INTERNATIONAL CONFERENCE
ON NUCLEAR POWER AND ITS FUEL CYCLE

SALZBURG, AUSTRIA • 2–13 MAY 1977

INTERNATIONAL ATOMIC ENERGY AGENCY

IAEA-CN-36/3

Title: Possibility of Regional Fuel Cycle Centres in the Context of Bangladesh.

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Abstract

A brief analysis of economic feasibility of the regional fuel cycle centres in South and South East Asia is presented where the countries considered are Afganistan, Pakistan, India, Ceylon, Bangladesh, Burma, Malayasia, Thailand, Singapore and Indonesia. The break-even costs and break-even plant sizes for the various fuel cycle services are estimated and the timing for their establishment on the basis of IAEA and ESCAP nuclear power projection in the region, is indicated. The paper also discusses the need for achieving regional self reliance in this context. Bangladesh, as a possible site for the regional fuel cycle centres, is also discussed.

ECONOMIC CONSIDERATIONS

Demand For Nuclear Power

Existing and the projected nuclear power demand for the region is summerised below:

Table-I. Existing and Projected Power Demand of the Region

Y e a r	Generation Capacity (MWe)
Existing	537
1981	3,900
1985	8,200
1990	16,000
beyond 1990	Uncertain

Projected demands, as given above, are based on the IAEA market survey projections [1,2] and the ESCAP[3] report of 1976.

HWR Vs. LWR in The Region

The region, at the moment, has predominantly HW reactors with a total generation capacity of 537 MWe. It is, however, not possible to predict whether the region as a whole is going to have predominantly HWR or LWR systems in the future.

Considering the various fuel cycle services it can be seen, first, that the HW reactors do not require the enrichment service. Second, the demand for reprocessing of spent fuel from the HW reactors is limited for the following reasons:

Pu-recycling is not yet attractive commercially. The main reason is the absence of demand for Pu (to be used in fast reactor) in the near future. There is also the lack of a regulatory atmosphere suitable for consideration of mixed oxide reload batches. In addition, economic burden in the "throw-away" fuel cycle for the HWR is small[5] on the total fuel cycle cost.

In view of the above considerations this study is based on the assumption, that the region will have predominantly PWR systems.

Economic Feasibility

For economic feasibility the following assumptions are made:

1) Reference Plant Construction Cost: Cost estimates for the construction of various fuel cycle establishments are taken from the Fitts-Fuji report [6] and reproduced below in somewhat modified form:

Table-II. Indicative Construction Costs of Fuel Cycle Facilities

Type of Plant	Capacity	Construction Cost (Million US $)	Electricity Generations Supported (MWe)
Conversion	5000 MTU/Yr	50	6,000
Enrichment	3000 MT-SWU/Yr	1,000	40,000
Fabrication	1500 MTU/Yr	200	50,000
Reprocessing	1500 MTU/Yr	1,000	50,000

2) Extrapolation of Reference Plant Construction Cost: Extrapolation is done by the relation;

$$Cm = \left(\frac{C_o}{2^m}\right) f^m$$

Where, C_o = Cost of the reference plant of size S_o as in Table - II

Cm = Cost of a plant of size Sm

Where, $Sm = \left(\frac{S_o}{2^m}\right)$

Factor f will vary with m; but for lack of reliable data of costs for various sizes, f is given a constant value. The study assumed that f = 1.33

3) Break-even Cost: Expected market cost for each of the fuel cycle service in the near future is assumed as the break-even cost. Table - III gives the break-even costs.

Table-III. Break-even Costs for Fuel Cycle Services.

Fuel Cycle Services	Break-even Cost (US $ / KgU)
Conversion	3
Enrichment	100 [a]
Fabrication	120 [b]
Reprocessing	200 [c]

(a) Cost is per Kg.-SWU. Cost trend indicates 2-3% increase every six months. Expecting a severe escalation in cost of enrichment service, break-even cost is assumed to be US $ 100 / Kg.-SWU.

(b) Cost resonably stable

(c) Cost is not expected to be below $200 and cost estimates are uncertain

4) Unit Production Cost: UPC is given by,

$$UPC = \frac{A}{P \times l}$$

Where, P = total number of units produced per year

l = load factor

A = total annual cost

given by A= CRF + AR + OM

Where, $CRF = \frac{i}{1-(1+i)^{-n}}$, the standard annual capital recovery factor.

AR = annual replacement cost of plant equipment

OM = annual operation and maintenance cost

i = interest on capital

Interest on capital is assumed to be 10%. AR and OM values are taken as 0.5% and 4% respectively and are somewhat higher than the customary.

5) Plant life and load factor are taken to be 20 years and 70% respectively: UPC for . ch fuel cycle service is calculated for different plant size, plotted and the break-even plant size corresponding to the break-even cost is determined. Generation capacity that can be supported by the break-even plant and the year (approximately), in which the region is expected to generate that much of electricity from nuclear plants, are also determined. The results are given in Table-IV.

Table-IV. Indication of year in which a Fuel Cycle Service is Feasible in the Region.

Type of Plant	Break-even Plant Size (MTU/Yr)	Generation Capacity the Break-even Plant can Support(MWe)	Year in which the Region may have the required Generation Capacity
Conversion	3,400	4,000	1985
Enrichment	1,900[(a)]	25,000	Uncertain
Fabrication	65	2,000	1980
Reprocessing	830	27,000	Uncertain

(a) Plant size in MT-SWU/Yr

It turns out, therefore, that fabrication can be economically feasible as early as 1980 (even though the plant construction cost, in Table-II, is higher than the expected). Conversion is also feasible around 1985 as per demand projection. Reprocessing and enrichment plants may be considered only after 1990.

REGIONAL SELF-RELIANCE IN FUEL CYCLE SERVICES

Regional self-reliance in the technological as well as commercial aspects of fuel cycle services should not be overlooked in any regional planning. In economic terms, it is important to weigh the cost of individual fuel cycle services against the total fuel cycle cost. If "fuel cycle cost" for nuclear power generation is defined by "the costs which must be recovered in order to meet all expenses associated with consuming and owing the fuel in a nuclear power plant", then the various proportions[5] of these costs (present magnitude) is given in Table-V.

Table-V. Unit Cost of different Fuel Cycle Components as percentage of Total FCC.

Cost Component	Percentage of total FCC (%)
Ore	50
Enrichment	30[a]
Fabrication	17
Others	3

(a) Expected to be much higher in the future.

From regional self-reliance point of view, therefore, it is important to not that Ore, enrichment and fabrication make 97% of total FCC of which Ore alone constitutes 50% followed by enrichment (30%) and fabrication (17%). Exploration of natural Ore can therefore be stressed in any regional planning for nuclear fuel cycle. Fabrication, as already indicated, is feasible for the region as early as 1980; and it is not capital intensive also. The region, therefore, can be self sufficient in fabrication in the near future.

Enrichment, however, is a problem are and the following points are to be considered seriously:

(1) Enrichment, at present, make more than 30% of the total FCC. It is expected to rise to more than 40% in the coming decade.

(2) Enrichment is the most essential item for any light water nuclear critical system.

(3) Supply of enriched uranium is becoming extremely difficult even under commercial terms; and a world shortage of enriched uranium is expected in the near future. Right now, one must sign an enrichment contract (U.S.A.) roughly 10 years before the fuel is needed.

(4) The world, in the near future, appears to be divided into three blocks: (i) the oil block, (ii) the enriched uranium block and (iii) Others. The region considered, being in the 3rd category, its nuclear power programme may suffer heavily unless supply of enriched uranium can be ensured through strong international understanding or otherwise.

The above points are raised only to make it clear that the region must consider the scientific aspects of the fuel cycle seriously and simultaneously with the economics in view of the difficulties with enriched uranium as discussed above.

It is highly recommended, therefore, that the rigion should have a centre for the study of the fuel cycle in order to optimise it for the rigion.

BANGLADESH AS A POSSIBLE SITE

Bangladesh is more or less centrally located when South Asia and South East Asia is considered as a region. It is open to the Bay of Bengal and, therefore, shipping connection is possible with every country in the region (with the exception of Afganistan).

The country has a nuclear power programme of its own. Various sites have been investigated in the past for construction of nuclear power plants. These investigations were made on the basis of standard siting criteria for nuclear power plants and at least ten sites were found suitable for the purpose. From siting point of view, therefore, conversion, enrichment (electricity is expected to be supplied from a nuclear power plant) and fabrication (siting criteria much simpler) indicate no problem as long as they are economically feasible.

Reprocessing, however, needs more careful considerations because of the following reasons:

(1) Siting criteria for a reprocessing plant (particularly for large size) is more involved than that for a nuclear power plant.

(2) Waste disposal technique is not yet fully developed.

(3) High population density in Bangladesh e.g. nearly 1480/Sq.mile.

The study indicated that the possibility of waste disposal alone becomes the predominantly deciding factor (7-12). It was assumed that waste disposal has to be done in the same country where the reprocessing plant is constructed. Disadvantages of waste disposal in Bangladesh are the followings:

(1) geological data do not indicate any "Salt dome" in Bangladesh,

(2) population density is high

(3) average height of Bangladesh above the sea level is about 7 feet and the land is riverine. Abundance of water in Bangladesh, particularly in the rainy season, is severe constraint for nuclear waste disposal with the available technology.

To sum up, it can be said that, with the present technology, Bangladesh is unsuitable for large waste disposal. With the advancement of technology in the problem areas such as waste solidification, leachability, deep under-ground disposal etc., large waste disposal in this country may be possible.

An interesting possible site for large waste disposal, provided leachability problem is reasonably solved, is the sea-canyon in the Bay of Bengal South of Bangladesh with depth (from sea bed) varying roughly from 1,000-4,000 feet and is called the "Swatch of no ground". The area is estimated to be over thousand square miles. The canyon is gradually being filled up by large amount of silt coming from the flow of the Ganges and the Brahmaputra rivers. Any disposal in the canyon will be gradually covered up by natural siltation. Details of rate of siltation etc. are, however, beyond the scope of the study.

CONCLUSION

In view of the various aspects of the nuclear fuel cycle considered, this study indicates that the regional approach to the nuclear fuel cycle problems is the only solution for a healthy nuclear power development in the region. It can also be stressed that the regional fuel cycle centres should be undertaken under international control and, possibly, supervised by the I.A.E.A. This will help in 1) financing, 2) management and 3) protecting the nuclear material from misuse.

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