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## ARTICLES

# Nuclear Power and Proliferation

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The day when the United States must join other countries in turning to nuclear power cannot be long delayed. The main reason, as stated by the American Physical Society's study, *Nuclear Power and Proliferation Resistance: Securing Benefits, Limiting Risk*, is that "Global electricity demand is expected to increase by more than 50 percent by 2025. Nuclear power is a primary carbon-free energy source for meeting this extensive global energy expansion." Realistically, the only alternative to nuclear power for such an expansion is coal, and even "clean" coal emissions have a large impact on human health and the environment. In the developing world, as recent history shows, environmental and health concerns come last.

In dealing with the risks of the increased use of nuclear power, the APS study appropriately singles out proliferation. The study maintains that:

"The technologies used in peaceful nuclear power programs overlap with those used in the production of fissionable material for nuclear weapons. . . . Nuclear reactors themselves are not the primary proliferation risk; the principal concern is that countries with the intent to proliferate can covertly use the associated enrichment or reprocessing plants to produce the essential material for a nuclear explosive. Further, poorly secured nuclear materials present a risk of proliferation through theft and transfer to a country or terrorist groups."

We are in full agreement.

The study suggests a number of steps that should be taken, including:

1. Significantly strengthen the federal Technical Safeguards R&D program: increase resources, identify near-term technology goals, formulate a technology roadmap, and improve interagency coordination.

2. Increase the priority of proliferation resistance in design and development of all future nuclear energy systems.

3. Develop & strengthen international collaborations on key proliferation-resistant technologies.

4. Align federal programs to reflect the fact that there is no urgent need to initiate reprocessing or to develop additional spent fuel repositories in the US.

We agree with the first three recommendations, and discuss the fourth below. In general, we feel that the report does not examine the nature of the proliferation problem carefully enough, and the recommendations are too timid to deal with the potential for proliferation.

Today's proliferation fears go back to two portions of the *Non-Proliferation Treaty*, Paragraph 3 of Article III, and Paragraph 1 of Article IV. The first states:

"The safeguards required by this article shall be implemented in a manner designed to comply with Article IV of this Treaty, and to avoid hampering the economic or technological development of the Parties or international cooperation in the field of peaceful nuclear activities, including the international exchange of nuclear material and equipment for the processing, use or production of nuclear material for peaceful purposes in accordance with the provisions of this article and the principle of safeguarding set forth in the Preamble of the Treaty."

The second emphasizes that

"Nothing in this Treaty shall be interpreted as affecting the inalienable right of all the Parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes without discrimination and in conformity with articles I and II of this Treaty."

In other words, signatories to the Treaty have the right to develop a full-scale fuel cycle, including the production of nuclear materials and the reprocessing of spent fuel. This is the origin of the proliferation risk singled out by the APS study, and constitutes technological license that is simply no longer tolerable.

The APS study implicitly recognizes the unacceptability of the current nonproliferation regime when it notes that:

"President Bush made a two part proposal to restrict the spread of enrichment and reprocessing technologies: 1) the world's leading nuclear exporters should ensure that states have reliable access at reasonable cost to fuel for civilian reactors, so long as those states renounce enrichment and reprocessing; and 2) The 40 nations of the Nuclear Suppliers Group should refuse to sell enrichment and reprocessing equipment and technologies to any state that does not already possess full-scale, functioning enrichment and reprocessing plants."

The study says, of the Bush proposal,

"Such fuel assurances and pledges to restrict sales are important components of a strategy to reduce the proliferation risks of nuclear power. However, no single diplomatic, military, economic, or technical initiative alone will be able to fully deal with the proliferation challenge."

While we don't disagree with that, we think it diminishes the proposal's importance.

The existence of the "nuclear club" has always implied a two-tiered world composed of the nations that have nuclear weapons, and those that do not. Correcting the proliferation problem means formally freezing this difference in place, while requiring the nuclear club to live up to new international obligations.

While the Bush proposal is fine, as far as it goes, we believe it must be formalized by amending the Nonproliferation Treaty to eliminate the right of each nation to develop its own full-scale fuel cycle. Of course, this could be revisited in the future—and the developing world would surely insist on provision for that sort of review.

In return, the nuclear club needs to formally guarantee fuel services and disposal of the true waste at reasonable prices through an international entity such as the International Energy Agency or the International Atomic Energy Agency. The negotiations will not be easy, even though Article VIII of the Treaty allows any party to the treaty to propose amendments.

Some nations, and many individuals, will raise the mantra of Article VI of the Treaty, which declares:

"Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on the effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control."

Even those who deeply believe in the goals of that article on moral grounds must realize that its invocation in the past has been primarily for political reasons. When the treaty was negotiated, the "arms race" was between the Soviet Union and the United States. This has certainly ended. "Complete [nuclear] disarmament," given human nature, is not likely in the foreseeable future—and may not even be desirable, since the end point may be unstable. Realistically, what is important is to minimize the probability of war, and, contrary to popular perception, nuclear weapons may actually enhance stability by making people very, very careful. At least, that is what we must hope.

It is the potential connection between reprocessing and proliferation, along with the deficiencies of the Nonproliferation Treaty, that undoubtedly led the APS study to conclude that the United States should not soon reverse its stance against reprocessing:

"Any decision to reprocess spent fuel in the United States must balance the potential benefits against the proliferation risks. Fortunately, there is no near-term urgency to make a decision on implementing reprocessing in the United States. No foreseeable expansion of nuclear power in the US will make a qualitative change to the need for spent fuel storage over the next few decades. Even though Yucca Mountain may be delayed considerably, interim storage of spent fuel in dry casks, either at current reactor sites, or at a few regional facilities, or at a single national facility, is safe and affordable for a period of at least 50 years.

Further, any spent fuel that would be emplaced at Yucca Mountain would remain available for reprocessing for many decades. Nuclear Regulatory Commission regulations require that the Yucca Mountain repository, if licensed, remain open and the waste be retrievable for 50 years after emplacement of the waste. In the meantime, the repository would provide excellent protection of spent fuel from terrorist threats, and would be capable of serving as a final disposal solution if that is eventually judged to be appropriate.

The decision on a second repository—or on whether to reprocess—can therefore be comfortably deferred, and should be deferred, for at least a decade. . . .

In the longer term, the balance among the benefits, costs, and risks of reprocessing may change significantly. By reprocessing spent fuel and burning the recovered uranium and plutonium in a nuclear "breeder" reactor, it is possible to get as much as 50 times more energy out of the original uranium. Therefore, if nuclear energy expands substantially in the future and puts pressures on the availability of low-cost uranium fuel, then reprocessing and breeder reactors could become the preferred option if the associated proliferation risks can be addressed."

While most of the above is technically correct, we suggest that those proliferation risks not only can be addressed, but must.

The study misses two points: First, the rest of the world is going its own way whether the United States reprocesses spent fuel or not, so the U.S. decision to reprocess should be based primarily on U.S. interests, not fear that such a decision would promote international proliferation. The past has shown that there is little if any connection between U.S. reprocessing policy and the proliferation of nuclear weapons.

Second, and more important, the APS conclusion that reprocessing can be delayed ignores the political dimension. Recent polls have shown that the primary public concern about nuclear power is the disposal of the used fuel, seen as "waste." Public fears revolve around the perception that the used fuel must be isolated for more than 10,000 years, and that perception is embodied in regulatory and judicial requirements based on the fact that some of the plutonium and other transuranics produced in reactors have radioactive half-lives in the thousands of years.

If, however, the uranium and transuranics were removed from the waste, only the true waste—the fission products—would be left. After about 10 years, the fission-product activity is dominated by just two isotopes, cesium-137 and strontium-90. They are soluble in water, so they must be securely contained. However, since both have half-lives of about 30 years, their activity is down by a factor of 1,000 after 300 years, and by then they are no longer a significant hazard.

The transuranics can indeed be removed and consumed. A combination of pyrometallurgical recycling and fast reactors can do it, operating at the back end of the current thermal-reactor cycle. The long-term proliferation benefit is obvious—plutonium is removed from circulation and consumed.

Making an early decision in favor of reprocessing would eliminate the waste-security concern, since the radioactivity of the fast-reactor waste falls below that of the original ore in less than 500 years.

But not just any type of reprocessing. Only in a fast neutron spectrum can all the plutonium and other long-lived transuranic isotopes be consumed. A point perhaps understressed in the APS statement is that "breeders" (translation: fast-neutron reactors) must be part of the recycling system.

Reprocessing fuel from current (thermal) reactors to cycle the plutonium back into those same reactors cannot come even close to doing the job. Even with such recycling, less than 1 percent of the energy latent in the mined uranium can be used, versus 99+ percent with fast reactors (the factor 50 in the APS statement is a gross underestimate).

An important proliferation consideration not mentioned in the APS report is that the pyrometallurgical reprocessing that is made possible by metal-fueled fast reactors never produces plutonium with the chemical purity needed for weapons. This is sharply different from the PUREX process now used (but not in the United States) for recycling plutonium in oxide form back into thermal reactors. When the U.S. ban on reprocessing was instituted, "reprocessing" was synonymous with PUREX. That is no longer true.

Arguably, enriched uranium is a more pressing proliferation concern than plutonium. Therefore it is worth noting that, since fast reactors breed their own fissile material, they can eliminate the civilian need for uranium enrichment facilities.

Bearing directly on the second and third of the APS recommendations (pertaining to international controls), but ignored in the report, is the "hub-spoke" concept. The idea is that "nuclear batteries"—self-contained nuclear reactors, perhaps in the 100–300 MWe range—would be manufactured at a central location and rented to nations needing more energy. The units would be sealed and fail-safe, to be run by operators with little by way of nuclear expertise. At the end of their 20-odd year life, the exhausted reactors would be traded for rejuvenated ones. Such concepts have been discussed by Seinicki et al [1], Wade [2], and Feiveson [3].

In summary, there is much of value in the APS report, especially background information about proliferation and current activities. And, in a significant contribution to a rational global energy policy, it clearly recognizes that the international spread of nuclear power is inexorable. It fails, however, to describe how nuclear power can be managed to address proliferation concerns, and therefore offers little help in formulating for diplomatic initiatives.

[1] James Sienicki et al, "STAR Performer." *Nuclear Engineering International,* pages 25–28 (July 2005). "STAR is an advanced portable reactor that could provide electricity, hydrogen, and potable water."

[2] D.C. Wade**,** "The STAR Concept: a Hierarchical Hub-Spoke Nuclear Architecture Based on Long-Refueling-Interval Battery Reactors and Regional Fuel Cycle Centers." Annex 11 of *Innovative Small and Medium Sized Reactors: Design Features, Safety Approaches and R&d Trends. Final Report of a Technical Meeting Held in Vienna, 7–11 June 2004.* IAEA-TECDOC-1451, pages 171–191 (May 2005)

[3] H. A. Feiveson, "Comments on the Development Path Needed for Proliferation-Resistant Nuclear Power." Published in *New Energy Technologies: A Policy Framework for Micro-nuclear Technology*, Rice University, August 2001.

**http://www.rice.edu/energy/publications/docs/NewEnergyTechMicroNuclear_MainStudy.pdf**

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