THE GLOBAL NUCLEAR ENERGY PARTNERSHIP: WILL IT ADVANCE NONPROLIFERATION OR UNDERMINE IT?

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ABSTRACT

In February 2006, the Department of Energy announced the creation of a major new program known as the "Global Nuclear Energy Partnership" (GNEP). Although details are sketchy at this time, the program as currently described would involve the institution of international arrangements by which certain "supplier" nations, including the United States, would lease nuclear fuel to other nations, in exchange for commitments that the recipient nations would not seek nuclear fuel production facilities of their own. The supply agreements would also provide for the return of the spent fuel to one or more of the supplier nations. An integral part of the GNEP proposal would be the development and deployment of modified reprocessing technologies that would be used to extract plutonium and other actinides from spent fuel, as well as fast neutron reactors capable of efficiently using fuel incorporating the recovered actinides. Among the various motivations cited for the program, its alleged benefits for nonproliferation have been stressed. According to DOE, "The Partnership would demonstrate the critical technologies needed to change the way nuclear fuel is managed ... while simultaneously promoting non-proliferation." However, DOE has not been able to convincingly explain how this proposal would actually advance nonproliferation. On the other hand, critics maintain that a reversal of the de facto moratorium on reprocessing in the United States would only undermine efforts to keep existing stockpiles of weapon-usable materials out of the hands of states of concern and terrorists. This paper will analyze whether the GNEP proposal is likely to strengthen or weaken efforts to fight proliferation and the nuclear terrorism threat, with particular attention to the claim that the system will be "proliferation-resistant."

INTRODUCTION

The Global Nuclear Energy Partnership (GNEP), announced with fanfare by the Department of Energy in February 2006 and later publicly mentioned several times by President Bush, is billed as a "comprehensive strategy to increase U.S. and global energy security, encourage clean development around the world, reduce the risk of nuclear proliferation, and improve the environment."[1] In fact, this proposal will only increase nuclear proliferation and terrorism threats.

Fundamental to GNEP is a complete abandonment of the nonproliferation policy developed and implemented by the Ford and Carter Administrations: a policy based on a recognition of the dangers posed by the reprocessing of spent fuel and the commercial use of plutonium. In fact, this policy, although enshrined in laws such as the 1978 Nuclear Nonproliferation Act, has steadily eroded since the Reagan Administration, which lifted the ban on reprocessing in the United States and pledged to remove "regulatory impediments" but refused to provide funding, expecting the private sector to "take the lead in developing commercial reprocessing services." This effort to revive reprocessing failed because the economics were too unfavorable. But today, the Bush Administration appears prepared to also renounce the Reagan policy by having the federal government take the lead in funding the development, deployment and operation of commercial spent fuel reprocessing plants.

In justifying this reversal of both the Ford/Carter and Reagan policies on reprocessing, DOE officials stress their belief that the policy was a failure. At the GNEP rollout, Deputy Energy Secretary Clay Sell said that

> "We stopped reprocessing because the technology of that day separated plutonium, and that presents a significant proliferation concern, but the rest of the world – France, Japan, Russia, the United Kingdom – went on and continued to develop these reprocessing technologies, and we now have over 200 metric tons of separated civil plutonium around the globe today."[2]

However, history provides a different perspective. First of all, in 1981 the Reagan Administration reversed the Carter reprocessing policy not only domestically but also internationally, pledging not to "inhibit or set back civil reprocessing and breeder reactor development abroad in nations with advanced nuclear power programs where it does not constitute a proliferation risk." So the fact that France, the U.K. and Japan continued to pursue reprocessing has no bearing on the effectiveness of the Carter policy. On the other hand, programs were terminated in at least six other countries that in the late 1970s either operated or had firm plans to build civil reprocessing plants: Argentina, Belgium, Brazil, Italy, Sweden and West Germany. In addition, in the 1970s there was active interest in acquiring reprocessing technology by Pakistan, South Korea and Taiwan – countries who claimed to seek it for civil purposes but actually intended it for use in covert military programs. But as a result of the more muscular foreign policy on reprocessing derived from the evolving U.S. position in the Ford and Carter Administrations, the U.S. acted to block attempts by France to export reprocessing plants to these three countries.

Thus although a few states (primarily those already engaging in military reprocessing) pushed forward to develop a domestic civil reprocessing capability even after the Carter policy was declared – an effort facilitated by the Reagan policy – many other states eventually abandoned their plans, and as a result reprocessing activities and separated plutonium inventories worldwide fell far short of earlier projections. In 1980, participants in INFCE (the International Nuclear Fuel Cycle Evaluation) predicted that by 2000, the amount of spent fuel discharged by the world's nuclear reactors would total over 226,000 metric tons, of which nearly 100,000 metric tons (nearly 44%) would be reprocessed, separating a total of 885 metric tons of plutonium.[3] While INFCE's prediction of total spent fuel arisings was very close to the actual figure in 2000 (around 224,000 metric tons, according to IAEA), its prediction of the fraction that would be reprocessed, and the size of the separated plutonium inventory in 2000, were way off. Less than 25% of the plutonium in spent fuel generated worldwide by 2000 (about 300 metric tons) had been separated, and the total amount of separated plutonium in 2000 was only about 200 metric tons. (About one-third, or 100 metric tons, was made into MOX fuel for light-water reactors).

One indisputable benefit of the Carter policy and the subsequent abandonment of reprocessing in the U.S. is that the U.S. nuclear industry does not have to bear the cost and inconvenience of providing security for a large stockpile of civil plutonium, unlike its counterparts in countries that pursued reprocessing.

The U.S. spent fuel inventory today contains approximately 500 metric tons of plutonium. The costs and risks associated with the extraction from spent fuel of such a massive amount of weapon-usable material, and its circulation in commerce, would be overwhelming. At a rate of about $2 per gram annually, it would cost on the order of $1 billion per year to safely and securely store this material, roughly ten times than the annualized cost of dry-storing the original spent fuel containing this plutonium. The only way to reduce the long-term security costs of separated plutonium would be to transform it back to a Category III material, another massively expensive proposition. The U.S. is struggling to dispose of a mere 34 metric tons of weapon-grade plutonium by conversion to MOX fuel and irradiation in light-water reactors, at a total cost now estimated as over $6 billion; a similar approach for 500 MT of plutonium would approach $50 billion.

The direct impact of separating 500 MT of plutonium from U.S. spent fuel on the domestic threat of diversion or theft of plutonium would be bad enough. But the indirect impact of GNEP on proliferation risk abroad could be far more dangerous. Given that the Carter policy, even though partially undone by the Reagan Administration, appears to have had some inhibitory effect on reprocessing activities, it is likely that the GNEP proposal's enthusiastic endorsement of reprocessing will relax any remaining constraints and lead to a global reprocessing free-for-all.

Nonetheless, GNEP's promoters paint the program as a nonproliferation initiative. They argue that GNEP will dramatically reduce the threat of proliferation worldwide by (1) instituting a global two-tier fuel cycle regime in which only fully trustworthy states will be able to operate enrichment and reprocessing facilities, and all other countries will be guaranteed access to nuclear fuel and reactors in exchange for their commitment not to pursue development of fuel cycle facilities of their own; and (2) developing "proliferation-resistant" reprocessing and fuel recycle technologies that, unlike the conventional PUREX process, do not produce "separated plutonium."

However, there is a fundamental contradiction between these two objectives. If reprocessing facilities are only going to be located in fully trustworthy states that pose no proliferation concerns, then why is it necessary to develop "proliferation-resistant" recycle technologies? And conversely, if the "proliferation-resistant" technologies that are under study have such potential to reduce proliferation and nuclear terrorism risks, then why are they too dangerous to be widely exported? Countries like South Korea that are already pursuing similar technologies are not likely to understand why they would be asked to give them up under the GNEP regime.

The only consistent way to resolve these contradictions is to conclude that no one really believes that the proliferation-resistance of these systems is going to be effective. In fact, it appears that DOE is using the "proliferation-resistance" moniker merely to "brand" GNEP for sale to the public, just like the other banal and oversimplifying adjectives like "clean," "safe" and "secure" which appear in DOE's GNEP promotional materials and may well be the outcome of focus-group message testing conducted by the GNEP program's PR firm, Potomac Communications.

But in its zeal to create the dangerous and false notion that there are effective technical fixes to the proliferation and terrorism risks posed by conventional reprocessing, DOE is undermining the Bush administration's nonproliferation policy goal of stopping the spread of sensitive fuel cycle technologies. In fact, the damage to the nonproliferation regime caused by the enthusiastic promotion of reprocessing and plutonium use by the United States is likely to overwhelm any of the minor benefits to nonproliferation touted by GNEP supporters.

The mixed messages that DOE is putting out only serve to strengthen the notion that reprocessing is highly desirable, worthy of huge government infrastructure investments, and can be employed in a fully proliferation-resistant manner. No self-respecting nation would be receptive to a message that reprocessing and plutonium recycling are essential technologies for fully realizing the benefits of nuclear power, yet must remain off limits to all but a few privileged countries. The consolation prize – highly dubious "guarantees" of fresh fuel supply and spent fuel return – is not likely to be sufficiently enticing to attract participants willing to give up their right to pursue a domestic reprocessing capability. Iran is the test case whether this approach will succeed with regard to uranium enrichment, yet the U.S. and other nations have already abandoned the principle that Iran should not receive Western nuclear assistance and other incentives unless it permanently renounces its right to possess enrichment technology. No other nation is likely to accept a deal less favorable to them than the one Iran ultimately receives. The case of Iran has already made clear that the "grand bargain" at the heart of GNEP is a failure in practice.

WHAT IS "SEPARATED PLUTONIUM"?

The claim that GNEP will advance non-proliferation through the development of "proliferation-resistant" reprocessing technologies that do not produce "separated plutonium" also has little justification. In fact, there does not appear to be a common definition of "separated plutonium" in either a formal or an operational sense. DOE has at different times proposed three variants of the UREX+ process, producing Pu+Np, Pu+Np+other minor actinides, or Pu+minor actinides+lanthanides, as well as the Pu+MAs+Ce-144 product of electrometallurgical treatment ("pyroprocessing") as meeting this definition. Japan has asserted that the mixture of plutonium and uranium to be produced at the Rokkasho Reprocessing Plant (RRP) – a 50%-50% blend – is not separated plutonium. France is claiming that an "integrated recycling plant" that produces conventional MOX fuel as an end-product does not produce "separated plutonium." But these approaches are merely superficial modifications to conventional reprocessing that would have no significant impact on the ability of skilled adversaries to divert or steal weapon-usable material from the nuclear fuel cycle and build nuclear weapons within the accepted IAEA conversion times.

There is little question that a simple blending of plutonium with uranium without introducing a high external radiation barrier, even in the form of a bulky MOX fuel assembly, affords little proliferation resistance relative to separated plutonium, and would not affect the intensity of safeguards applied by the IAEA or physical protection measures called for by international standards.[4] On the other hand, blending with sufficient quantities of highly radioactive fission products in principle could be effective, but the product and fresh fuel would be so cumbersome and dangerous to handle that the cost and risk of generating nuclear power could increase dramatically.

These and other proposals to modify the nuclear fuel cycle to reduce the accessibility of plutonium have been discussed for decades, yet DOE officials like Clay Sell falsely assert that the Carter moratorium on reprocessing was instituted because such options were not available. For instance, on February 27, 1978, within a year after the Carter policy statement, U.S. and U.K. scientists announced the development of Civex, "a method of reprocessing spent fuel from atomic power plants that would not produce pure plutonium, which could be used to make atomic bombs."[6] The statement went on to say that "in the Civex process, spent fuel would be treated so that it could be reused as fuel … but the plutonium in it would not at any stage be purified to the extent that it could be used for a bomb … the fuel, at every stage of the process, would be so highly radioactive that it could not be handled directly by human beings, a fact that would presumably deter terrorists from attempting to steal the material."[7]

Sound familiar? This is exactly the same gimmick that is being pushed today by promoters of UREX+ and pyroprocessing. But the Carter Administration was fully aware of the proposal and expressed interest – Joseph Nye, then at the State Department called it "an example of the kind of fruitful suggestions we want to see studied"[8] – and the proposal was reviewed during INFCE. The General Accounting Office reviewed the proliferation-resistance characteristics of Civex and similar approaches at the time and found that they would have little impact on diversion by states, although they would provide enhanced protection against terrorist theft.

But the products of the various UREX+ processes would be far less self-protecting than the Civex product, which would retain some cesium-137. Neither the UREX+1a or pyroprocessing flowsheets result in a plutonium product that is "so highly radioactive that it could not be handled directly by human beings." In a response to questions for the record of a March 2006 budget hearing from Congressman Edward Markey (D-MA), DOE has conceded this point by saying that "The plutonium mix from UREX+ would not meet the self-protection standard of spent fuel and, therefore, the physical protection measures and safeguards associated with the process will need to be stringent."[9] But DOE deemphasizes the importance of this admission, stating that "the GNEP model works because only the supplier states will be engaged in the recycling of spent fuel. These are states with strong non-proliferation records … and in most cases are nuclear weapons states."[10]

This response recalls the question asked earlier: why then do we need to develop more proliferation-resistant reprocessing technologies at all? When DOE officials are questioned on this point in private conversations, they say that these technologies will provide enhanced protection against subnational threats. Yet they have provided no evidence that these approaches would be effective. It has already been well-established that the UREX+1a product, a mixture of plutonium and minor actinides (neptunium-237, americium and curium), does not have a significantly greater resistance to theft than does the plutonium itself. The bulk barely increases and the radiation barrier at 1 meter remains below 1 rem per hour. Moreover, the addition of neptunium-237 and americium isotopes do not affect the level of protection that must be afforded to the mixture. According to DOE guidelines, separated neptunium-237 and separated americium must be "protected, controlled and accounted for as if they were SNM" (U-235, in particular).[11] Thus the addition of these isotopes to plutonium would not change the attractiveness level of the mixture and would only lead to a minimal increase in the Category I threshold quantity of the product.

Argonne's response to this is to suggest that instead of using UREX+1a, UREX+1 should be used instead. This separates a mixture of plutonium, minor actinides and lanthanides. Of all the lanthanide fission products, only cerium-144 (actually its short-lived daughter, Pr-144) and europium-154 are relatively long-lived and generate significant external dose rates from hard gamma emission.[12] According to David Hill, GNEP program director at the Idaho National Laboratory (INL), with lanthanides included, the UREX+ product would be classified as DOE Attractiveness Level D.[13] This would imply that the dose rate of the mixture would be between 15 rem/hour and 100 rem/hour at 1 meter; again, below the IAEA self-protection standard and the NRC and DOE definitions of highly irradiated material.[14] According to DOE guidelines, Attractiveness Level D materials can never be categorized as Category I. But adding lanthanides into the mixture would add even more complications to the proposed GNEP fuel cycle (see below).

Moreover, if the goal is to reduce the attractiveness of the reprocessing product to Level D, there is a far easier way and less hazardous way: simply blend the plutonium with uranium to a plutonium concentration below 10%.[15] In fact, this is consistent with the French claim that light-water reactor MOX fuel is not "separated plutonium" (although not with fast reactor driver fuel with plutonium contents of 15% or higher). However, both approaches would be completely ineffective in reducing the vulnerability of the closed fuel cycle to terrorist theft.

Another paradoxical aspect of the GNEP proposal is that although it carries an implicit criticism of conventional reprocessing programs that separate pure plutonium, it refuses to address the threat posed by these programs. As a result, the quantity of separated plutonium in the world is likely to increase, rather than decrease, over the next several decades.

DOE Secretary Samuel Bodman said in November 2005 that "in addressing reprocessing … we are guided by one overarching goal: to seek a global norm of <u>no separated plutonium</u>. I think everyone would agree that the stores of plutonium that have built up as a result of conventional reprocessing technologies pose a growing proliferation risk that requires vigilant attention."[17] However, there is no sign that DOE is willing to actually do anything to address the current proliferation risk associated with existing plutonium stockpiles. Soon after GNEP was rolled out in February, the Rokkasho Reprocessing Plant (RRP) began active testing with spent fuel, which will ultimately result in the separation of about four metric tons of plutonium. When the plant reaches full-scale operation, it will produce about eight metric tons per year. But Japan has already accumulated a plutonium stockpile in excess of forty tons, in contradiction to its 1997 pledge that its nuclear fuel cycle was based on the principle of "no surplus plutonium." There is every indication that countries that now utilize PUREX, including France, Japan, the U.K., Russia and India, regard GNEP as an endorsement, not a rejection, of their current practices.

In fact, Areva NC, the French national nuclear fuel cycle company, declared in mid-2006 its intention to develop a new generation of reprocessing plants for export to at least a dozen countries, potentially including the other four nuclear weapon states, Japan, Germany, Canada, Australia, the Netherlands, Argentina, Brazil and South Africa. Such a plan would have been unthinkable before DOE's GNEP announcement in February 2006. An Areva official said that the prospects for this plan were "boosted" by the "goal of organizing world commerce in spent fuel reprocessing" under the GNEP program.[18] The basis for the alleged proliferation resistance of this plant would be a process that would involve co-extraction of plutonium and uranium – as discussed before, a meaningless measure.

GNEP AND NUCLEAR MATERIAL ACCOUNTANCY

Despite the IAEA's increasing emphasis on the use of containment and surveillance (C/S) and other qualitative measures in designing safeguards systems, "nuclear material accountancy remains a safeguards measure of fundamental importance."[19] Consequently, any modifications to the nuclear fuel cycle that have the potential to interfere with the application of accurate and precise nuclear material accountancy measures would have a negative impact on both national and international safeguards, even if the changes enhanced the effectiveness of C/S measures. Yet this would be precisely the effect that the proposed "proliferation-resistant" reprocessing systems would have. And given the difficulty the IAEA is already apparently experiencing in meeting its safeguards goals at large-throughput conventional reprocessing plants like the Rokkasho Reprocessing Plant, the likelihood that safeguards goals could be met at so-called "proliferation-resistant" reprocessing plants is even lower.

First, changes to the reprocessing and fuel fabrication process streams to include minor actinides or minor actinides and lanthanides would degrade the ability to make precise measurements of the special nuclear material content of product and process streams. In particular, the use of non-destructive assay (NDA) methods to measure the plutonium in already difficult settings such as holdup (both in-process and residual) and waste streams would be affected by the inclusion of additional neutron and α-emitters that would contribute to the spontaneous fission neutron and (α,n) source terms. Second, the retention of high-activity materials in product streams would increase the hazards and complexities of sampling for destructive assay (DA) throughout the process.

The presence of minor actinides in product streams, even at the relatively low concentrations in LWR spent fuel, "could compromise the accuracy of the plutonium measurement if not properly taken into account."[20] But because the minor actinides neptunium and americium themselves must now be accounted for as if they were SNM, according to recent DOE guidance, each minor actinide would have to be separately assayed, greatly complicating material accountancy. And since the expected precision of minor actinide measurements using standard assay techniques is considerably lower than that for plutonium,[21] the overall precision of measurement of weapon-usable isotopes will decrease, with a corresponding effect on the ability to meet material accountancy goals.

The material accountancy challenges posed by including minor actinides and fission products in product streams would be compounded by the large number of separations and fuel fabrication plants contemplated in the proposed GNEP scheme. In one version of the fuel cycle circulated by Argonne National Laboratory officials, LWR spent fuel would be reprocessed at large, centralized UREX+ plants to extract a product containing plutonium, minor actinides and lanthanides. The product would then be shipped as oxide around the country to multiple "advanced [fast] burner reactors" (ABRs), each with its own integral metallic spent fuel pyroprocessing and fuel fabrication plant. (The lanthanides, cerium-144 and europium-154 in particular, would be retained in the product for transport because the radiation barrier provided by the actinides alone would be insufficient to provide appreciable self-protection.) At each site, the lanthanides would be removed at small aqueous separations plants, and the plutonium and minor actinide metal product would be fed into each fuel fabrication plant, along with the plutonium and actinides recovered by pyroprocessing. Therefore, each advanced burner reactor would have an aqueous separations plant, a pyroprocessing plant and a fuel fabrication plant. Since approximately three ABRs would be required to absorb the annual production of plutonium and actinides from about four LWRs of the same power rating (about one MT), if the total nuclear generating capacity increases to 500 GWe by 2050, over 200 1 GWe ABRs would be required. Even if located four to a site, this would still imply that approximately 50 sites would contain multiple bulk-handling facilities requiring domestic (and perhaps international) safeguards. The resolution of shipper-receiver differences and site MUFs, given the reduced precision of product assays, would be a formidable task.

The IAEA acknowledges that not all potential "intrinsic measures" for increasing the proliferation resistance of the nuclear fuel cycle can be incorporated into any one system, because "some of them are mutually incompatible."[22] Features that reduce accessibility to SNM, such as incomplete separation from actinides and other fission products, will necessarily conflict with other objectives, such as developing "nuclear energy systems with inventories and flows of nuclear material that can be specified and accounted for in the clearest possible manner." Proponents of GNEP have yet to demonstrate that the loss of confidence associated with the impairments to material accountancy inherent in their proposed system could be adequately compensated for by the minimal level of reduced accessibility provided by the incomplete separations.

CONCLUSION

The Bush Administration has failed to make a convincing case that implementation of the GNEP plan would lead to a reduction in the proliferation and nuclear terrorism threats inherent in the nuclear fuel cycle. In fact, because of the boost the plan has given to conventional reprocessing programs worldwide, it may well result in a vast increase in the worldwide flow of weapon-usable nuclear materials, and a corresponding increase in the threat that such materials will fall into the hands of rogue states or terrorists. The Administration could better promote non-proliferation by strengthening efforts to discourage the separation of plutonium and to promote the once-through cycle by demonstrating the technical and political viability of geologic disposal of spent fuel.

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