Risks of GNEP's Focus on Near-Term Reprocessing

TESTIMONY OF
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Mr. Chairman and members of the committee, it is an honor to be here today to discuss the Global Nuclear Energy Partnership (GNEP). I should emphasize that I am expressing my own views, which should not be attributed to Harvard University or to any committees or organizations of which I am a member. I have been asked to focus on the proliferation and security issues.[1]

A key GNEP goal is to expand global reliance on nuclear energy without increasing proliferation risks. Controlling the spread of enrichment and reprocessing – the technologies that make it possible to produce nuclear bomb material – is a critical part of achieving that objective.

Some elements of GNEP could make important contributions to reducing proliferation risks. Unfortunately, GNEP's heavy focus on building a commercial-scale reprocessing plant in the near term would, if accepted, increase proliferation risks rather than decreasing them.

Proliferation risks of near-term U.S. reprocessing

The first set of proliferation risks that should be considered relates to the spread of nuclear weapons-related technologies to additional states. Since 1976, the U.S. message has been, in effect, "reprocessing is unnecessary; we, the country with the world's largest nuclear fleet, are not doing it, and you do not need to either." Now, with GNEP, the message is "reprocessing is essential to the future of nuclear energy, but we will keep the technology away from all but a few states."[2] This shift is likely to make it more difficult

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[1] For a more comprehensive account of the issues surrounding near-term reprocessing in the United States, see Matthew Bunn, "Assessing the Benefits, Costs, and Risks of Near-Term Reprocessing and Alternatives," testimony before the Subcommittee on Energy and Water, Committee on Appropriations, U.S. Senate, 14 September 2006, available as of 12 November 2007 at www.belfercenter.org/ publication/3222/); see also Frank von Hippel, *Managing Spent Nuclear Fuel in the United States: The Illogic of Reprocessing* (Princeton, N.J.: International Panel on Fissile Materials, Research Report 3, January 2007, available as of 11 November 2007 at http://www.fissilematerials.org/ipfm/site_down/ ipfmresearchreport03.pdf). For broader assessments of the future of nuclear energy that come to similar conclusions, see John Deutch and Ernest J. Moniz, co-chairs, *The Future of Nuclear Power: An Interdisciplinary MIT Study* (Cambridge, MA: Massachusetts Institute of Technology, 2003, available as of 12 November 2007 at http://web.mit.edu/nuclearpower/); and Keystone Center, *Nuclear Power Joint Fact-Finding* (Keystone, Colo: Keystone Center, June 2007, available as of 12 November 2007 at http://www.keystone.org/spp/documents/FinalReport_NJFF6_12_2007(1).pdf).

[2] This formulation is adapted from Frank von Hippel, "GNEP and the U.S. Spent Fuel Problem," congressional staff briefing, 10 March 2006.

to achieve President Bush's goal of convincing other countries not to build their own reprocessing facilities. It has already led South Korea to express new interest in reprocessing, and France to begin considering exports of reprocessing plants to non-nuclear weapon states.[3]

While it is often said that the rest of the world did not listen to us on reprocessing, the evidence suggests the opposite. Since Japan launched its first reprocessing plan in 1977, no other non-nuclear-weapon state has begun reprocessing; Argentina, Belgium, Brazil, Germany, and Italy have shut down their pilot-scale reprocessing plants; and Taiwan and South Korea have abandoned their laboratory-scale reprocessing efforts (both of which were associated with secret nuclear weapons programs).[4] Japan is now the only non-nuclear weapon state that reprocesses spent fuel on its territory.

Department of Energy (DOE) officials respond by arguing that under GNEP, the United States will provide assured fuel services that will reduce countries' incentives to build their own enrichment and reprocessing plants. That is a worthwhile objective, and as I will discuss later, programs to take away countries' spent nuclear fuel could be a dramatic new incentive for them to rely on the international nuclear fuel market rather than building their own facilities. But U.S. reprocessing is irrelevant to providing assured fresh fuel supply – the principal focus so far – and if the United States or other countries are going to take back limited quantities of spent fuel from new countries developing nuclear energy, there is no requirement that this fuel be reprocessed.

It is important to pursue these objectives carefully, so as to follow the dictum "first, do no harm." Ironically, the period since President Bush's 2004 speech in which he laid down the objective of preventing the spread of enrichment and reprocessing technologies to countries that did not already operate such plants has seen the greatest explosion of interest in uranium enrichment in the nuclear age, with states such as South Africa, Argentina, Australia, Canada, Ukraine, and Belarus suddenly expressing renewed interest. If states perceive that a new line is to be drawn between technology "haves" and "have nots" – a perception that early GNEP presentations on dividing the world into "supplier states" and "recipient states" contributed to – they will rush to try to ensure that they are on the "have" side of the line.

DOE officials then argue that the reprocessing approaches to be pursued in GNEP are "proliferation resistant." But having other countries pursue processes in the UREX+ family rather than PUREX would be only a modest improvement. While UREX+ facilities could be designed so that modifying them to separate pure plutonium would be moderately costly and observable, states with UREX+ facilities would gain experience, infrastructure, and materials that would allow them to produce plutonium for nuclear weapons more rapidly and at less cost. For these reasons, the State Department has

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[3] On South Korea, see, for example, Mark Hibbs, "ROK to Chart Fuel Cycle Policy Course Beyond 'Wait-and-See'," *NuclearFuel,* 23 April 2007; on the French export ideas, see Ann MacLachlan, "Areva Dual-Track Strategy Aimed at Two Reprocessing Plants," *NuclearFuel,* 3 July 2006. Areva, the state-owned French nuclear conglomerate, is quoted as saying that GNEP "boosted" its plans for exporting reprocessing plants.

[4] For a discussion, see von Hippel, *Managing Spent Fuel in the United States,* p. 20. Other than Japan, the major commercial reprocessing facilities in the world are in nuclear weapon states: France, the United Kingdom, and Russia. Since 1976, many of their customers (such as Germany and Sweden, among others) have joined the United States in abandoning reprocessing in favor of direct disposal. In general, the poor economics of reprocessing have driven decisions more than U.S. policy.

publicly expressed the view that UREX+ facilities, like PUREX facilities that separate pure plutonium, must remain "forever confined" to a small number of supplier states.[5] That is a challenging objective, which will be made more difficult by the United States emphasizing the importance of reprocessing.

Similarly, non-nuclear weapon states operating pyroprocessing facilities would gain in-depth experience with plutonium processing and metallurgy, which would be very helpful to a nuclear weapons program. The United States should understand that pyroprocessing is a form of reprocessing, and the United States should oppose the spread of this technology to additional countries just as it opposes the spread of aqueous reprocessing technologies. Recent reports suggesting that the United States is willing to support pyroprocessing in South Korea are particularly troubling, as South Korea, in addition to its past reprocessing-based nuclear weapons program, also has an agreement with North Korea prohibiting enrichment and reprocessing on the Korean peninsula. A South Korean move away from that agreement would likely make elimination of North Korea's nuclear weapons program more difficult to achieve.

Another difficulty is that these processes may make it easier for states to divert a significant quantity of plutonium without detection by international inspectors. Nuclear material accounting for safeguards is already an immense challenge at traditional PUREX reprocessing plants that separate pure plutonium, with accounting uncertainties in the range of 1 percent at plants processing 6-10 tons of plutonium every year. By keeping a variety of radioactive materials with the plutonium, UREX+ and pyroprocessing approaches will make accurate nuclear material accounting for safeguards substantially *more* difficult, forcing a greater reliance on containment and surveillance.[6]

A second set of proliferation issues focuses on possible theft of plutonium by subnational groups. While reactor-grade plutonium would not be the preferred material for making nuclear bombs, it does not require advanced technology to make a bomb from reactor-grade plutonium: any state or group that could make a bomb from weapon-grade plutonium could make a bomb from reactor-grade plutonium.[7] Despite the remarkable progress of safeguards and security technology over the last few decades, processing, fabricating, and transporting tons of weapons-usable separated plutonium every year – when even a few kilograms is enough for a bomb – inevitably raises greater risks than not doing so. Indeed, while many of the stocks of civil plutonium that have built up are well-guarded, critics have argued that some operations in the civilian plutonium industry are potentially vulnerable to nuclear theft.[8]

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[5] James Timbie, U.S. Department of State, remarks to an open meeting of the U.S. National Academy of Sciences-Russian Academy of Sciences Committee on Internationalization of the Nuclear Fuel Cycle, 17 October 2006.

[6] For a discussion, see Edwin S. Lyman, "The Global Nuclear Energy Partnership: Will it Advance Nonproliferation or Undermine It?" in *Proceedings of the Institute for Nuclear Materials Management 47th Annual Meeting,* Nashville, Tennessee, 16-20 July 2006 (Northbrook, IL: INMM, 2006, available as of 11 November 2007 at http://www.npec-web.org/Essays/20060700-Lyman-GNEP.pdf); see also von Hippel, *Managing Spent Fuel in the United States,* pp. 23-24.

[7] For an authoritative unclassified discussion, see *Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives,* DOE/NN-0007 (Washington DC: U.S. Department of Energy, January 1997), pp. 38-39.

[8] Ronald E. Timm, *Security Assessment Report for Plutonium Transport in France* (Paris: Greenpeace International, 2005; available as of 12 November 2007 at www.greenpeace.fr/stop-plutonium/en/TimmReportV5.pdf).

The administration has acknowledged that the huge stockpiles of weapons-usable separated civil plutonium built up as a result of traditional PUREX reprocessing (now roughly equal to all world military plutonium stockpiles combined, remarkably) "pose a growing proliferation risk" that "simply must be dealt with." [9]

In claiming that GNEP processes would pose lower risks, DOE officials have repeatedly emphasized that GNEP approaches will produce "no pure plutonium." Remarkably, DOE reports that this was the "only requirement" the department imposed on the technologies industry could propose for near-term construction.[10] But "no pure plutonium" is a slogan, not an analysis of proliferation resistance. Pure plutonium is not needed to make a nuclear bomb.

The COEX process proposed by some for a near-term reprocessing plant, for example, which extracts the plutonium and some of the uranium together, poses nearly as much risk as processes that separate pure plutonium. The uranium-plutonium mix could be used directly in a bomb, or the plutonium could readily be separated even in a crude, jerry-rigged glove box, using commercially available equipment and materials.. Any state or group capable of doing the technically challenging job of making a nuclear bomb from pure plutonium would likely be able to do the simpler job of getting pure plutonium from a plutonium-uranium mix without fission products. For these reasons, under either Nuclear Regulatory Commission (NRC). or international guidelines, such a mixture would still be considered Category I material, posing the highest levels of security risk and requiring the highest levels of security.[11] When such approaches were last seriously considered in the United States three decades ago, the Nuclear Regulatory Commission concluded that "lowering the concentration of plutonium through blending [with uranium] should not be used as a basis for reducing the level of safeguards protection," and that the concentration of plutonium in the blend would have to be reduced to ten

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[9] Samuel Bodman, "Carnegie Endowment for International Peace Moscow Center: Remarks as Prepared for Secretary Bodman" (Moscow: U.S. Department of Energy, 16 March 2006; available at http://energy.gov/news/3348.htm as of 12 November 2007). This characterization seems oddly out of tune with the schedule of the administration's proposed solution, advanced burner reactors that will not be available in significant numbers to address this "growing" risk for decades. In a similar vein, the British Royal Society, in a 1998 report, warned that even in an advanced industrial state like the United Kingdom, the possibility that plutonium stocks might be "accessed for illicit weapons production is of extreme concern." The Royal Society, *Management of Separated Plutonium* (London: Royal Society, 1998, available as of 12 November 2007 at http://www.royalsoc.ac.uk/displaypagedoc.asp?id=18551). The Royal Society renewed this warning and analyzed the options for action in a 2007 report. See The Royal Society, *Strategy Options for the UK's Separated Plutonium* (London: The Royal Society, September 2007, available as of 12 November 2007 at http://www.royalsoc.ac.uk/displaypagedoc.asp?id=27169).

[10] U.S. Department of Energy, Office of Nuclear Energy, "DOE Response to NAS-NRC Report Review of DOE's Nuclear Energy Research and Development Program" (Washington DC: 29 October 2007, available as of 11 November 2007 at http://www.gnep.energy.gov/pdfs/NAS_Response.pdf).

[11] See, for example, the categorizations in U.S. Nuclear Regulatory Commission, "Part 73-Physical Protection of Plants and Materials," in *Title 10, Code of Federal Regulations* (Washington, D.C.: U.S. Government Printing Office; available as of 12 November 2007 at http://www.nrc.gov/reading-rm/doc-collections/cfr/part073/full-text.html); International Atomic Energy Agency, *The Physical Protection of Nuclear Material and Nuclear Facilities*, INFCIRC/225/Rev.4 (Corrected) (Vienna: IAEA, 1999; available as of 12 November 2007 at http://www.iaea.or.at/Publications/Documents/Infcircs/1999/infcirc225r4c/rev4_content.html). Any effort to define such a facility at only requiring Category II safeguards, on the basis of DOE's starkly different (and in important respects misguided) categorization guidelines, should be firmly rejected.

percent or less – far less than being considered for COEX – for the safeguards advantages to be "significant."[12]

For the longer term, GNEP is looking at processes such as the UREX+ family, in which the actinides and possibly some of the lanthanide fission products would stay with the plutonium. But the processing proposed in UREX+ still takes away the great mass of the uranium and the vast majority of the radiation from the fission products, making it far easier to recover plutonium from the product than from unprocessed spent fuel. Actinides with which the plutonium would be mixed, such as neptunium, are also potentially potent nuclear bomb materials. The situation for pyroprocessing is different in specifics, but not in the overall conclusion. Indeed, the plutonium-bearing materials that would be separated from aged spent fuel in either the UREX+ process or by pyroprocessing would not be radioactive enough to meet international standards for being "self-protecting" against possible theft.[13]

Proponents of reprocessing and recycling often argue that this approach will provide a nonproliferation benefit by consuming the plutonium in spent fuel, which would otherwise turn geologic repositories into potential plutonium mines many hundreds or thousands of years in the future. But the proliferation risk posed by spent fuel buried in a safeguarded repository is already modest; if the world could be brought to a state in which such repositories were the most significant remaining proliferation risk, that would be cause for great celebration. Moreover, this risk will be occurring a century or more from now, and if there is one thing we know about the nuclear world a century hence, it is that we know almost nothing about it. We should not increase significant proliferation risks in the near term in order to reduce already small and highly uncertain proliferation risks in the distant future.[14]

In short, all of the spent fuel processing approaches proposed for GNEP pose higher, not lower, proliferation risks than are posed by not processing the spent fuel at all and continuing to rely on a once-through fuel cycle. Some of these approaches do offer modest proliferation advantages compared to the traditional PUREX reprocessing approach. But there are no grounds for confidence that our pursuit of these technologies will convince other countries to phase out the PUREX processes in which they have made large investments, particularly as processes such as UREX+ add several complex steps and are therefore likely to be more expensive.

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[12] Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, *Safeguarding a Domestic Mixed Oxide Industry against a Hypothetical Subnational Threat*, NUREG-0414 (Washington, D.C.: NRC, 1978), pp. 6.8-6.10.

[13] Keeping the actinides with the plutonium provides only a small fraction of the radiation level considered "self-protecting" by international standards – 1 Sievert/hr at 1 meter, a standard that should itself be fundamentally reexamined in an age of suicidal terrorists. The lanthanide fission products have relatively short half-lives, and only provide substantial radiation fields if the spent fuel is processed fairly quickly after discharge. See Jungmin Kang and Frank von Hippel, "Limited Proliferation-Resistance Benefits From Recycling Unseparated Transuranics and Lanthanides From Light-Water Reactor Spent Fuel," *Science and Global Security*, Vol. 13, pp. 169-181, 2005, available as of 12 November 2007 at http://www.princeton.edu/
~globsec/publications/pdf/13_3%20Kang%20vonhippel.pdf.

[14] For a discussion, see John P. Holdren, "Nonproliferation Aspects of Geologic Repositories," presented at the "International Conference on Geologic Repositories," October 31-November 3, 1999, Denver, Colorado).

Ultimately, proliferation resistance should not be judged solely on how much material other than plutonium there may be in the product of a particular process, or how radioactive that product might be. Rather, it should be judged by a full life-cycle examination of how the deployment of such technologies by some states might affect the spread of sensitive technologies to other states; how much access to the materials, facilities, and expertise involved in the proposed fuel cycle would reduce the time, cost, and observability of a state nuclear weapons program; and how the large-scale adoption of such a fuel cycle would affect the risks of nuclear theft and nuclear terrorism around the world.[15]

Security against sabotage

Construction of a large reprocessing facility using the technologies available now or in the near term would also be likely to increase risks of terrorist sabotage. While such facilities could be designed and operated with stringent anti-terrorist security measures, reducing this risk to a modest level, transporting and processing thousands of tons of intensely radioactive spent nuclear fuel inevitably involves more opportunities for terrorist mischief than leaving that spent fuel in large steel or concrete casks.

Not the biggest risks

In a world facing challenges from North Korea, Iran, black-market nuclear networks, and nuclear materials more vulnerable to terrorist theft than GNEP facilities are likely to be, the risks I have just described are not the biggest proliferation problems. But they are entirely unnecessary risks to run.

Costs of reprocessing and recycling

Reprocessing using technologies available now or in the near term is likely to be substantially more expensive than direct disposal of spent fuel.[16] The UREX+ technology now being pursued adds a number of complex separation steps to the traditional PUREX process, and would likely be even more expensive. The capital cost of fast-neutron reactors such as those proposed for GNEP has traditionally been significantly higher than that of light-water reactors. A National Academy of Sciences review of separations and transmutation technologies such as those proposed for GNEP concluded that the additional cost of recycling compared to once through for 62,000 tons of commercial spent fuel "is likely to be no less than $50 billion and easily could be over

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[15] For a discussion, see Matthew Bunn, "Proliferation-Resistance (and Terror-Resistance) of Nuclear Energy Systems" lecture, Massachusetts Institute of Technology, 1 May 2006, available at http://www.belfercenter.org/files/proliferation_resist_lecture06.pdf as of 12 November 2007. For a more elaborate methodology, see *Evaluation Methodology for Proliferation Resistance and Physical Protection of Generation IV Nuclear Energy Systems* (Paris: Gen. IV International Forum, November 2006, available as of 12 November 2007 at http://www.gen-4.org/Technology/horizontal/PRPPEM.pdf).

[16] Matthew Bunn, Steve Fetter, John P. Holdren, and Bob van der Zwaan, *The Economics of Reprocessing vs. Direct Disposal of Spent Nuclear Fuel* (Cambridge, MA: Project on Managing the Atom, Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University, December 2003, available as of 12 November 2007 at http://www.belfercenter.org/files/repro-report.pdf).

$100 billion."[17] While spent fuel management is only a small part of the cost of nuclear energy, the proposed GNEP approach would also require construction of a large fleet of fast reactors whose capital costs – the key driver of nuclear energy costs – have always been higher than those of light-water reactors. If the capital costs of fast reactors remained significantly higher in the future, processing all U.S. spent fuel in this way would cost tens or hundreds of billions of dollars more than a once-through approach. Who will pay these costs? Are we talking about many decades of government subsidies, or onerous regulations requiring private industry to pay for uneconomic activities?

The Boston Consulting Group study outlines the hope that if new facilities could be built with a much larger capacity for only modestly more money – and would operate close to capacity throughout their lives, something no real reprocessing plant has ever done – the unit costs of reprocessing might be much reduced. But the real experience of building a plant similar to the French reprocessing plant in Japan has been unit costs several times *higher* than those in France, not lower; the costs of the MOX fuel plant private firms are building for DOE, also based on French technology, are also several times *higher*, not lower, than those of the French plants. One can argue – correctly – that each of these new plants has unique problems, but why should we expect that a new reprocessing plant in the United States would avoid similar problems? No policy-maker should make decisions about reprocessing based on an expectation that the costs will be similar to those projected in the Boston Consulting Group report.

Rather than relying solely on paper analyses, one can look at the evidence from the commercial market. The British reprocessing plant will be closed in a few years because it cannot get enough contracts to keep running; the French and Russian reprocessing plants are operating at far less than capacity because of a lack of contracts; to pay the huge costs of the Japanese reprocessing plant, Japanese utilities insisted on a government bailout in the form of a wires charge that will increase the price of electricity for *all* users in Japan for many years to come. When utilities have a choice, they do not choose to reprocess their fuel.

Room at Yucca Mountain

Similarly, it is by no means clear that effective nuclear waste management and disposal in the United States will require reprocessing and recycle. Recent studies indicate that the technical capacity of the Yucca Mountain repository is far larger than the legislated capacity – large enough to support a growing nuclear energy enterprise for many decades to come.[18] GNEP is likely to make it more difficult, rather than easier, to get a license for Yucca Mountain, by creating uncertainty over what, exactly, would be disposed of there, and raising the possibility that wastes from a far larger number of reactors would be emplaced there. If Yucca Mountain opens and begins operating

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[17] U.S. National Research Council, Committee on Separations Technology and Transmutation Systems, *Nuclear Wastes: Technologies For Separation and Transmutation* (Washington, D.C.: National Academy Press, 1996), p. 7. Note that these figures are expressed in 1992 dollars; in 2006 dollars, the range would be $66-$133 billion.

[18] *Program on Technology Innovation: Room at the Mountain – Analysis of the Maximum Disposal Capacity for Commercial Spent Nuclear Fuel in a Yucca Mountain Repository* (Palo Alto, Calif: Electric Power Research Institute, May 2006, available as of 12 November 2007 at http://www.epriweb.com/public/000000000001013523.pdf).

successfully – and a repository will certainly be required whether we continue to rely on a once-through fuel cycle or shift to a closed cycle – it may well be easier to get a license for using the next ridge over for an additional repository than it will be to get political approvals and licenses for several large reprocessing plants and dozens of fast neutron reactors.

What's best for the future of nuclear energy?

Mr. Chairman, to be against near-term reprocessing is not the same as being against nuclear power. It is precisely because I hope for a vibrant and growing future for nuclear energy, to help cope with climate change, that I am against near-term reprocessing. Nuclear power's future will be best assured by making it as cheap, simple, safe, and proliferation-resistant as possible – and near-term reprocessing points in the wrong direction on every count.[19]

Technical maturity

Fortunately, there is no pressing need to move forward with construction of a reprocessing plant in the United States in the near term. Dry casks offer a safe and proven technology that makes it possible to store spent fuel for decades at low cost. As a result, there is no need to rush to make these decisions – we can make these decisions more responsibly in the decades to come, when technology has developed further and economic, security, and political circumstances have clarified. What is needed now is patient R&D and in-depth systems analysis, rather than a rush to build commercial-scale facilities. As Richard Garwin has put it, by picking winners prematurely, the proposed GNEP approach "would launch us into a costly program that would surely cost more to do the job less well than would a program at a more measured pace guided by a more open process."[20]

It would certainly not be a sign of U.S. leadership to decide now to build a reprocessing plant little different from what France, Russia, the United Kingdom, and Japan have already built – to build, as one GNEP participant put it to me, a 1975 Cadillac. Rather, it would lock the United States in to spending many billions of dollars on decades-old technologies whose high costs and proliferation risks are already well known, and which are already failing to win contracts in the commercial marketplace.

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[19] For a similar argument that the GNEP approach "threatens to set back the nuclear revival," see, for example, Richard Lester, "New Nukes," *Issues in Science and Technology,* Summer 2006, pp. 39-46. For earlier discussions of this point, see, for example, John P. Holdren, "Improving US Energy Security and Reducing Greenhouse-Gas Emissions: The Role of Nuclear Energy," testimony to the Subcommittee on Energy and Environment, Committee on Science, U.S. House of Representatives, 25 July 2000, available as of 12 November 2007 at http://www.belfercenter.org/publication/3244/.; and Matthew Bunn, "Enabling A Significant Future For Nuclear Power: Avoiding Catastrophes, Developing New Technologies, Democratizing Decisions – And Staying Away From Separated Plutonium," in *Proceedings of Global '99: Nuclear Technology- Bridging the Millennia*, Jackson Hole, Wyoming, August 30-September 2, 1999 (La Grange Park, Ill.: American Nuclear Society, 1999, available as of 12 November 2007 at www.belfercenter.org/publication/2014/).

[20] Richard L. Garwin, "R&D Priorities for GNEP," testimony to the U.S. House of Representatives, Committee on Science, Subcommittee on Energy, 6 April 2006, available as of 12 November 2007 at www.fas.org/rlg/060406-gnep.pdf.

The idea of sending spent fuel from decommissioned U.S. reactors to France to be reprocessed, as DOE is reportedly considering,[21] has even less merit, and should be soundly rejected. The reprocessing would cost well over a billion dollars, far more than continuing to store this fuel where it is, and would simply add to the multi-billion dollar problem of excess plutonium the United States already has. DOE has correctly identified large global stockpiles of separated plutonium as a dangerous problem; dealing with that problem by reprocessing more plutonium is like using gasoline to put out a fire.

The recent National Academy of Sciences review has provided an excellent discussion of just how premature it would be to build commercial-scale facilities now, unanimously recommending against proceeding with a GNEP program focused on near-term large-scale construction. As they concluded: "There is no economic justification to go forward with this program at anything approaching commercial scale. Continued research and development are the appropriate level of activity, given the current state of knowledge." I urge the Committee to hear from the National Academy panel, to get the insights gained from their in-depth examination of the GNEP program in the context of other nuclear R&D.

Positive elements of GNEP

As I mentioned at the outset, other elements of GNEP could be significant steps to reduce the proliferation risks of nuclear energy. Unfortunately, these other elements have not received comparable emphasis and funding in the program to date.

Fuel leasing. First, providing assured fuel services, so that countries have strong incentives not to build enrichment or reprocessing plants of their own, is a potentially important idea.[22] The current emphasis is primarily on assured supplies of fresh nuclear fuel; while this is an important goal, it should be recognized that the commercial market already provides high assurance of fuel supply (except for countries that are special cases outside of or in violation of global nonproliferation norms, such as Iran and India). less need to build enrichment or reprocessing fuel leasing – that is, providing fresh fuel to countries with a promise to take the spent fuel away – would allow countries to enjoy the benefits of nuclear energy without having to build repositories. This would create a powerful new incentive for countries starting new nuclear energy programs to rely on foreign fuel supply rather than building enrichment and reprocessing of their own. (Note that existing reprocessing services offered by Britain and France, which require that the wastes be sent back to the customer, would not have this advantage.) Moreover, widespread fuel leasing would mean that plutonium-bearing spent fuel need not build up in countries all over the world. There are obvious political problems with one country taking another country's spent fuel, but we should be working to address these problems – as we have in the case of taking back spent research reactor fuel. It is important to note that take-back of modest quantities of foreign spent fuel from the small numbers of reactors likely to be build in coming decades in new nuclear countries would not in any way require that this fuel be reprocessed. Russia has already passed legislation that allows it to enter the fuel leasing business, and signed a contract with Iran that requires

[21] Jeff Beatie, "DOE Pushing to Recycle Closed Plants' Spent Fuel," *Energy Daily*, 7 November 2007.

[22] For a useful account of such fuel assurances, see Ashton B. Carter and Stephen LaMontagne, "Toolbox: Containing the Nuclear Red Zone Threat," *The American Interest*, Vol. 1, No. 3 (Spring 2006), pp. 28-40.

all of Iran's spent fuel to be shipped back to Russia. Other countries have considered being hosts for international waste storage facilities. It only takes one of the world's 190 countries to agree to host an international repository (and if one country launched such an effort successfully, others might decide to compete with them in that highly profitable business). The country providing the fresh fuel and the country accepting the spent fuel would not necessarily have to be the same. The United States should be doing far more to make this vision a reality.[23]

Reducing stockpiles of separated plutonium. Second, the huge global stocks of weapons-usable civilian separated plutonium – now as much as all the plutonium in all the world's nuclear weapons stockpiles – pose significant risks, and continue to grow. Building a reprocessing plant or a single demonstration fast reactor in the United States will not do much to solve that problem. The United States should be doing much more to work with other countries to ensure that all these stockpiles are secured to the highest practicable standards, to limit or phase out unneeded plutonium separation where possible, and to ensure that plans are put in place for reducing these immense stocks over time. In particular, the Bush administration should renew the talks with Russia, almost completed in the Clinton administration, concerning a 20-year moratorium on plutonium separation in both countries, and should cooperate with other countries to work out disposition paths for plutonium stockpiles for which there is no current plan for use or disposal.[24]

Small, exportable reactors. Third, the concept that is sometimes called a "nuclear battery" – small reactors that might be produced in a factory, shipped to a deployment site with their fuel already included, generate electricity there for 10-20 years, and then be shipped back to the factory with their spent fuel – could make it possible to have widespread use of nuclear energy with little spread of sensitive materials and expertise and few proliferation risks. Within GNEP, even the small level of funding devoted to "small and medium reactors" is largely devoted to medium-sized reactors that could not be factory-built in this way. GNEP should devote higher priority to R&D on nuclear battery concepts, and particularly to approaches that might reduce their costs – currently the main barrier to implementing this approach.

Advanced safeguards development. Fourth, as the American Physical Society has pointed out, the United States needs a major reinvestment in safeguards and security

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[23] See discussion of such international approaches in Chapter 4 of Matthew Bunn et al., *Interim Storage of Spent Nuclear Fuel: A Safe, Flexible, and Cost-Effective near-Term Approach to Spent Fuel Management* (Cambridge, Mass.: Project on Managing the Atom, Harvard University, and Project on Sociotechnics of Nuclear Energy, Tokyo University, 2001; available as of 12 November 2007 at http://www.belfercenter.org/publication/2150/), pp. 95-116. Some of the best current work in both analyzing and promoting regional or international approaches to storage or disposal of spent fuel and nuclear waste is being done by the Arius consortium. Much of this work was available as of 12 November 2007 at http://www.arius-world.org/.

[24] For a discussion, see Matthew Bunn and Anatoli Diakov, "Disposition of Excess Plutonium," in *Global Fissile Materials Report 2007* (Princeton, NJ: International Panel on Fissile Materials, October 2007, available as of 12 November 2007 at http://www.fissilematerials.org/ipfm/site_down/gfmr07.pdf), pp. 33-42. The Royal Society's report, *Strategy Options for the UK's Separated Plutonium*, outlines approaches that could be pursued for the United Kingdom's huge stock of separated civilian plutonium. The United States should encourage all countries with military or civil stockpiles of excess separated plutonium to bring unneeded separation of plutonium to an end, undertake similar examinations of their options, and implement approaches to safe and secure disposition of these stockpiles as rapidly as practicable.

technologies to support a new nuclear era.[25] DOE is taking the first steps in that direction, but much more needs to be done.

Recommendations

What, then, should be done?

First, I recommend that Congress follow the bipartisan advice of the National Commission on Energy Policy;[26] the advice of the recent National Academy of Sciences review of GNEP;[27] and the advice of the American Physical Society study of nuclear energy and nonproliferation,[28] by rejecting proposals to spend many billions of dollars on near-term construction of a commercial-scale reprocessing plant and a commercial-scale fast reactor in the United States. The Committee would be hard-pressed to find any independent scientific or engineering group that believes such construction is a good idea in the near term.

Second, Congress should redirect GNEP to focus on long-term research on (a) advanced technologies that might have the potential to overcome the large liabilities of past reprocessing and recycling approaches; (b) improved approaches to once-through systems; and (c) in-depth studies of the real repository capacity likely to be available in different scenarios and of global uranium resources. This should include a much broader set of reactor and spent fuel processing technologies than GNEP is currently pursuing; it would be a mistake to down-select and focus only on technologies that could be deployed soon, when other technologies may have more long-term promise.[29] As improved recycling and once-through technologies develop, we should regularly re-examine which of them appear to offer the best combination of cost, safety, security, proliferation-resistance, and sustainability. At the same time, we should not allow an expansion of nuclear R&D to overwhelm R&D on other promising energy technologies: the United States urgently needs to undertake expanded investments in a wide range of energy R&D.

Third, Congress should increase the funding for the positive elements of GNEP I have enumerated, and direct the administration to devote greater attention to pushing them forward. On these points, I believe the approach proposed by the Senate Energy and Water Appropriations Committee is a major step in the right direction.

Fourth, Congress and the administration should work to establish cost-effective dry cask storage approaches to address the spent fuel storage problems and costs that have resulted from continuing Yucca Mountain delays, including at least a small amount

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[25] Nuclear Energy Study Group, American Physical Society Panel on Public Affairs, *Nuclear Power and Proliferation Resistance: Securing Benefits, Limiting Risk* (Washington, D.C.: American Physical Society, May 2005, available as of 12 November 2007 at http://www.aps.org/policy/reports/popa-reports/proliferation-resistance/upload/proliferation.pdf).

[26] National Commission on Energy Policy, *Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges* (Washington, D.C.: National Commission on Energy Policy, December 2004, available as of 12 November 2007 at http://www.energycommission.org/files/contentFiles/report_noninteractive_44566feaabc5d.pdf), pp. 60-61.

[27] Committee on Review of DOE's Nuclear Energy Research and Development Program, *Review of DOE's Nuclear Energy Research and Development Program* (Washington, D.C.: National Academy Press, October 2007, available as of 12 November 2007 at http://www.nap.edu/catalog/11998.html).

[28] APS, *Nuclear Power and Proliferation Resistance.*

[29] For a discussion, see Garwin, "R&D Priorities for GNEP." For a discussion of R&D that should be pursued on improved once-through options, see Deutch, Moniz, et al., *The Future of Nuclear Power.*

of centralized storage to address problems at decommissioned reactors.[30] Whatever option for spent fuel disposal or processing we pursue, additional interim storage capacity will be needed. Storing spent fuel in dry casks leaves all options open for the future, as technology develops and political and economic circumstances change. (Indeed, since the Yucca Mountain repository will remain open for a century or more, even direct disposal will leave all options open for a long time to come.) At least some centralized storage capacity is needed to address particular needs; whether nearly all of the spent fuel should be moved to a centralized away-from-reactor site or site depends on a number of factors that require further analysis. Here, too, we should not let frustration with the current state of affairs prevent us from taking the time to get it right: a rushed process for siting and licensing such facilities is a recipe for public opposition and ultimate failure, adding to the long history of failed attempts to site centralized interim storage facilities in the United States. In a 2001 study, we provided a detailed outline of a democratic and voluntary process for siting such facilities, based on approaches that had been applied successfully in siting other hazardous and unwanted facilities, and I would urge that such an approach be followed here.[31]

Fifth, Congress and the administration should work together to redouble U.S. efforts to stem the spread of nuclear weapons – resolving the crises with Iran and North Korea, securing nuclear stockpiles around the world, stopping black-market nuclear networks, and more.[32] Ultimately, this will also require reducing the demand for nuclear weapons, in part by reducing the number, roles, and readiness of our own.

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[30] For recent discussions, see, for example, American Physical Society, Nuclear Energy Study Group, *Consolidated Interim Storage of Commercial Spent Nuclear Fuel: A Technical and Programmatic Assessment* (College Park, MD: American Physical Society, February 2007, available as of 12 November 2007 at http://www.aps.org/policy/reports/popa-reports/upload/Energy-2007-Report-InterimStorage.pdf); National Commission on Energy Policy, *Energy Policy Recommendations to the President and the 110th Congress* (Washington, D.C.: National Energy Commission, April 2007, available as of 12 November 2007 at http://energycommission.org/files/contentFiles/NCEP_Recommendations_April_2007_4656f9759c345.pdf), pp. 21-22; and Keystone Center, *Nuclear Power Joint Fact-Finding*, pp. 75-79.

[31] Bunn et al., *Interim Storage of Spent Nuclear Fuel*, pp. 95-116.

[32] For a reasonable first cut at an agenda of steps to be taken, see George Perkovich et al., *Universal Compliance: A Strategy for Nuclear Security* (Washington, D.C.: Carnegie Endowment for International Peace, 2005; available at http://www.carnegieendowment.org/files/UC2.FINAL3.pdf as of 13 May 2007). For an agenda of steps to be taken specifically on preventing nuclear terrorism, see Matthew Bunn, *Securing the Bomb 2007* (Cambridge, Mass.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, September 2007, available as of 12 November 2007 at http://www.nti.org/e_research/securingthebomb07.pdf).