of these individual forecasts is influenced by National Economics. Any criticism of Escom's planning must therefore be judged against the ability of others to predict economic growth.

An important part of Escom's planning is the provision of a safety margin in generating capacity. This safety margin is a form of insurance against unforeseen outages. Like all insurance it is expensive and unproductive if never used. However, the amount of insurance required is governed not by economic factors but by strategic policy considerations. How safe should the provision of electricity be? If there is never a black-out due to lack of reserve capacity then there is most probably too much reserve and a burden on the consumer in terms of higher costs. If black-outs happen very frequently then there is too little reserve capacity, and this is most probably an economic cost to the country in terms of lost production capacity. Somewhere in between there is an optimum situation. This is probably an area of policy formulation to which Escom has not given sufficient attention.

In terms of generation capacity the planning of new stations has to consider operating resources. At present there is a preoccupation with water shortages in the Transvaal and in Natal, and pressure appears to be growing for Escom to conserve water, at all costs. When it is considered that power generation uses only 2% of the total water demand in South Africa then such pressures are unrealistic.

Coal is Escom's main operating resource and the future of coal must be carefully considered. There is however, a
conflict of interests in Escom's approach towards the country's coal position. Escom's operating instructions, as laid down in the Electricity Act No 40 of 1958 as amended, lays down that Escom should supply electricity at the lowest possible price. This can be in conflict in relation to using the country's coal resources in the most efficient manner. However, it is not possible to ask Escom to look at the country's broader interest, or else the problem would have no bounds, and would in many instances be based on subjective analysis. It is rather the function of government to decide on broad strategy policies and then by suitable inducement to steer Escom in the required direction. Thus it is illogical to expect Escom to decide on what would amount to internal cross-subsidisation for the good of a particular group of consumers or for a certain sector of the national economy.

In the case of Escom's planning the goal should be the lowest possible cost commensurate with an acceptable level of reliability. This concept of reliability is however, a subjective issue. The larger the Power Station unit size (turbine or boiler) the lower the cost per kWh. For a number of years in the mid-1960's to mid-1970's, preoccupation with the largest economic size led to a decrease in reliability, or availability as it is termed. Set sizes were still smaller than those of other countries such as the U.K. for example (see Figure 3). Availability has a direct effect on the amount of reserve capacity which has to be installed. In hindsight, the cost of unavailability can be calculated but for forecast purpose it has to be an inspired guess. Escom only started publishing its system availability since 1978 so it is not possible to make any general comments but the last five years have seen a general decrease in availability by about 10%.

On the subject of resource utilization by Escom, two further components should be considered namely, capital and people.
With the use of large set sizes, economies of scale should be evident. The savings should be evident in terms of the average real cost of capital employed per unit of installed capacity, or, since Escom’s Load Factor has not changed appreciably, the real cost of capital employed per unit of electricity sold. Both these quantities are shown in Figure 4. The curves have been drawn for the real cost of capital employed by Escom, using the GDP deflator and 1975 as base year. It is evident that the efficiency of capital utilization has been improving steadily with a large drop in capital requirement during the period 1970 to 1976. Of the two curves in Figure 4, the capital use per MW is a better measure of the utilization of capital since it is not affected by changes in Load Demand which is, amongst other factors, a function of economic activity.

The utilization of labour by Escom for administration, operation, and maintenance is illustrated in Figure 5. It is evident that economies of scale, which involve not only the number of operating personnel but also the design and construction staff employed by Escom, have resulted in a gradual decrease in the number of employees per unit of electricity sold. It is not possible to determine whether the number of employees is correct since the number of employees is not directly proportional to the number of sets installed. Thus there is a fixed number which is proportional to the number of power stations installed, and another number which is a constant for the whole of Escom. If the number of employees required was inversely proportional to number of units, then the 1980 actual number of employees, using 1960 as a base, would appear to be double the required number.

ESCOM INTERNAL EFFICIENCY

The relative efficiency of Escom, on the basis of its year-to-year operation, can be considered under the following
headings:

a) Efficiency of generation and transmission
b) Coal utilization
c) Water utilization
d) Capital utilization
e) Employee utilization

Items d) capital utilization, and e) employee utilization have already been discussed above. It has been shown that the efficiency of capital utilization has been increasing with time though it is not possible to determine whether the reduction in capital employed per MW of installed capacity is adequate. Similarly, the number of employees per unit sold is decreasing though it would appear that the reduction is not as great as might be expected.

The efficiencies of transmission has been fairly constant over the last 30 years and is approximately 94 %. Thus it is unlikely that any improvement can be achieved by, for instance, better planning or better management.

The average efficiency of Escom's Power Stations has been increasing steadily. In 1950, the average thermal efficiency was 18,2 % and had risen to 30,5 % by 1982. The increase in average efficiency was affected by the greater efficiencies of the modern high pressure power stations. Thus the efficiency of Klip Power Station, commissioned in the mid-1930's and operating at steam conditions of 2,5 MPa and 390°C has an efficiency of 17 % compared with Arnot Power Station operating at 15,9 MPa and 510°C, and an efficiency of 33 %. The steam conditions are determined largely by set size which is, in turn, determined by stability considerations and by estimates of availability. Thus the efficiency of Escom's Power Stations can be considered as satisfactory. Coal usage is directly related to Power
Station Efficiency and thus the improvement from 0.869 kg of coal per unit sent out in 1950 to 0.551 kg of coal per unit sent out in 1982 is directly related to the improvement in station efficiency.

Escom's water consumption has fallen from a value of 5.34 litres per kWh in 1960 to 2.45 litres per kWh in 1982. Part of this decrease is due to the general increase in station efficiency. However, if station efficiency were the only criterion for water consumption then the 1960 value of 5.34 litres should have fallen to 3.9 litres by 1982. The fact that it has fallen to 2.45 litres indicates that measures adopted by Escom are having a significant effect on water conservation.

In general, therefore, the trends in Escom's internal efficiency are moving in the right direction. However, it is not possible on the basis of an internal comparison to determine whether the rate of trend movement is adequate and other measures have to be adopted to determine Escom's efficiency in absolute terms.

ELECTRICITY PRICE

Much of the concern about Escom's operations is directly related to the large price increases which occurred between 1974 and 1982. Over the period 1950 to 1974 Escom's average selling price rose by 3.9 % pa. Over the period 1975 to 1982 the price rose by 19.7 % pa. In addition the price rose by 22 % pa over the period 1975 to 1979. The question is therefore whether this price rise was due to bad planning by Escom or whether it is attributable to external factors. The Escom electricity has been deflated by the Gross Domestic Product deflator to arrive at the real cost of electricity. The results, related to the year 1975, are shown in Figure 6. Here the curve indicated by "A" is the current price of Escom Electricity,
whilst curve "B" is the real or deflated price using 1975 as the base year. The choice of the Gross Domestic Product deflator as a measure of inflation in this case is based on the general nature of the costs which make up the price of electricity as opposed to the more specific Consumer Price Index, or Production Price Index. The choice of deflator is largely academic since the indices of interest do not vary by more than about 10 - 15 % from the Gross Domestic Product deflator. Therefore the general conclusions will not be different whatever the index used.

It is seen from Figure 6 that the inflation from 1971 to 1975 was not being passed on to the consumer, leading to a decrease in the real price of electricity. As a result the price rises that occurred in 1976 - 1978 were steeper than should have been necessary. Since 1978 the price increases were slightly less than the inflation rate, leading to a slow but steady decrease in real prices up to 1982. It is noteworthy that the real price of electricity in 1982 was approximately the same as in 1950.

During the period 1950 to 1974, when electricity prices were rising by 3.9 % pa, coal prices were rising by 5.3 % pa. During the period 1975 to 1982 coal prices rose by 16.4 % pa. Since the cost of coal makes up approximately 25 % of electricity prices, these increases should directly influence the increase in price of electricity.

Whilst these figures show that the real cost of electricity has, except for the period 1975 - 1977 been falling, it still does not indicate whether the rate of fall was adequate in view of the growing economies of scale. Firstly, it is possible to compare electricity prices in South Africa with those in other utilities around the world. A survey carried out recently has shown that of a sample of 21 countries, the 1979 electricity prices (latest year available in South Africa) are the third lowest and these
were only 9% higher than the lowest price - that of King Country in New Zealand. These values are given in Table 1.

Prices alone are insufficient. Escom's position as third lowest is indicative of efficiency, especially since the other countries at the lower end of the price scale are predominantly hydro-electric producers. In general hydro-plant is very cheap in capital cost when compared with steam plant and has negligible operating costs. Thus hydro-plant should always give lower energy costs than other plant. The trends in prices should be informative and aid in the understanding of electricity price patterns.

It would be unwise to compare Escom's price pattern with any other utility since the plant mix would have a large effect on price movements. Thus a power station using oil would show a very good correlation between world oil prices and electricity production costs whilst hydro-plant would not show such a good correlation. There are however, only a very small number of utilities which are as coal-based as Escom. Of the utilities considered in the price analysis mentioned above, only five have a coal component greater than 66%. These are:

- Australia - S.E.C. Queensland - 93% coal
- S.E.C. Western - 89%
- S.E.C. Victoria - 77%
- Canada - Alberta - 92%
- Saskatchewan - 66%

These five utilities have been compared with Escom in Figure 7. It is evident that the trends in the 6 utilities are similar. It is noteworthy that the slope of the real price curve is steeper for the Canadian and Australian utilities than for Escom. However, other utilities in Canada, for instance, which rely more heavily on hydro-plant have
similar slopes to Escom. It is apparent, however, that these utilities have experienced the same financial forces in the mid 1970's but in general the real price curve is downward.

**TARIFFS**

There is great confusion in the minds of the general public concerning the tariff structure, the relationship between the various class of consumer, and the differences between Escom prices and the prices of local municipality suppliers. A tariff is of necessity a subjective method of recovering expenditure on production. The relationship between the various classes of consumer is based on the tariff setter's assessment of the power and energy costs for each particular type of consumer. Thus the relationship between the average cost of power to a domestic consumer, to a small consumer, and to a large consumer is based on an assessment of the cost of supplying such classes of consumer. In the case of the domestic consumer, the cost of equipment to measure maximum demand would be out of proportion to the bill paid by an individual and thus a single change per unit consumed is levied as opposed to the two part tariff levied on larger consumers. The two part tariff is an attempt to separate the capital and operating portion of the cost of supply. The principal behind the tariff structure should always be the most equitable method of levying costs on those who accrue costs. In terms of national economics, this concept should be applied to all those who use electricity. Thus a consumer who is remote from a point of supply should cover the cost of such supply. This means that consumers remote from power stations are required to pay more than those close to power stations. This is logical since a new consumer setting up an enterprise would optimize his cost of transport of materials, cost of transport to market, cost of water supply, and cost of electricity. By optimizing these costs, he minimizes costs in the national sense. Thus any distortion in this mechanism by, for instance,
reducing the cost of electricity for a non-economic reason would result in an increased national cost. It is thus illogical to request that electricity prices should be uniform throughout the country since it would mean certain consumers subsidizing other consumers. If the price of electricity to a certain group of consumers needs to be reduced for sociological or political reasons, then such reduction should be made by means of a subsidy paid by government. In this way, the assistance is seen, for what it is, and can be quantified. It is not suitable that Escom should by its tariff structure, apply hidden cross-subsidization.

The tariff structure should encourage the wise use of electricity. In this connection, the steadily increasing maximum demand (capital component) part of Escom's tariff is correctly accentuating the cost of capital. An increase in the demand charge has resulted in more attention being paid to load levelling and maximum demand limiting, which, by making better use of capital equipment, is to the economic benefit of the country.

It would be unwise to compare Escom's tariff structure with those of other countries. For instance, requests are often made for "time-of-day" tariffs on the mistaken idea that, by using energy at off-peak periods, a saving in capital equipment can be achieved. Escom has an extremely high load-factor which, on an annual basis, is usually in the 60%'s and, on a daily basis, can reach 90%. Under such conditions, especially if pumped storage is used, the scope for off-peak tariff use is minimal. The best way of adjusting peak demand is by the use of pumped-storage systems and by the use of ripple control of domestic hot-water systems by municipalities.

There has been concern expressed that increases in tariffs can be counterproductive by decreasing demand for electricity with the consequent higher unit cost due to underutilization of capital equipment. This cannot happen in a
period of expansion in electricity supply and demand, at most it can delay the installation of new plant. Moreover, it is unlikely that the elasticity of demand is as great as is advocated by proponents of such a situation. Figure 8 is a graph of electricity demand against GDP. This curve shows that during the period when GDP was in fact decreasing, and when electricity prices were going up by 19%, the per capita consumption of electricity was rising significantly. This points to a marked inelasticity of the supply curve, at least within the limits already experienced, and at the present stage of development in South Africa.

PRIVATE PARTICIPATION IN ELECTRICITY SUPPLY

This report has been concerned mainly with Escom, since Escom provides 94% of the electricity in South Africa. It is considered that because of the large economies of scale and complexity of infrastructure, it would not be possible, in terms of national economics, for other utilities to be able to compete with Escom. It is recognized that the role of private organizations and municipalities would be mainly in local distribution, leaving Escom to be a bulk wholesaler of electricity and a retailer to those consumers not covered by another organization.

There is scope, however, for various organizations to provide electricity to Escom through the use of waste products etc. Because of the inconvenience of accepting supply from such small consumers, this has been (passively) resisted by Escom. In view of the benefits to the country as a whole, the use of such small producers should be encouraged, and a rational approach to the costing of such power should be made. The present marginal cost method of assessing the worth of such supply is considered to be inadequate and is a disincentive to such supply.
PUBLIC IMAGE

Whilst Escom's image in the engineering sphere is high, the same cannot be said of its public image. Since most of Escom's problems and solutions are engineering ones, Escom tends to consider the general public as incapable of making any meaningful comment, and that the public should not interfere in its working. This has led to an arrogance which is evident not only in its dealing with the general public, but also in its dealing with companies contracting for Escom.

Escom's poor public image can be illustrated by reference to its double page advertisement inserted into a number of popular or semi-popular magazines. This advertisement has been appearing, in the same format, over a number of years. Comments received from a number of people who were asked for their views on this advertisement included: not a very inspiring picture, - it looks like a recruiting ad for school leavers, - a solid uninspiring organization, etc. In no case did it make a positive impact.

Similarly, the various incidents at the Koeberg Power Station have been completely mishandled from the public relations point of view.

In general, Escom is seen as being a large arrogant organization, not interested in communicating with the public.

Whilst Escom has many positive features, it is not accentuating these, nor does it appear to know what sort of impact it makes in South Africa.

RESEARCH AND EDUCATION

Whilst one cannot fault Escom in the work it does in the area of research and development for itself, it does not appear to understand the effect that it could have on the development of the country itself. This applies both in
the scientific/technological area, and in the area of education.

If Escom was a private company, it would be considered natural that it should play a leading role in the development of the country. In most other countries, utilities are seen as part of the community and with a role to play within the community. This is especially true of utilities in the U.S.A. where the main emphasis of a public relations campaign is to highlight such participation. Due to the technological nature of a utility's work, involvement is usually of a scientific nature. Thus Escom should be more active in promoting technological development in South Africa. Whilst this should be aimed mainly at its own sphere of interest, this is so encompassing that it includes most scientific and technological activities.

In the area of education, Escom has bursaries and scholarships as a recruiting aid to obtain staff, and as a fringe benefit for its own staff. One would expect some specific commitment to improving education even if only in its own special area of interest. However, Escom has not shown any such interest.
FIGURE 1: GROWTH IN GDP AND ELECTRICITY SUPPLY

FIGURE 2: PER CAPITA ANNUAL ELECTRICITY CONSUMPTION

FIGURE 3: MAXIMUM SET SIZE FOR ESCOM & CEGB
FIGURE 4: CAPITAL USED IN POWER GENERATION PER UNIT SOLD AND PER MW OF INSTALLED POWER (VALUES DEFLATED BY GDP DEFLATOR)
FIGURE 5: NUMBER OF ESCOM PERSONNEL PER kWhr OF ELECTRICITY SOLD
FIGURE 6: ESCOM ELECTRICITY PRICES - CURRENT AND REAL
FIGURE 7: COMPARISON OF ELECTRICITY COST
FIGURE 7 (cont'd): COMPARISON OF ELECTRICITY COST
FIGURE 8:
ELECTRICITY CONSUMPTION VERSUS
GROSS DOMESTIC PRODUCT
SUBMISSION TO THE:

COMMISION OF ENQUIRY INTO THE SUPPLY OF ELECTRICITY IN SOUTH AFRICA

Nuclear Power In South Africa

R K Dutkiewicz
January 1985

Energy Research Institute
UNIVERSITY OF CAPE TOWN
SUBMISSION TO THE:

COMMISSION OF ENQUIRY INTO THE SUPPLY OF ELECTRICITY IN SOUTH AFRICA

R K Dutkiewicz

November 1983

Energy Research Institute
UNIVERSITY OF CAPE TOWN
Nuclear Power in South Africa

Nuclear power should only be expanded in South Africa on sound economic grounds and taking account of all the related costs, not only of the capital and operating cost of the power station itself. The decisions taken on nuclear power in the past were not done on this basis and the decision was unduly influenced by political considerations.

Besides the political pressure brought to bear on the initial decision to go nuclear the following spurious arguments were also used:

(a) South Africa must go nuclear in order to conserve dwindling coal resources.
(b) Nuclear power at the coast will conserve inland water resources.
(c) One should go nuclear in order to build up a sound nuclear industry.

The first argument is fallacious. There is no doubt that nuclear power will be the preferred energy source in the future but the point at which nuclear should be introduced should be dictated by economic considerations. Thus when coal becomes scarcer its cost will rise until the point when nuclear power becomes cheaper - a situation which has already arisen in Europe and in parts of the U.S.A. South Africa's coal reserves are still large enough, and will still become larger with further exploration, for the question of coal scarcity not to influence decisions at present. (This does not mean that long term planning should ignore the potential scarcity.)

The second argument - concerning water supplies - can be answered in a similar manner to that dealing with coal. The huge amounts of water required for evaporative cooling towers are not necessary if more expensive cooling systems are adopted. Thus dry cooling towers decrease the water requirements appreciably, though at an increase
in capital cost, and in operating cost. Binary system using refrigerants are also possible: the decision on nuclear power should thus involve the economics of cooling within the total cost comparison and not on the basis of emotive appeals to conserve water.

The third argument concerning the building up of a nuclear industry has been used on a number of occasions, and is also completely fallacious. If it is considered possible, and necessary, for South Africa to develop a reactor design-and-construct capability, then a viable nuclear industry is a prerequisite. Since such a high technology venture is unlikely, and even undesirable, South Africa will import nuclear reactor technology, and the need for a large nuclear industry is unnecessary.

The only remaining reason for increasing South Africa's nuclear energy capability should be then that of economic benefit.

In the past the economics of nuclear power have been based on a break-even situation considering capital and operating costs and the cost of transmission. Such an approach is undesirable since the introduction or expansion of nuclear energy capability should be based on the overall economics to a country. Moreover, because of the potential danger of a nuclear incident, real or perceived, there should be a net positive effect on the economics of a nuclear reactor, to make it worth while in terms of national economics.

Whilst cost benefit analyses are difficult to carry out, comparison between the economics of nuclear power and alternative methods of electricity production should include the cost of de-commissioning and the costs of safety measures required to be adopted by other organizations. Thus it appears illogical that the cost of infrastructure for evacuation in the event of an incident should not be included in the overall cost. It appears also illogical that the cost
of such infrastructure, or even part of such an infrastructure, should be borne by local authority and not by the utility.

The criterion to be used for comparing nuclear power with other forms of energy should be thus that of economic viability when costs, both direct and indirect, are included. Because of the attractiveness of a nuclear power station for sabotage, in South Africa's political situation, and because of the untold damage which a nuclear incident would have on the world's nuclear industry, the level of safety and security in nuclear plant in South Africa needs to be substantially higher than in many other areas of the world.

Conclusion

There should not be any problems in the expansion of nuclear power in South Africa because of technical reasons. The sole criterion for such expansion should be economic advantage, taking into account all direct and indirect costs for the competing energy sources.
IN057/C

SUBMISSION BY THE ENERGY RESEARCH INSTITUTE TO THE COMMISSION OF ENQUIRY INTO THE SUPPLY OF ELECTRICITY IN SOUTH AFRICA:

1. General Submission - Nov. 1983

R K DUTKIEWICZ
March 1985