THE ECONOMICS OF NUCLEAR POWER

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The problem of deciding whether it would be advantageous to a country to construct a nuclear power station can be considered in two parts :

1. The long term problem of the reserves of fossil fuels

and 2. The short term problem of comparative costs, these to include both capital and running costs.

It seems probable that the year 2000 A.D. wall form a rough boundary between the two stages, i.e. before this date nuclear power stations should only be built where the costs are lower than other forms of energy. After 2000 A.D. the knowledge that the fossil fuels are becoming exhausted will render the development of new power sour ces essential. Today short term problems are obviously of more importance but it is interesting to consider briefly the long term problem.

Estimates of power supplies and demand are very approximate since there are so many variables involved. The demand is increased by factors such as population growth, economic growth, changes in living habits (more heating, cooling, etc.), On the other hand supplies of fossil fuels are continually being increased by new techniques of winning and then using the fuels. If the world population is assumed to be 1000 mil lion in 2000 A.D. then the future world energy requirements will probably mean the supplying of about 8000 million tons per annum of fuel in the form of solid fuel, petroleum and natural gas. This figure is based on the present average fuel consump tion of 1 ton per person per annum and it is of some importance to realise that in advanced countries the consumption is approximately 4 tons per person per annum. On the basis of these figures if a further world population growth of 2 % is assumed then there is a prospect of fossil fuel being exhausted approximately by 2200 A.D. With a 3 % population growth approximately 90 years after 2000 A.D. would be required before exhaustion. Of course fossil fuels can be augmented with hydroelectric schemes but power from this source is unlikely to exceed 1000 million tons equivalent in 2000 A.D. Thus ultimately we must use nuclear power or another perhaps yet un discovered source of power. In a nuclear power station 1 ton of uranium fuel produces the energy of several thousands of tons of coal and on this basis the world's supply of uranium will, last for very many years.

Short term planning

First of all two non-economic factors should be mentioned,

1. Military purposes

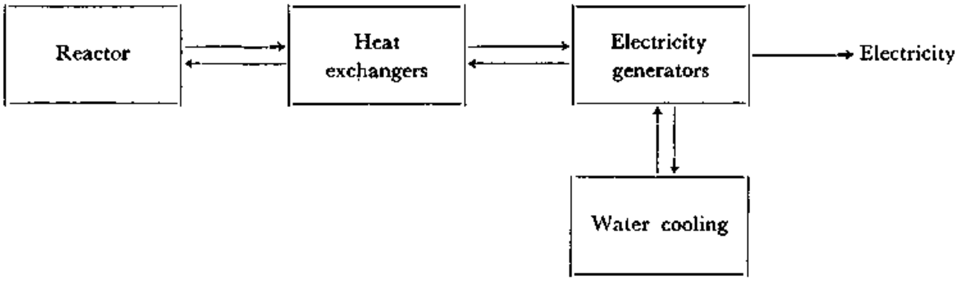
and 2. Prestige.

Atomic weapons give a country some power in world affairs. Once a country has the factories and the know-how the production of atomic bombs is quite cheap. For instance 1 small atomic bomb is equivalent in destructive power to several thousands of tons T.N.T. and it costs 99 % less. The fuel used in atomic weapons is plutonium and the production of plutonium can also be combined with the production of power for peaceful purposes, though at a very uneconomic rate. However in the United Kingdom reactors which supply uneconomic power were originally built primarily to produce plutonium. It should be borne in mind that Britain, America and Russia are all in an advanced state in the development of nuclear power stations primarily due to decisions taken 20 years ago to develop nuclear power for military purposes.

The second non-economic reason is due to the fact that many poorer and younger nations like the glamour and prestige associated with «atomic power». Governments play a large part in investment decisions and politicians have to impress popular opinion so that an expenditure of a few millions on an atomic reactor, often a quite uneconomic proposition, is frequently carried out. Also many emergent countries still associate atomic power with cheap power due to some early exaggerated claims but now most countries are prepared to appraise atomic power possibilities on a sound cost basis.

Economics

In order to appreciate the economics it is necessary to understand briefly how a nuclear power station works.



Basically the only difference between a conventional power station and a nuclear power station is in the type of fuel consumed and in the way it is consumed. In a nuclear reactor, the uranium fuel is used up in the fission process which results in the release of a lot of energy in the form of heat. This heat is transferred to a coolant (liquid or gas) circulated through the reactor and is subsequently transferred through heat exchangers to steam circuits. The steam drives turbo-alternators to produce power in the conventional fashion. To compete economically with conventional power stations the nuclear power station must be able to offer some advantages, if not in the capital costs, then in the day to day running costs.

In any country a detailed survey of its electrification needs must first be drawn up before decisions are taken on how to supply its needs. Every country is different in this respect but basically there are a few reasons for and against the use of nuclear power.

For

1. *Transport.* — Atomic power stations require little fuel. For instance 1 ton of uranium is equivalent to several thousands tons of coal. Thus where a coal fired power station requires many train loads of fuel each week, a few lorries can supply a nuclear power station. In a large country, such as India, where long distances are involved from fuel producers to consumers (power stations) then a considerable saving on the cost of transportation of the fuel is involved.

2. *Deployment of industry.* — Electricity supply is more useful for urban rather than sparsely populated rural areas, due to the large costs of distribution of the electric power. Ideally therefore a large concentration of large-scale manufacturing is ideal for the supply of electrical power. Hower small reactors appear to offer a valuable way of supplying electrical power to rural areas where farming is highly industrialised and uses a lot of electricity. It should also be borne in mind that the construction of a nuclear power station may also attract further industry to an area which is underdeveloped.

3. *Natural mineral deposits.*— Deposits of nuclear fuels such as uranium and for breeder reactors, thorium, may considerably reduce the costs to a country of running a nuclear power station.

4. *Trained personnel.* — The possession of a number of suitably trained engineers and scientists to construct and/or operate a nuclear power station is a tremendous asset to any country. It takes many years to train people to the high standard required and a training programme for the production of nuclear engineers is essential to any country thinking of a nuclear power station in the future.

Against

1. *Natural abundant supplies of fossil fuels.* — Certain countries have ample supplies of fossil fuels and in these countries nuclear power is unlikely to be able to compete economically for a very long time. Examples are Venezuela (oil), Brazil (enormous hydroelectric potential) and Pakistan (natural gas supplies).

2. *Good supplies of fossil fuels.* — Certain countrie shave reliable and cheap supplies of fossil fuels, plus the advantages of good ports and transport facilities internally so that conventional power stations can be operated quite cheaply. In these countries it is likely to be in the 1970' s before nuclear power can compete economically.

3. *Lack of trained personnel.* — This is a severe disadvantage to any country thinking of a nuclear power station since suitable personnel are extremely difficult to obtain from abroad for any length of time.

Costs

We can consider first two general points regarding the overhead costs of supplying electricity by any method.

1. Peak loading requirement. Electricity cannot be stored in appreciable quantities and thus the power supply must be able to meet the peak loading. This makes the power outputs of electricity stations rather high with a consequent increase in the capital construction costs.

2. The distribution of electric power is expensive and amounts to more than half the cost of power to the consumer. Thus any saving ultimately in the cost of production of electricity is unlikely to be felt by the consumer.

Capital costs. — Research and development is expensive. To develop a new reactor from beginning to commercial use takes 10-15 years. Approximately 1500 men are needed and much equipment is used so that the cost is likely to be approaching £ 50 millions. This outlay initially will affect the cost of a reactor even to countries which buy a reactor from a commercial firm.

At present the construction cost of a nuclear power station is about £ 110 per k. w. installed and this figure must be compared with the initial cost of building a conventional power station which in Britain is about £ 50 per k.w.

Running costs. — To build a power station a government normally borrows the money. Since a nuclear power station is at present roughly twice the cost of a conventional power station then twice as much money must be borrowed and thus the interest charges on the loan are doubled. The insurance of nuclear power station is also higher than for conventional stations but this cost may decrease with an increase in the use of nuclear power. In Britain labour charges are much the same as for conventional power stations but this is again a charge which may be reduced as nuclear power stations become more standardised and automated. Fuel costs are appreciable in existing reactors and the exact cost of fuel is rather difficult to estimate since the price varies with the amount consumed and hence purchased. Alternatively a country may produce its own fuel in a suitable form. At present the power produced per ton of fuel is equivalent to that produced from several thousand tons of coal. A rough figure for the cost of the uranium is about £ 10 per kg for a reactor using about 1000 tons per annum. Of course some of this cost may be offset against the usefulness to a country of the plutonium produced. At present however comparative running costs are as follows :

Conventional power stations . . . . 0.5 *d* per k.w.h.
Nuclear power station — Berkeley, Bladwell in Britain . . . . 1.0 *d* per k.w.h.

Thus at present nuclear power stations cost twice as much to build and cost twice as much to run as conventional power stations.

However certain facts which are encouraging for the future have been brought out by an appraisal of the performance of Britain's early reactors.

1. One reactor at Chapelcross has given a 30 % rise in heat production over its design output.

2. Fuel elements are proving to have a life in excess of 3000 M_w d/t assumed at first.

3. All reactors very reliable and can operate at full load for 85 % of the time.

4. Wear and tear and thus depreciation is negligible.

All of these factors thus contribute to a lower running cost than predicted. In addition reactor technology is steadily improving so that the design of more efficient reactors is continuously proceeding. Reactors now being constructed in Britain have a concrete pressure vessel instead of the steel formerly used and this has reduced the capital cost to about £ 90 per k.w. installed. The installation of fewer and bigger heat exchangers and turbo - alternators will also help to reduce capital costs. Running costs of the reactor can be improved by an increase in the efficiency of the reactor and in Britain it is hoped to achieve greater efficiency by operating the reactors at a higher temperature. Existing reactors operate at about 330°C but it is planned to operate the Advanced Gas Reactor (AGR) at 550°C and the High Temperature Gas Reactor (HTGR) at 800°C. In this way it is hoped to bring the running costs down to a figure of 0.35 *d* per k.w.h.

Current costing based on planned reactor design in Britain suggests that by 1970's the cost of nuclear power electricity will be down to that of conventional electricity at present. In contrast, as coal supplies decrease conventional electricity may become more expensive. It should also be noted that current costing is based on a 20-year life for a station operating under a 75 % load. Experience with existing reactors suggests that better figures are possible.

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