Letters

SDI Report

Science has long been the nation's most penetrating publication on national security issues that involve technology. Hence it is disturbing that William Booth insinuates (News & Comment, 10 July, p. 127) that both the report on the Strategic Defense Initiative (SDI) issued by the American Physical Society (APS) and the criticisms thereof by Lowell Wood and Gregory Canavan are characterized by a "steady drift from the technical to the ideological realm."

The APS panel is not merely "composed of experts," but counts among its members people who are actively engaged in SDI, including the directors of the Air Force Weapons Laboratory and the Massachusetts Institute of Technology's Lincoln Laboratory, as well as two senior scientists from the Sandia National Laboratory. The 423-page report is endorsed by its authors without one dissent on any topic. The study was reviewed by a group that included a former director and serving associate director of Lawrence Livermore National Laboratory and a Nobel laureate who chaired a panel on MX missile basing for President Reagan. The notion that these people produced an ideologically biased brief against SDI is preposterous.

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Plutonium Recycling

The Perspective "Why recycle plutonium?" by David Albright and Harold Feiveson (27 Mar., p. 1555) deserves response. The motive for recycling plutonium is certainly a clear one: resource efficiency. Recycling in light water reactors reduces demands on uranium—a depletable resource when one considers only higher quality, cheaper ore—and in fast breeder reactors it would effectively multiply the fuel resource by many orders of magnitude. Thus, an unstated result of not recycling plutonium would be to foreclose nuclear power as a long-range energy option.

Albright and Feiveson point out, correctly, that shipment of plutonium demands a high level of security. However, so does shipment of diamonds. The question really is: "Is appropriate security affordable?". To the users of reprocessing services, the answer seems to be affirmative.

The authors omit from their discussion any mention of the poor quality (as a weapons material) of recycled plutonium, which contains enough of the higher isotopes of plutonium to compromise easy use in a weapon. A bomb can be made of "reactor grade" plutonium, but it requires more expertise than for "weapon-grade" (*1*). This is why no weapons power has seriously considered diverting such plutonium to its weapons stockpile. The United States did consider the option of using isotope separation to purify the ^{239}Pu, which indicates what our military thinks about using reactor-grade plutonium in our nuclear arsenal. We have abandoned this idea in favor of dedicated weapons material production reactors, however. Thus, the principal concern for the safeguarding of this material is to avoid its hijacking by terrorists, and this, contrary to fictional scenarios, is not an expensive security exercise.

The authors make light of the extra difficulties entailed in direct disposal of spent fuel as compared with disposal of reprocessed waste. These difficulties are due to the more awkward and fragile nature of the spent fuel package and the higher heat generation of spent fuel, due largely to its plutonium content. As a result, spent fuel must be buried in a much larger repository. The higher costs cited for spent fuel disposal testify to the greater difficulty of the operation. Even so, its risk factor is doubtless very much greater, for the following reason: while fission product waste, with only a small actinide content, decays to hazard levels comparable with those of natural uranium deposits in less than a few millennia, the time scale for plutonium decay is at least 100 times greater (*2*). Moreover, spent fuel, if it encounters oxidizing agents, is much more readily destroyed and leached than is glassified fission product waste (*3*). One wonders what public response will be when these facts become known.

As a final item of rebuttal, I must remark on the costs that Albright and Feiveson quote for reprocessing and fabrication. These costs are those that pertain now. However, when one examines the actual results that these operations achieve, the high prices are unreasonable as compared with similar processes that do not deal with radioactivity, and even unreasonable if one tries to assess the extra costs of dealing with that radioactivity. Thus, they are subject to drastic reduction in the future. Alternative fuel fabrication techniques such as spherepac or spherecal (*4*) seem intrinsically more capable of automation than present methods of making mixed-oxide fuel are, with resulting drastic decrease in fabrication cost; and we are currently examining at Iowa State a flow sheet, tailored to reprocessing of 10-year cooled fuel, which should greatly reduce the costs of reprocessing in the PUREX system (*5*).

My argument on this point is that it is fallacious to make long-term decisions on the basis of current costs unless these costs are intrinsic. It would be a little like abandoning the development of jet aircraft on the basis of 1939 costs.

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1. E. L. Zebroski and B. I. Spinrad, in *Nuclear Energy—A Sensible Alternative*, K. O. Ott and B. I. Spinrad, Eds. (Plenum, New York, 1985), pp. 207–221; B. I. Spinrad and E. L. Zebroski, *ibid.*, pp. 265–269.
2. M. Benedict, T. H. Pigford, H. W. Levi, *Nuclear Chemical Engineering* (McGraw-Hill, New York, ed. 2, 1981), pp. 565–626 (particularly figure 11.31, p. 623).
3. If oxygenated water contacts UO_2, it will be in the long run oxidize it to U_3O_8. This would increase the volume of the material and would lead to powdering and splitting the cladding, permitting easy leaching of the contents. No similar reaction occurs in glassified waste.
4. Spherepac involves sol-gel formation of fuel-particle spheres which, when dried and internally sintered, can be poured into a cladding tube without further handling. Spherecal uses the same spheres, dried and calcined, as the powder for pellet fabrication. Both methods significantly reduce the amount of dry powder handling during fabrication.
5. O. Zabunoglu, in preparation.

Albright and Feiveson may be correct as to the economics of recycling plutonium in today's nuclear power reactors, but that is not the whole story. In 1977 President Carter initiated an international study of the economic and, more important, the nuclear proliferation implications of reprocessing today's nuclear reactor spent (that is, burned-up) fuels to recover plutonium, and of possible alternative nuclear fuel cycles. The nations that are now starting to reprocess their nuclear spent fuels participated in this study quite responsibly.

The costs for nuclear fuel are small relative to the capital costs to build nuclear power plants and to operate them. Albright and Feiveson's estimates were reasonable before the U.S. dollar began to fall relative to the mark and the yen. A dollar or mark or yen spent for uranium or enrichment overseas has a different value than if spent at home.

It does not make sense to bury this spent fuel or the depleted uranium that accumulates at enrichment plants. About 0.5% of the fission energy is extracted today. With breeders it could be 50% or more. Because it takes much longer for plutonium to decay to harmless daughters than is the case for fission products, designing permanently safe repositories for spent fuel is more difficult than for the radioactive fission products from reprocessing.

None of these technical-economic reasons seem very important. Our European friends and the Japanese are as concerned about nuclear proliferation as we are. It is not conceivable that they will provide plutonium-bearing fuels to countries which might extract the plutonium to make nuclear explosives. By reprocessing to recover the plutonium and burning it in their reactors they may about break even economically as they figure it. They will have converted some of their spent fuel with about 1% undesirable-for-weapons plutonium to plutonium much less desirable for weapons should it ever be reprocessed again.

If one takes a longer view, oil will really run out in 40 to 50 years, Japan and Europe do not have much coal, and fast breeders will probably become very important, as well as conservation and solar power. To demonstrate one breeder may not require a big investment of effort. To replace half of the electric generating capacity in the world by breeders in 2030 is another matter.

The United States has a lot of coal, some gas and oil, uranium, and sunshine. Our dependence on imported oil is increasing today. With a reasonable program to exploit our coal, gas, and oil reserves, and to develop solar power and nuclear power, we could become net exporters of energy rather than importers who will drive up the prices for the have-nots.

But primarily I object to our telling our friends in Europe and Asia, and elsewhere, that they should do this or that to avoid nuclear proliferation. We started it and have not done very well at containing it.

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I fully agree with Albright and Feiveson that reprocessing should not be performed to recover pure plutonium, since that can be readily used in a weapon. However, reprocessing should be performed to extract the stable fission products while the remaining very long-lived transuranics (Pu, Am, Cm, and so forth) and the long-lived fission products (^{137}Cs, ^{90}Sr, and so forth) should be recycled unseparated into fuel elements for burning and producing energy in power reactors (*1*). This avoids long-term geological-age storage of high-level waste that no one wants in their backyards, and the fissile material becomes available for power generation.

Present reprocessing plants are based on chemical processes that were primarily developed to produce pure plutonium required for making weapons. Civilian nuclear power reactor fuel needs only small concentrations (~3%) of fissile plutonium or uranium. The so-called "plutonium economy" is based on recovering and handling pure plutonium. By keeping the plutonium and uranium in dilute and unseparated form for recycling into fuel elements, the fuel material will not be prone to diversion because of its inherent radioactivity. This material will be safeguarded by virtue of its use in power reactors. Placing spent fuel elements in idle long-term storage only proliferates the stockpile of plutonium. The real fission product waste is the stable elements formed by fission and decay of short-lived isotopes. The stable fission products can be disposed of just as any other ordinary waste matter. Reprocessing for extraction and disposal of stable waste and recycling transuranics and long-lived fission products for power production should gain acceptability by the public and countries that foresee an expanding need for nuclear energy in their future.

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Response: Higinbotham and Steinberg agree with us that reprocessing and the fabrication of mixed-oxide fuels pose proliferation and diversion risks. However, Steinberg is more optimistic than we are that reconstituted fuel rods containing radioactive fission products could be used economically in commercial reactors. Higinbotham is more optimistic than we are in insisting that "It is not conceivable that [the Japanese and Europeans] will provide plutonium-bearing fuels to countries which might extract the plutonium to make nuclear explosives." It seems to us more likely that, once a substantial commercial market in separated plutonium and mixed-oxide fuels is established in Europe and Japan, it will be exceedingly difficult to prevent other countries from obtaining these materials and the facilities to produce them. Higinbotham also objects to "our" telling friends in Europe and Japan what to do. Certainly, the U.S. government should not be self-righteous in criticizing the nuclear policies of other countries. But does this mean that American analysts must forever be quiet about these policies?

None of the letters quarrel with our assessment of the near-term economics of recycling plutonium. But Spinrad argues that the costs of recycling are subject to drastic reduction in the future. Perhaps this is so (though we have not seen the evidence), but how can this possibility justify a substantial *commercial* expansion of reprocessing and recycling in the immediate future—the focal point of our Perspective? We may not have wanted to abandon the development of jet aircraft on the basis of 1939 costs, but we surely would not have wanted to encourage the construction of a commercial jet fleet at that time!

Spinrad takes comfort that, while shipment of plutonium demands a high level of security, so does shipment of diamonds. But, in fact, security of diamond shipments is far from perfect. This imperfection may be tolerable for diamonds. It would not be so for plutonium.

Spinrad also downplays the risk that reactor-grade plutonium would be used for weapons. However, since reactor-grade plutonium could—as Spinrad agrees—be used to make a bomb, it must be protected from theft and diversion as carefully as weapon-grade plutonium. Furthermore, while reactor-grade plutonium is not ideal weapons material, a country that wished to demonstrate a weapons capability rapidly might decide to use available reactor-grade plutonium initially and then later use its commercial reprocessing and plutonium fuel fabrication facilities to separate and fabricate weapon-grade plutonium.

With respect to final disposal of spent fuel and high-level waste, there remain some unresolved issues. But spent fuel and high-level waste have initially similar heat outputs per ton of original uranium and essentially identical fission product contents. The OECD study that we referred to in our Perspective concluded that "[I]n terms of repository design, the problems posed by spent fuel and highly active waste are broadly similar"; and the study attributed very little difference in cost to final disposal of the two different waste forms (*1*).

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1. Nuclear Energy Agency, *The Economics of the Nuclear Fuel Cycle* (Organization for Economic Cooperation and Development, Paris, 1985), pp. 13, 101.

Erratum: In Deborah Barnes' Research News article "Debate over potential AIDS drug" (10 July, p. 128), Douglas Brenneman was incorrectly identified as a scientist at the National Institute of Neurological and Communicative Disorders and Stroke. Brenneman works at the National Institute of Child Health and Human Development.