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Union of Concerned Scientists Comments on the Department of Energy's Notice of Intent to Prepare a Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership

Overview

The Union of Concerned Scientists (UCS) continues to oppose the Department of Energy's Global Nuclear Energy Partnership (GNEP) in the strongest terms, as stated in its May 8, 2006 comments on the March 22, 2006 Advance Notice of Intent (ANOI). Although the proposal described in the January 4, 2007 Notice of Intent (NOI), is considerably different from the program described in the ANOI, our specific comments on the ANOI still continue to apply to the full-blown GNEP program, instead of the now-defunct Technology Development Program (TDP). To reiterate, UCS calls for a full assessment of the impacts of the proposed action on the threats of nuclear proliferation and nuclear terrorism; a comprehensive assessment of the costs to taxpayers and ratepayers of the full GNEP program necessary to achieve its highly ambitious waste management goals; a full evaluation of radiological sabotage impacts, and an assessment of the impacts of storage and disposition of the reprocessed uranium that would be separated. UCS requests that all prior comments on the ANOI be addressed in the PEIS.

UCS finds the revamped GNEP program to be even more objectionable than the initial GNEP proposal. In particular, what began as a research and development program into so-called "proliferation-resistant" reprocessing, fuel fabrication and burner reactor technologies has transmuted into a much more extensive program involving the near-term construction of industrial-scale reprocessing and plutonium-based fuel fabrication plants and fast neutron reactors, all based on conventional, proliferation-prone PUREX technology or minor variants thereof. Although UCS does not believe that the technologies proposed for development under GNEP would actually be proliferation-resistant in any meaningful sense, UCS did appreciate DOE's acknowledgment that the growing stockpiles of separated plutonium around the world produced by ongoing reprocessing

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activities presents a major proliferation threat. However, the new GNEP proposal would undermine efforts to get those stockpiles under control.

The conventional facilities DOE is now planning under GNEP would commence operation before completion of R&D on the "proliferation-resistant" alternatives, and would somehow be later modified to utilize those alternatives. In the interim period, which could last for several decades, these conventional facilities would separate, store, transport and process vast quantities of vulnerable, direct-use nuclear weapon materials, of which only a small fraction would actually be utilized in reactor fuel and irradiated to a self-protecting state. The net outcome would be a major increase in the risk of diversion or theft of weapon-usable materials and an associated risk of nuclear terrorism.

The cost of providing security alone for the GNEP complex would be an enormous burden. In an attempt to reduce costs, it is likely that the Nuclear Regulatory Commission (if given licensing authority over GNEP facilities) will continue its efforts to substantially weaken physical protection and material control and accounting requirements for weapon-usable materials at civil facilities. Such a relaxation of security requirements, presumably inconceivable in the post-September 11 era, has already begun as NRC seeks to change its rules to weaken the security requirements for storage of mixed plutonium-uranium oxide (MOX) fuel at reactor sites.

An even worse consequence of the GNEP program is the erroneous message that it has already sent around the world that reprocessing of spent fuel is not only useful but essential for the future of nuclear power. DOE's feeble protestations that it does not seek to encourage the additional production of "separated plutonium" is clearly disingenuous given that it has not required any commitment from its GNEP international "partners" such as France, Russia, China and Japan to halt the senseless growth of stockpiles of separated plutonium or to convert their reprocessing facilities to use "proliferation-resistant" technologies if such technologies become available.

And in any event, UCS and others have already extensively documented that the so-called "proliferation-resistant" technologies being proposed for development under GNEP will not be effective. By continuing to perpetuate the discredited notion that technical fixes can be found for the proliferation risks of reprocessing and the closed fuel cycle, DOE is providing cover for a large-scale reversal of the international reluctance to pursue reprocessing. A case in point is the spent fuel electrometallurgical treatment ("pyroprocessing") facility under development in South Korea, which may be sanctioned by the United States as a "proliferation-resistant" technology under GNEP even though many studies have shown that pyroprocessing presents serious proliferation concerns.[1]

Thus there is little doubt that despite its grandiose visions for the long-term, the outcome of the GNEP program for the foreseeable future can only be more separated weapon-usable materials and more risk. Therefore, UCS strongly endorses the "no-action alternative" and urges DOE to abandon the GNEP program before it does further damage to international non-proliferation and counter-terrorism efforts.

Specific Comments

1. The PEIS must provide a clear, consistent and rational basis for any claims of proliferation resistance for the fuel cycle technologies it considers for GNEP. The "no separated pure plutonium" standard cited in the NOI, as applied to date by DOE, does not have a technical basis. The PEIS should undertake a detailed comparison of the proliferation risks of the various alternatives, including comparison of the once-through cycle (direct geologic disposal of spent fuel) with conventional PUREX technology, COEX, all UREX variants, and electrometallurgical treatment ("pyroprocessing").

Section III of the NOI states that "to meet its non-proliferation goals with regard to SNF recycling, DOE will only assess as reasonable alternatives those technologies that do not separate pure plutonium." However, as UCS has repeatedly pointed out, DOE has not clearly defined what it means by "pure plutonium,"[2] and some examples of materials it asserts are not "pure plutonium" -- thus acceptable under GNEP -- are functionally equivalent to pure plutonium with regard to their attractiveness to terrorists seeking nuclear weapons and to their vulnerability to theft or diversion.

In contrast, UCS maintains that the only acceptable definition of "impure plutonium" consistent with existing regulations and international norms and commitments is plutonium diluted with fission products to the extent that it is as resistant to theft or diversion as the plutonium contained in spent fuel at every stage of the process. On the other hand, a plutonium mixture that would not be significantly more difficult for skilled adversaries to divert or steal and process into a weapon-usable form than plutonium oxide (the product of PUREX reprocessing) cannot be regarded as proliferation-resistant and must be classified as the functional equivalent of "pure plutonium."

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[1] See, e.g., National Research Council, *An Assessment of Continued R&D into an Electrometallurgical Approach for Treating DOE Spent Nuclear Fuel*, National Academy of Sciences, 1995, p. 27, 30.
[2] See, e.g., Edwin S. Lyman, "The Global Nuclear Energy Partnership: Will it Advance Nonproliferation or Undermine It?" Proceedings of the 47th Annual Meeting of the Institute of Nuclear Materials Management, Nashville, TN, July 2006.

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DOE already incorporates a notion of nuclear material purity into its material control and accountability procedures through the concept of "attractiveness level," that is defined, according to the DOE 1995 glossary of safeguards and security terms, as **"**a categorization of nuclear material types and compositions that reflects the relative ease of processing and handling required to convert that material to a nuclear explosive device." According to the DOE Graded Safeguards Table, plutonium oxide is categorized as Attractiveness Level C, with 6 kilograms or more considered a Category I quantity. In contrast, plutonium contained in spent fuel with a dose rate of at least 100 rem/hour at 1 meter (considered "highly irradiated") would be considered Category IV, Attractiveness Level E no matter how high the plutonium content.[3] UCS believes that at a minimum, any truly proliferation-resistant reprocessing technology would never generate materials requiring safeguards beyond Category IV.

However, under current plans for both the "interim" and long-term GNEP programs, the process materials at numerous points in the cycle would be very similar to plutonium oxide with regard to their classification on the DOE Graded Safeguards Table.

For the interim program, Assistant Secretary Spurgeon has said that the COEX process being promoted by Areva would meet the "inviolate requirement" of not producing separated plutonium and hence would be eligible for consideration under GNEP. Such a conclusion would be inconsistent with DOE guidance. Under the Graded Safeguards Table and the associated 1995 guidance, which is still in effect, mixed oxides with special nuclear material content greater than 100 g/kg (10 weight-percent), or fuel elements with more than 10 weight-percent special nuclear material, would be considered Attractiveness Level C and hence would require the same level of security as separated plutonium oxide.[4] Although Alan Hanson of Areva NC has refused to confirm the actual isotopic composition of the proposed COEX process for GNEP,[5] it is clear that to manufacture fuel for fast reactors, the plutonium concentration will have to be well over 10 weight-percent. This means in practice that the COEX process will have to produce an interim product with an even higher plutonium concentration, since mixed-oxide fuels are typically fabricated with a "master mix" with a plutonium concentration much greater than that of the final product. So on the basis of the plutonium content alone, the process stream will eventually have to be enriched in plutonium to a level that would make it Attractiveness Level C, and the facility

[3] U.S. Department of Energy, *Nuclear Material Control and Accountability*, DOE M 470.4-6, August 26, 2005, p. I-9.
[4] U.S. Department of Energy, *Guide for Implementation of DOE 5633.3B, Control and Accountability of Nuclear Materials*, April 1995, p. I-3. (Although DOE 5633.3 B is no longer in effect, this guidance document still applies to the current Graded Safeguards Table.)
[5] Daniel Horner, "Seeking Faster Results, DOE Ponders Adding Near-Term Track to GNEP," *NuclearFuel*, August 14, 2006, p. 1.

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would require Category I security, since the plutonium inventory at the plant would be far in excess of the 6 kg Category I threshold.

Hanson of Areva testified before Congress in 2006 that the COEX "recycling plant" would remain a Category II facility by "limiting the concentration of solution anywhere in the process facility consistent with attractiveness level D or below."[6] According to DOE's Graded Safeguards table, this would mean that all plutonium solutions would have to contain less than 25 grams per liter of special nuclear material. It is conceivable that the reprocessing portion of the plant could keep plutonium solutions in such a dilute form by not producing a concentrated plutonium nitrate solution. However, in order to fabricate the fuel, this solution would eventually have to be converted to an oxide, metal, carbide or nitride with a plutonium concentration of well over 10%, again increasing to Attractiveness Level C. And driver assemblies for large fast reactors typically each contain dozens of kilograms of plutonium, well over the 6 kilogram threshold for Category I, so that even a single fast reactor driver assembly would require Category I protection.

When presented with these facts at a public briefing by a UCS staff member, Assistant Secretary Spurgeon, simply said "you're wrong" without further explanation. UCS would appreciate a detailed written response in the PEIS explaining how this analysis is "wrong."

Looking ahead, the proposed evolution to "transmutation fuels," containing the transuranic elements neptunium, americium and possibly curium, will not confer any significant additional proliferation resistance to that of the conventional PUREX/COEX cycles.

It has already been well-established that the UREX+1a product, a mixture of plutonium and other transuranics (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.[7] Moreover, the addition of neptunium-237 and americium isotopes do not diminish the usefulness of the mixture for making nuclear weapons. According to revised DOE guidelines, separated neptunium-237 and separated americium-241 and -243 must be "protected, controlled and accounted for as if they were SNM," and are considered equivalent to U-235 in the revised Graded Safeguards table.[8] 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.

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[6] Statement of Alan Hanson before the Committee on Senate Appropriations, Subcommittee on Energy and Water Development, September 14, 2006.
[7] E.D. Collins, Oak Ridge National Laboratory, "Closing the Fuel Cycle Can Extend the Lifetime of the High-Level-Waste Repository," American Nuclear Society 2005 Winter Meeting, November 17, 2005, Washington, DC, p. 13.
[8] U.S. Department of Energy, *Nuclear Material Control and Accountability*, DOE M 470.4-6, August 26, 2005.

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Moreover, the proposed transuranic enrichment of the “transmutation fuels” for certain low conversion ratio designs would be at least 50% and as much as 93%.[9] For metal fuel elements, one of the options being proposed, this raises the possibility (depending on the TRU enrichment and amounts of other elements in the alloy) that the transuranic fuels could contain more than 50 atom percent special nuclear material and hence would qualify as Attractiveness Level B material, that is, material that could be converted using non-chemical operations to produce a nuclear weapon or improvised nuclear device.[10] The production and use of such highly concentrated materials in the GNEP fuel cycle would require the same level of security as weapon components and would completely undermine any claim that the system has meaningful proliferation resistance.

Although this possibility of retaining fission products with plutonium in addition to transuranics is not explicitly stated in the NOI, GNEP program officials have suggested elsewhere that to increase the radiation barrier, UREX+1 could be used instead of UREX+1a, which would keep lanthanide fission products in the mix with plutonium and other transuranics. The lanthanides would later be separated from the transuranics at reactor sites.

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.[11] According to David Hill, GNEP program director at the Idaho National Laboratory (INL), with lanthanides included, the UREX+1 product would be classified as DOE Attractiveness Level D, which implies the mixture would be “moderately irradiated,” according to the DOE grades safeguards classification.[12] Referring to the 1995 DOE guidance, this would imply that the dose rate of the mixture would be between 15 rem/hour and 100 rem/hour at 1 meter, below the IAEA self-protection standard and the NRC definition of highly irradiated material.[13] Even with such a minimal radiation barrier, as Attractiveness Level D material, no quantity of the

[9] M.A. Smith, E.E Morris and R.N. Hill, “Physics and Safety Studies of Low Conversion Ratio Sodium Cooled Fast Reactors,” Proceedings of Global 2003, New Orleans, LA, November 16-20, 2003, p. 423-433; DOE Secretary Samuel Bodman, Responses to Questions for the Record, Hearing of the Senate Committee on Energy and Natural Resources, February 9, 2006.
[10] U.S. DOE, *Guide for Implementation* (1995), op cit., p, I-2.
[11] E. Lyman, “Interim Storage Matrices for Excess Plutonium: Approaching the Spent Fuel Standard Without the Use of Reactors,” PU/CEES Report No. 286, Center for Energy and Environmental Studies, Princeton University, Princeton, NJ, August 1994; J Kang and F. von Hippel, “Limited Proliferation-Resistance Benefits From Recycling Unseparated Transuranics and Lanthanides From Light-Water Reactor Spent Fuel,” *Science and Global Security* **13** (2005) 169-181.
[12] Daniel Horner, “Nonproliferation Benefits Claimed, Disputed in Debate over GNEP,” *NuclearFuel*, May 8, 2006, p.13.
[13] U.S. Department of Energy, “Guide for Implementation of DOE 5633.3B, ‘Control and Accountability of Nuclear Materials,” April 1995.

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lanthanide-containing product could be categorized as Category I under DOE guidance. But adding lanthanides into the mixture would further complicate the proposed GNEP fuel cycle, increasing the hazards of handling and transporting fresh reactor fuel feedstock and requiring aqueous separations capacity at reactor sites to separate out the lanthanides prior to fabrication into usable reactor fuel. And after removing the lanthanides, the attractiveness level of the material would increase again to Level C or higher, so that Category I security and safeguards would be required at reactor sites in any event.

DOE should also evaluate the impact on the GNEP program of a potential major increase in the threshold that defines “highly irradiated” materials in its graded safeguards classification. A recent review by Oak Ridge National Laboratory found that the current 100 rem per hour threshold was inadequate to deter terrorists willing to die for their cause, and recommended that the threshold be increased by a factor of 100. Based on this and other recommendations, DOE has been considering a dramatic increase in the threshold.[14] Such an increase would instantly increase the security requirements for many nuclear materials around the DOE complex, and would make even more apparent the extreme inadequacy of the miniscule dose rates of plutonium-containing materials in the GNEP system for providing any meaningful self-protection against terrorist theft and diversion.

UCS wishes to emphasize that most approaches for increasing the proliferation resistance of the closed fuel cycle, by increasing the intrinsic hazards of process materials, would also increase the potential harm to workers and the public resulting from both normal operations and accidents. Also, by reducing the purity and accessibility of special nuclear materials, the application of conventional material accounting measures essential for both domestic and international safeguards would become more costly and less effective. These are important tradeoffs which must be fully considered in assessing the impacts of GNEP alternatives.

2. The PEIS nuclear terrorism assessment should analyze the impacts of nuclear explosions resulting from the theft or diversion of weapon-usable materials from the GNEP fuel cycle.

In addition to the other elements of the nuclear terrorism threat assessment that UCS described in our May 2006 comments on the ANOI, the PEIS should analyze the impacts of terrorist nuclear explosive attacks on U.S. cities and other high-value targets resulting from the theft or diversion of plutonium and other weapon-usable materials from GNEP facilities. In addition to scenarios involving off-site production and assembly of nuclear devices following the theft of a variety of materials expected to be stored and processed under GNEP, the potential for GNEP materials,

[14] J. Rivers and D. Whaley, “Review of the Department of Energy Graded Safeguards Table,” Proceedings of the 47th Annual Meeting of the Institute of Nuclear Materials Management, Nashville, TN, July 2006.

including highly plutonium-enriched fast reactor driver fuel assemblies, to be used to assemble crude "improvised nuclear devices" at GNEP facilities sites should also be evaluated. NNSA officials apparently alluded to the possibility that plutonium in addition to highly enriched uranium could be used to fabricate INDs in a February 2007 press conference.[15]

The precedent for such an analysis can be found in the draft safeguards supplement accompanying GESMO, the 1970s generic environmental impact statement on the use of MOX fuel in light-water reactors, which described in some detail the risks associated the theft of plutonium from a domestic plutonium fuel cycle industry by terrorist groups. The report discussed both the capabilities of terrorists to assemble crude nuclear devices and the potential consequences of such devices.[16] Surely this analysis needs to be updated after 30 years.

3. The PEIS should consider the consequences of "hypothetical core disruptive accidents" (HCDAs) and other severe reactivity accidents at "advanced recycling reactors."

Liquid-metal-cooled fast spectrum reactors, such as those proposed as candidates for the GNEP "advanced recycling reactor" (ARR) are vulnerable to a variety of severe accidents, including the so-called "hypothetical core disruptive accident," or HCDA. Because fast reactor cores are not in their most reactive configurations during normal operation, the potential exists for events that cause reactivity excursions so severe that the fuel can be vaporized and expelled into the environment by an explosive energy release equivalent to the detonation of many tons of TNT. Coupled with the large inventory of highly radiotoxic transuranic elements in the core of the proposed ARR, such an event could result in a catastrophe far worse than a core melt and containment failure in a conventional light-water reactor. The horrific consequences of such events must be fully analyzed. The many uncertainties that are to be anticipated in the analysis of novel reactors such as the ARR should be compensated for by choosing conservative source terms for transuranic release.

4. The PEIS should analyze the impacts of human intrusion on GNEP nuclear waste storage facilities beyond a time frame in which institutional control can reasonably be assured.

The GNEP objective of greatly increasing the waste disposal capacity of Yucca Mountain requires that the "short-lived" fission products cesium-137 and strontium-90 be separated from spent fuel and placed into "decay storage" in surface facilities for a period of some 300 years. However, this length of time is well beyond the time frame during which the present generation can provide

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[15] G. Lobsenz, "NNSA Moving to Counter 'Improvised Nuclear Devices,'" Defense Daily, February 8, 2007.
[16] U.S. Nuclear Regulatory Commission, "Safeguarding a Domestic Mixed Oxide Industry Against a Hypothetical Subnational Threat," NUREG-0414, May 1978, 3-30 to 3-36.

assurances of the presence of active institutional controls necessary to maintain these sites and to deny access to intruders. Therefore, the PEIS should evaluate the risks associated with a breakdown of control at "decay storage" facilities and the potential for inadvertent human intrusion to disturb these sites and cause radiation-related injuries and widespread radiological contamination. UCS proposes that 100 years is the upper limit of the period over which institutional control can be reasonably anticipated to be projected.

5. The PEIS must assess the impacts of the stockpile of separated weapon-usable material that will be accumulated as the result of implementation of the domestic GNEP "proposed action."

Under the GNEP proposed action, a spent fuel separations plant with a capacity of up to 3,000 metric tons heavy metal (MTHM) per year and a sodium-cooled fast reactor with a capacity of up to 2,000 MW-thermal would be built. At the upper end of the scale, the separations plant would produce annually about 30 metric tons of plutonium (and about 3 metric tons of other weapon-usable transuranics, after conversion to UREX+). At the upper end of the scale, a 2,000 MW-thermal fast reactor nominally would require less than 10 MT of plutonium (or plutonium and other TRUs) to start up, and well under 2 MT in reload fuel per year after that. Enough plutonium for the initial core would be separated after only a few months of operation, and in steady state the reprocessing plant would produce over 28 MT of plutonium in excess of what could be loaded in the fast reactor. Meanwhile, the reactor itself would only fission at most a few hundred kilograms of plutonium per year, with the remainder left in the spent fuel. If this spent fuel were reprocessed it would only contribute to the plutonium glut. The outcome will be an enormous accumulation of weapon-usable material that will pose an ongoing security threat and will require vast resources to safeguard. And this situation will persist indefinitely unless the full-scale GNEP program is implemented, with sufficient fast reactor capacity to absorb this accumulating mountain of plutonium and other TRUs, and to continuously reprocess and recycle the spent fuel for the tens to hundreds of cycles that would be needed to make a significant dent in the total TRU inventory, as the National Academy of Sciences has demonstrated in its seminal 1996 report on transmutation.

The PEIS should provide realistic analyses of the cost, environmental and security impacts of such an outcome.

Sincerely,

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