LETTERS TO THE EDITOR

COMMENTS ON "FEASIBILITY OF ONCE-THROUGH THORIUM FUEL CYCLE FOR CANDU REACTORS"

A recent paper[1] is a valuable contribution to the subject of once-through thorium fuel cycle for Canada uranium deuterium (CANDU) reactors insofar as the publication of the author's calculations are concerned, but unfortunately he draws some conclusions based on these results that could mislead.

In the first place, the entire justification for considering once-through thorium cycles in CANDU reactors is as a means of converting fissile ^{235}U into fissile ^{233}U to be utilized only if necessary, with no penalties and without recourse to reprocessing. Thus the author's suggestion of "permanent disposal of the discharged thorium fuel" is a significant deviation from this philosophy. Similarly, his calculations assume that "uranium fuel is reprocessed after discharge"; thus the entire rationale for this work rests on the thesis that reprocessing and refabrication of uranium fuel is commercially feasible while that of thorium fuel will never be. Although this may be so, it is possible that refabrication of uranium fuel will also require remote handling which, as the author states, is the main impediment to commercial refabrication of thorium fuel. In any case "forever" is a long time.

In the second place, the author claims a saving in uranium requirements of ~50%, relative to a natural uranium cycle. While this may be true, the more germane comparison would be to investigate the saving in uranium relative to a CANDU operating with enriched and/or reprocessed uranium. The latest figures published in this regard[2] show that without reprocessing, it is possible to obtain ~10 MWd/kg of natural uranium using 1.2% enriched uranium (0.2% tails). Thus the author's cycle only reaps a benefit of 30%; with reprocessing it is possible to achieve a burnup of 14 MWd/kg natural uranium using plutonium/natural uranium recycle or 15.4 MWd/kg uranium using plutonium/depleted uranium without recourse to thorium; the author's cycle has no economic benefits or even a slight disadvantage as far as uranium savings are concerned. Thus I conclude that this paper has reproduced a known result in a new regime (20% enrichment): the first-generation use of thorium is never overwhelmingly beneficial; it only permits fuel cycles that are competitive with alternatives, but which can be justified as a means of (a) reducing the volume of discharged fuel, as the author correctly notes, and (b) creating fissile ^{233}U for future use if needed with no penalties, provided the fuel remains accessible (semipermanent storage?).

Third, the author uses the word "innovation" to refer to various parts of the concept. It should be pointed out that a segregated fuel arrangement (innovations 1 and 2) was suggested by Radkowsky and Bayard[3] at least as early as 1958 and by Lewis[4] in 1957, and the use of different reload rates (innovation 3) was again first suggested[5] by Lewis. The addition of small amounts of enriched uranium to the thorium (innovation 4) is well known to those who work in this field, but to the best of my knowledge Galperin is the first to suggest it in writing. It would also be relevant to refer to the closely related work[6] of Lungu and Isbasescu.

Finally, in Sec. IV the author states that his model for CANDU reactors requires 30 days refueling downtime, without emphasizing that batch fueling is an artifice of his model, not of the reactor. This is corrected, without emphasis, in the next-to-last paragraph.

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REFERENCES

1. A. GALPERIN, "Feasibility of Once-Through Thorium Fuel Cycle for CANDU Reactors," *Nucl. Technol.*, **73**, 343 (1986).

2. J. VEEDER and R. DIDSBURY, "A Catalogue of Advanced Fuel Cycles in CANDU-PHW Reactors," AECL-8641, Atomic Energy of Canada Limited (1985).

3. A. RADKOWSKY and R. T. BAYARD, "Physics of Seed and Blanket Cores," *Proc. 2nd Int. Conf. Peaceful Uses of Atomic Energy*, Geneva, P/1067 (1958).

4. W. B. LEWIS, "High Burn-Up from Fixed Fuel," AECL-531, Atomic Energy of Canada Limited (1957).

5. W. B. LEWIS, "The Super-Converter or Valubreeder, A Near Breeder Uranium-Thorium Nuclear Fuel Cycle," AECL-3081, Atomic Energy of Canada Limited (1968).

6. S. LUNGU and M. ISBASESCU, "A Data Base for a PHW Reactor Operating on a Once-Through Low Enriched Uranium-Thorium Cycle," IAEA-R-2573-F, International Atomic Energy Agency (1984); see also IAEA-Tecdoc-344, International Atomic Energy Agency (1985).

COMMENTS ON "RADIATION PROTECTION PRACTICES AND EXPERIENCE IN FRENCH OPERATING REACTORS"

In reading the paper by Gauvenet,[1] a number of anomalies were noted. This results in conflicting information in the paper.

Table IV, titled "Total Collective Doses at the End of 1982," states the total doses were 12 986 person-rem; the total energy produced was 282 545/GWh. Thus the ratio was 0.046 person-rem/GWh or 0.46 mSv/GWh.

Figure 3 of the paper shows the collective dose per gigawatt hour at 0.035 person-mSv/GWh for 1982.

This calls into question the scale in Fig. 3. Is it possible it is out by a factor of 10? Should the scale be 0 to 1 mSv/GWh? Also, the 1982 data do not agree, even with this factor of 10 correction.

It should also be noted that Fig. 4 has an incorrect conversion factor. It should be 1 Sv = 100 rem.

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REFERENCE

1. A. GAUVENET, "Radiation Protection Practices and Experience in French Operating Reactors," *Nucl. Technol.*, **72**, 246 (1986).

REPLY TO "COMMENTS ON 'RADIATION PROTECTION PRACTICES AND EXPERIENCE IN FRENCH OPERATING REACTORS'"

There is no contradiction between Table IV and Fig. 3 concerning the workers' collective doses in French nuclear stations.

The collective doses are given year by year in Fig. 3 while the data mentioned in Table IV are relative to the *total life of the stations* since their connection to the network ("*total* collective doses *at the end of 1982*" has this meaning).

This is the reason why the average dose on the central stations' *total* life is 0.045 person-rem/GWh while in the year 1982 it was 0.035 person-rem/GWh.

Van Berlo[1] is right in signaling a mistake on the vertical scale of Fig. 3. The scale must be in *person-rems* (and not in person-milliSieverts). In Fig. 4, of course, 1 Sv = 100 rem (100 was wrongly copied as 1 m in designing this figure).

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REFERENCE

1. J. P. van BERLO, "Comments on 'Radiation Protection Practices and Experiences in French Operating Reactors,'" *Nucl. Technol.*, **76**, 194 (1987).