

A. DE VOLPI

## More on thorium cycles and nuclear proliferation

The article by Amory Lovins on "Thorium Cycles and Proliferation," in the February *Bulletin*, while including some technically valid observations, offers a number of opinions not supported by evidence, contains inaccuracies, and appears to be a forum on tangential issues.

By failing to accredit arrangements for existing safeguards and physical security of sensitive materials, Lovins implies that the technical utility of uranium-233 as a fission-explosive is limited only by its supply. This is incorrect; there are substantial technical barriers against application of any fissile material to explosive purposes.

He compounds this error by claiming that denatured thorium-uranium cycles "...are not an effective safeguard even against subnational bomb-making." Surely, such an assertion requires substantiation in view of the historical record in which three decades have passed without *any* subnational nuclear weapons.

Another weakness of the article is the lack of consideration of the *relative ease* of diversion; the isolated possibility of assembling a critical mass is not sufficient to make the material attractive to would-be bomb makers. Nor should technical exchanges about the pros and cons of thorium, uranium, and plutonium be misinterpreted to infer that fissile materials are not already self-protected and secure. It is unwarranted to assume that the mere existence of fissile materials means that they would be useful to terrorists.

Lovins omits many considerations,

such as the importance of timely warning, the inclination of the rest of the world to proceed with nuclear power (with or without U.S. cooperation in safeguards), the relative appeal of other ways to get nuclear weapons, and the incentives to proliferation that arise from energy shortages. Further assertions of his to be challenged are

- that governments can deceive international inspectors "in . . . dozens of ways,"
- protecting international centers would be "impossible,"
- the long-term role he assesses for advanced converters, and
- his deprecating references to technical fixes and plutonium recycle.

The article's conclusions are misdirected by errors in its analysis of uranium-233 as a fission-explosive. For example, he claims a "substitution factor" of 5 or 10, based on a comparison of bare spheres. It is most unlikely that any weapon purpose would be served by unreflected materials; instead, an appropriate criterion is the ratio of uranium-reflected cores, about 5.7 kilograms for uranium-233 and 16 kilograms for uranium-235—a substitution factor more like 3.

Lovins oversimplifies the process of centrifuge enrichment by not taking into consideration the concomitant growth of uranium-234 and other isotopes that negate the potential value of isotopically separated uranium-233. As a result of the preceding considerations, the relative utility of fission-explosives derived from denatured uranium-233 is prob-

ably an order of magnitude less than he assigns.

Lovins cites only the minimum net production of plutonium-239 in a reactor, failing to point out that denatured thorium reactors are likely to generate as much as one-third the plutonium of undenatured uranium reactors.

Many of these errors could have been averted if Lovins, who normally is meticulous in citations, had paid heed to information in his possession. He cites a letter by H. C. Ott in *Power Engineering* but ignores the accompanying correspondence [1] and the original article [2] in which these facts were pointed out. Most of this information has been brought to the attention of readers of *The Bulletin* [3] and *Physics Today* [4]. In addition, Lovins has since September 1978 been in possession of a draft of my book—*Proliferation, Plutonium, and Policy* [5]. The material he has presented selects only one side of the story, and thus conveys an inaccurate message regarding nuclear power and fission-free energy strategies.

An objectionable practice in the article is the inflation and puncturing of sacrificial semantic balloons. "Technical fixes," a "minimal and partial basis for acceptability of the commercial fuel cycles," a "rush into the plutonium economy," and so forth are treated as established wisdom; these phrases and terminology appear to be contrived in order to have a deflatable target.

In the article are gratuitous and inaccurate references to nuclear power. It begins with: "If nuclear fission is to

be used as an energy source, . . . ” Yet, the Chicago area already derives nearly half of its electrical energy from nuclear power. The article ends with: “. . . the proliferation problem—a problem that is the most compelling reason to reject all forms of nuclear power in favor of fission-free energy strategies,” accompanied by a reference to Lovins’ articles on soft energy paths. Between beginning and end there is no support for these extreme positions—only a garbled contribution about an out-of-context feature of alternative fuel cycles.

One of the more bizarre aspects of Lovins’ article is that we are treated to the spectacle of a number of protagonists squabbling among themselves. Feiveson and Taylor proposed the denatured thorium cycle [6]. With certain concessions, Feiveson, von Hippel and Williams—without Taylor—recently reasserted the validity of the cycle [7]. Now Lovins attacks the concept and Taylor disowns it. I submit [5] that the exaggerated claims for the proposal were manifestly unsound and their propagation in unrefereed, quasi-technical journals has constituted repetition and advocacy, rather than dispassionate analysis.

There is a lesson to be learned. None of the above-mentioned protagonists has reactor-physics experience. Two have nontechnical degrees; two are formerly high-energy physicists; one is a consultant physicist. None have published technical articles on reactor physics in an appropriate refereed (or unrefereed) journal or show evidence of experience at reactor-research laboratories. This syndrome is not confined to these well-intentioned individuals, as demonstrated by a similar makeup of spokespersons for the Union of Concerned Scientists. I do not mean to address *ad hominem* remarks, but I

believe it is valid to point out that those who choose to speak up in technical domains must either support their case by rigorous arguments or, with some leeway, at least show technical credentials for acceptable ellipsis.

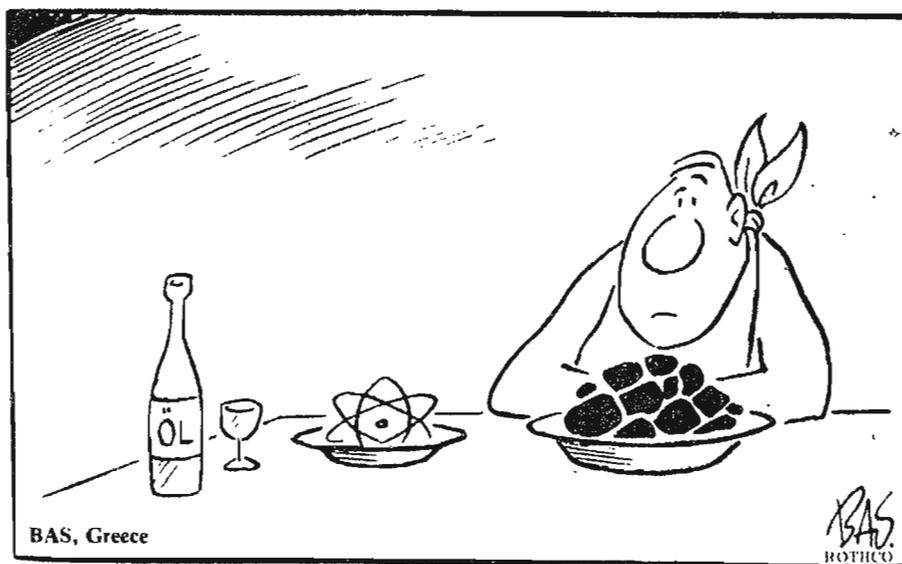
The *Bulletin* should be both acclaimed and chastised. It has maintained a unique and invaluable tradition of publishing maverick articles; more significantly, it has permitted a sustained dialogue to develop that tends to air the issues in an open and deliberative forum. There have been illuminating sequences of articles and letters, for example, regarding Sternglass on fallout; Goffman and Tamplin; the ABM dispute; Sternglass on reactor radiation; and most recently the exchange between Cohen, Morgan, and Rotblat.

On the other hand, the *Bulletin* has rejected several recent submissions, some of which would have tended to restore some balance in the discussion of nuclear energy, while accepting articles such as this one by Lovins, which should have been returned to the author for correction. Furthermore, one can’t help but notice that

at the time two of the three members of the *Bulletin’s* Editorial Advisory Board—von Hippel and Williams—were among the principals who have demonstrated a particular interest in the denatured thorium cycle. None of the Board had a reactor-related technical background; yet nuclear power is a major technical-political issue these days and has occupied many pages of the *Bulletin*.

Nuclear power is under attack by part of the intellectual community; people like me are reluctant to be involved because our expertise is also our meal ticket. Yet something must be done about slanted presentations. Could it be that the problem arises largely because there is no formalized national decision-making process? Those who raise justified concerns about potential misuse of technology and those who have the expertise to advise particular technological options do not have a forum that reconciles these factors in a rational manner [8]. □

1. A. De Volpi, “All Channels of Proliferation Must Be Considered,” *Power Engineering* (Nov. 1977), p. 32.
2. F. Olds, “Tail End of the Fuel Cycle: Coping with the Carter Edict,” *Power Engineering* (Aug. 1977), p. 38.



3. A. De Volpi, "Soft on Proliferation?" *Bulletin* (Sept. 1978), p. 62; erratum (Nov. 1978), p. 59.

4. A. De Volpi, "More on Proliferation," *Physics Today*, 31 (Dec. 1978), p. 84; erratum (July, 1979), p. 83.

5. A. De Volpi, "Proliferation, Plutonium, and Policy: Institutional and Technological Impediments to Proliferation" (New York: Pergamon Press, 1979).

6. H. A. Feiveson and T. B. Taylor, "Security Implications of Alternative Fission Futures," *Bulletin* (Dec. 1976), pp. 10-14.

7. H. A. Feiveson, F. von Hippel and R. H. Williams, "Fission Power: An Evolutionary Strategy," *Science*, 203 (Jan. 1979), p. 330.

8. K. R. Hammond and L. Adelman, "Science Values, and Human Judgement," *Science*, 194 (1976), p. 389.

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**Lovins' response:** My article was meant to analyze "several prevalent misconceptions" about thorium cycles. These were narrow and specific. De Volpi criticizes the article for not being a book about the general problem of nuclear proliferation. His broader (and, in my view, uniformly erroneous) points are dealt with in the seven general references cited in note 2 of my article, but are clearly beyond its scope. As for his few relevant contentions:

- Substitution factor: De Volpi has misunderstood this point. My text made it clear that for geometrical reasons, the factor is *not* simply the ratio of either bare-sphere or reflected critical masses (though these ratios are not very different).

- Centrifugal enrichment of parasitic isotopes: I did consider this point but found it unimportant. Uranium-234 is about two-fifths as abundant as uranium-233 in typical high temperature gas-cooled reactor discharge fuel, but is unlikely to "negate" the explosive properties of the uranium-233, since its fast fission cross-section is nearly as large. Less

fast-fissionable parasitic isotopes are less abundant, less well enriched, and less important (as well as being partly compensated by enrichment in residual uranium-235). Increased gamma dose from uranium-232 enrichment (which I mentioned on p. 19) does not affect explosive properties. De Volpi's "probably an order of magnitude" is wrong by an order of magnitude.

- Minimum net plutonium-239 production: contrary to De Volpi's assertion, the factor of three is stated in note 12.

- Further references by De Volpi and Olds: I am familiar with these but did not cite them because they were irrelevant or wrong or both—as De Volpi should know from specific comments and a long background paper which I sent him last year.

- "Protagonists squabbling": this is incorrect, as should be clear from the discussion in the *May Bulletin*. Taylor did not "disown" the concept, but criticized (as did von Hippel, Williams, and I) the misconception that denatured thorium cycles offer a technical fix for proliferation. Taylor's absence from the *Science* byline is an improper basis for any inference.

- If De Volpi does "not mean to address *ad hominem* remarks" he has an odd way of showing it. Attacking the credentials and competence of authors, or the editorial integrity of a journal, is no substitute for demonstrating technical errors in published arguments. This he has notably failed to do.

More broadly, as Dean Abrahamson has said, one does not have to be a chicken to judge the quality of an egg. De Volpi's implication that people with "a reactor-related technical background" are uniquely qualified to contribute to, or to judge, arguments about nuclear power ap-

pears to be contrary both to the scientific principle of open debate on the merits and to the democratic principle of informed decision by the people.\*□

\*A. B. Lovins, "Cost-Risk-Benefit Assessments in Energy Policy," *George Washington Law Review* 45 (Aug. 1977), pp. 911-943.

*Williams' and von Hippel's response:*

We are surprised to find De Volpi insisting that no one should do analyses relating to the viability and proliferation resistance of alternative nuclear fuel cycles other than those with reactor physics experience. Would he also insist that no one publish articles on the strategic arms race who hasn't either designed nuclear weapons or ballistic missiles? Obviously, any restriction on the contributions of outsiders to such debates other than on the basis of the quality of their work would be dangerous since it is usually outsiders who are willing to challenge the shared prejudices of the insiders.

If De Volpi has any specific technical criticisms of our article in *Science*, we would suggest that he write us a letter or submit a letter to the editor of that journal. We will be happy to make specific responses to specific criticisms—but please no more *ad hominem* attacks!

*Editor's note:* Our problem with much of De Volpi's criticism stems from our refusal to accept his thesis that only those working in the nuclear reactor field are technically competent to judge the technical-political issues of nuclear power—any more than we are prepared to pre-judge as biased the views of those, such as he, whose "expertise is also [their] meal ticket."