International
Nuclear
Fuel
Cycle
Evaluation

INFCE

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ECONOMIC EVALUATION OF REPROCESSING-PROGRESS REPORT

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INTERNATIONAL NUCLEAR FUEL CYCLE EVALUATION

WORKING GROUP 4: Reprocessing, Plutonium Handling, Recycle

SUB-GROUP 4A: Reprocessing

Economic Evaluation of Reprocessing
- A Progress Report

Technical Secretariat

1. At the fifth meeting of Sub-Group 4A the Technical Secretariat was actioned to arrange discussions between technical and economic experts to define more clearly the assumptions on which Figure 1 of Co-Chairman/WG4/55(A) was constructed. This present paper gives a progress report on work undertaken by the Technical Secretariat since the fifth meeting.

2. It did not prove possible to convene a meeting of experts in the intervening period since the fifth meeting, therefore the Technical Secretariat proposed that discussions should take place by telephone, telex or post, as appropriate.

3. The basic objective of the exercise was to "establish a more precise definition of uranium ore price, the fast reactor premium and its conversion to a price/kWhr; the position of the lines AC, BB' (on Figure 1 of Co-Chairman/WG4/55(A)) and their sensitivity to the size of a country's nuclear programme; the macro-economic assumptions that could be worked into the graph and how the CANDU reactor and its fuel cycle might be incorporated.

4. Six countries indicated their interest in participating in this specific exercise at the fifth meeting of the Sub-Group:

Canada
France
Federal Republic of Germany (FRG)
Japan
United Kingdom (UK)
United States of America (USA)

Subsequently the Commission of European Communities (CEC) indicated a wish to participate.

5. The Technical Secretariat proposed in a telex dated 13th December 1978 that:

(a) the Secretariat prepare a graph with the same axes as Figure 1 of Co-Chairman/WG4/55(A) with the lines AC, BB' located using a

"reference" set of parameters. This "reference" set of parameters was to be based upon economic ground rules consistent with those already tabled in either WG4, 5 or 8.

(b) the position of line BB' will be sensitive to the particular assumptions made in respect of thermal reactor recycle. The Secretariat proposed that this sensitivity be examined separately as part of the economic evaluation of recycle being undertaken by the Japanese Technical Secretariat for WG4B.

(c) each individual country be invited to prepare a line and/or an area indicating its perception of how the fast reactor premium/U_3O_8 ore price may vary with time. This information was to be prepared on the basis of the "reference" set of parameters. Where an individual country disagreed to a significant extent with the chosen parameters, an alternative case was to be prepared demonstrating the effect of the change in the value of that parameter.

6. In a telex dated 20th December 1978 the Technical Secretariat proposed that the exercise should be carried out on the following basis:

A. Present Worth Methodology

(a) reference date - reactor start-up in all cases
(b) discount rate - 5%
(c) load factor - 70% for all reactors
(d) reactor lifetime - 30 years for all reactors
(e) no allowance for inflation - 1978 dollars

B. LWR Fuel Logistics

Reference characteristics as in Co-Chairman/WG4/4(B) Rev.1, using a PWR/BWR ratio of 2:1 (S-3' for Pu recycle, S-3" for U recycle, S-3"' for once-through cycle). This is because Table I-10 of OECD Yellow Book is inaccurate and WG8/USA/Doc.12 relates to 0.2% tails rather than 0.25% tails (as used in the rest of WG4 work).

Further improvements in LWR technology in relation to uranium requirements are possible but the Technical Secretariat advised they should be omitted in the first instance. Individual nations, however, were invited to prepare an alternative version of the diagram, including such improvements if they considered it important to illustrate the effect.

C. U_3O_8 Price

The relevant figure is the ore price representing the mean over the reactor life weighted by discounting to reactor start-up. The first charge cost was to be included and the abscissa of the diagram to be labelled "uranium ore price $/lb U_3O_8".

D. Tails

The Secretariat advised that this should be assumed fixed throughout at 0.25% to be consistent with other WG4A work. The effect of optimization or other conceived improvements in tails could be

treated similarly to LWR improvements (shown as a subsequent adjustment if it was felt by any individual country that the effect was important to illustrate).

E. Plutonium Values

The classic problem arises of attaching a cost or value to plutonium. However, because interest centres entirely on "positions of indifference" the problem is simplified. At points of indifference bounding the area of "once-through preferred", (see Figure 1), it is clear that unseparated plutonium has an inherent value of zero and should be charged to either the recycle LWR or FBR at the net cost of its recovery, i.e. reprocessing plus all associated costs as a differential from the "once-through" mode, less credit for the recovered uranium. Similarly, credits for plutonium bred in the FBR and for the last charges in both plutonium-using reactors should be on the same basis. All these items should, of course, be discounted to the reference date, i.e. present worthed. The quoted cost for the various items, such as reprocessing, was assumed to refer en bloc to a date earlier than that at which the plutonium is loaded into the reactor; for the FBR by 0.5 yr and for the LWR by 1 yr. Likewise, the out-of-reactor inventories were assumed to be for the FBR 1 year reactor throughput and for the LWR 2 years reactor throughput.

As a prediction penetrates into the "FBR preferred" zone (Figure 1) more complex considerations will arise, requiring systems analyses for their resolution but for the limited purpose of the present exercise, actual values in this area are of no interest and the simpler procedure described above is considered adequate.

Where a prediction has passed from "once-through" into "LWR recycle" interest now centres on the indifference point between the latter and the FBR and a different situation arises. Here the plutonium has become an assist value at 0.8 times U235 (taken at an enrichment appropriate to LWR recycle, i.e. 3%). This value should be used in making charges or credits against both systems to determine the indifference position between them.

F. Fast Reactor Premium

Working Group 5D has a reference "2000 AD" design, but in any case it is expected that individual nations will have their own views on costs.

(a) Capital Costs (LMFBR/LWR Differential) including all initial charges such as utility's costs, site, interest during construction; except common items such as switchyard can be clearly ignored.

(b) Operating Costs including maintenance, insurance (but only if different between reactor cases).

(c) Fuelling Costs (excluding uranium), i.e. fabrication costs, reprocessing, transport, storage, disposal.

Since the comparison is being made against the "once-through" mode, the cost of reprocessing thermal reactor fuel to produce the plutonium for the initial charge of the fast reactor must be included (see "E" above). The "once-through" fuel cycle costs are to include spent fuel storage and disposal costs. All items to be "present worth" discounted to reactor start-up date.

G. Reference Costs

The Technical Secretariat proposed the following as generalized costs, whilst pointing out that they were:

(i) not to be regarded as appropriate to any individual country

(ii) preliminary and subject to alteration after discussion.

CAPITAL COST	
(including owner's cost and IDC)	LWR $900/kW(e) FBR parameter
OPERATIONAL AND MAINTENANCE	
All reactors	$10/kW(e)yr (FIXED) + $ 2/kW(e)yr (VARIABLE)

(Assumed equal for all reactor systems and therefore cancels out).

ENRICHMENT	$100/SWU
FUEL FABRICATION	
UO_2	$ 130/kg HM
MOX	$ 550/kg HM
FBR Pu/U core	$1300/kg HM
FBR Blanket	$ 200/kg HM
REPROCESSING	
LWR (UO_2)	$ 400/kg HM
(MOX)	$ 500/kg HM
FBR	$ 500/kg HM
WASTE MANAGEMENT	
LWR (once-through) (storage and disposal)	$ 230/kg HM (US DOE offer)
LWR (Pu recycle) (vitrification and glass storage/disposal)	$ 100/kg HM
FBR (vitrification and glass storage/disposal)	$ 100/kg HM

TRANSPORT

Spent fuel	$ 20/kg HM (Internal) $ 100/kg HM (Intercontinental)
Vitrified waste	$ 10/kg HM (Internal) $ 50/kg HM (Intercontinental)

7. The U.K. Secretariat have prepared the basic graph using the above set of "reference" parameters. This is given as Figure 1. In particular, the Secretariat wishes to emphasise the sensitivity of the position of line BB' to the particular assumptions made and to draw attention to the fact that the Japanese Technical Secretariat will be examining this point in some detail. Finally, the Secretariat would like to invite individual countries to proceed as indicated in paragraph 5(c) above.

FIG 1 DIAGRAMMATIC REPRESENTATION OF ECONOMIC FACTORS AFFECTING NUCLEAR FUEL CYCLE STRATEGY

(BASED ON "REFERENCE" SET OF PARAMETERS)