Hearing on R&D Priorities in the Global Nuclear Energy Partnership

Testimony of
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before the
Subcommittee on Energy
Committee on Science
United States House of Representatives

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Madam Chairwoman and Members of the Committee:

It is an honor to be called before you to discuss the subject of the Global Nuclear Energy Partnership, a matter of considerable importance to the future of nuclear energy as well as to the effort to prevent the further spread of nuclear weapons.[1]

The GNEP program offers a strategic vision for the expanded use of nuclear energy in the U.S. and the world. Its goals are to ease the long-term management of spent fuel by destroying the transuranic (TRU) elements that contribute most to the long-term radiological risk and to reduce proliferation risk by creating a fuel cycle supplier and user state regime. This will enable other nations, including developing nations, to acquire/expand nuclear energy while minimizing proliferation risk. Achievement of these goals as a long-term objective is highly desirable.

However, my concerns deal with the apparent schedule of rapid implementation of the GNEP program elements – a schedule which implies near-term choice and deployment of reprocessing technologies, fast reactor fuel, fast reactor design characteristics as well as associated reactor demonstration facilities. These near-term choices are not necessary since alternate approaches are sufficient for spent fuel and proliferation management over the time period before GNEP could provide an effect. Rapid implementation of choices is unwise since it threatens the successful execution of a GNEP program. By successful

[1] Previous hearings of this Subcommittee reviewed the security and economic aspects of reprocessing, a key element of the GNEP vision.

program execution I mean effective integration and coordination of the program elements, expenditures which are both reasonable and sustainable considering program benefits, protection of public as well as worker health and safety, facilities with adequate and demonstrable physical protection and an expanding nuclear deployment with adequate proliferation safeguards.

My focus this morning will be on the formulation and timing of the R&D program underlying such a successful GNEP program execution. The broader questions of the alternate approaches to deal with GNEP goals in the next several decades as well as GNEP's potential detrimental effect on nearer-term nuclear priorities such as achievement of the Nuclear Power 2010 program I'll set aside for industry representatives and your later questions.

I speak on the GNEP program based on the limited open literature materials I have found (Appendix A). As a member of the general nuclear community, I have not been briefed on GNEP; as a member of NERAC, I have had access to only a very general DOE briefing and the recent report of our relevant Subcommittee. In sum, I must say the depth of detail on GNEP provided by DOE through these sources is technically very meager.

I will frame my views through comment on the key facilities of GNEP and particularly their missions and timelines. (Appendix B) It is these deployment schedules which shape the allowed breadth and depth of the R&D associated with each facility. I have found no information on the projected costs of these facilities. This is not unreasonable since the process selection and designs of these facilities are likely in their infancy – a situation I respect but which reflects the significant R&D challenge ahead.

From the GNEP website, the first facility to be operational is the Simulation & Visualization Laboratory. Simulation and Visualization are properly the initial step underlying all subsequent selections among process, fabrication and reactor design choices. It is here that R&D data are used to formulate and/or validate predictive models for such selections. Our MIT Study on the Future of Nuclear Power (7/03) highlighted the lack of such capability in our nuclear program and recommended that it receive the largest sustained R&D expenditure ($100M/year over 10 years) among the eleven program elements we proposed.

The Engineering Scale Demonstration (ESD) is the next facility to be operational, in 2011. Here the process for separating uranium and short-lived fission products from the transuranics and longer-lived fission products is to be demonstrated at an engineering significant scale. The transuranics are to be supplied to the next facility, the Advanced Fuel Cycle Facility (AFCF), for conversion and fabrication into fast reactor fuel.[*] The selection of the ESD separation process is the first critical fuel cycle step of GNEP. The UREX+1 process and its capacity at 100-200 tons per year have been selected. This capacity is about 4 to 8% of the anticipated full-scale need for our LWR fleet. The important question is whether there exists satisfactory basis for this selection process for scale-up from the laboratory to a pilot plant. The criteria against which these questions must be answered are process economics, safety, materials accountability and physical protection. I have not been privy to the evidence which supports the current GNEP selections. Some demonstration above laboratory scale must be made – it must not be made prematurely because it locks GNEP into a critical, likely irreversible path.

The Advanced Burner Test Reactor (ABTR) is next operational in 2014. Nuclear fuel, because of the long lead time needed for irradiation testing, is always the critical path item in reactor development. For transmutation in TRU fueled elements such testing is essential, hence the need for a test reactor. Limited testing capability exists in Japanese, Russian, Indian and – for a very limited future period – French reactors, which I presume is being arranged. The U.S. facility, the FFTF, is now unavailable – is it irretrievably lost to us? I support the need for a U.S. fast spectrum test reactor as part of a robust R&D program. Timing dictates it be sodium cooled and, likely at least initially, oxide fueled. Since Advanced Burner Reactors of similar design may follow, the construction and safety standards as well as the regulatory review process developed for this test reactor

[*] Lanthanide fission products are likely extracted in the TAL SPEAK process before TRU conversion and fabrication into fuel elements.

can be tailored to set precedent and practice for this follow-on fleet. This was the practice followed in the execution of the FFTF project. While costly to the test reactor schedule, such a practice significantly enhances the progress of deployment of any follow-on power reactor fleet. A 2014 operational target date is most aggressive but the goal can be reached in the 2010s decade.

The Advanced Fuel Cycle Facility (AFCF) is envisioned as a multi module facility first operational in 2016. It will have modules to perform production scale

1) separations operations on spent LWR fuel,
2) remote fabrication of TRU-bearing fuel for Advanced Burner Reactors,
3) spent fast reactor fuel processing.

This is the mainstay facility for execution of the closed fuel cycle. It is critical that the fast reactor fuel selected allow achievement of both the desired fast reactor performance characteristics and the needed processing and fabrication characteristics. The economics, safety, materials accountability and physical protection of the GNEP closed cycle must be reasonably assured through simulation and visualization based on firm R&D results before construction of such a facility is undertaken. The announced schedule of achievement of operational modules for these three functions between 2016 and 2019 is highly optimistic.

The deployment of Advanced Burner Reactors (ABR) for TRU management then follows beginning in 2023. These fast reactors are likely to be sodium cooled, although gas and liquid lead cooled designs are possible. This selection was one of the goals of the Generation IV downselect process which the current level of research activity does not support. ABRs will be electricity producers owned and operated by industry along with the thermal LWRs needed to achieve expected nuclear power demand. Significant deployment of ABRs will be needed to measurably impact TRU management. It is therefore essential that these ABRs produce electricity at cost competitive with the LWRs. Given that the fuel cycle is likely to be more expensive than the existing once-through cycle and when last built in the 1990s sodium fast reactors were 1.2 to 1.5 times the capital cost of LWRs, this prospect is daunting. To achieve cost competitiveness a major R&D effort on cost efficient fast reactor innovations is essential. Its success is far from assured. The proposed timeframe of ABR deployment in 2023 is most unlikely considering the time needed to select and test its fuel, develop its reprocessing technology, make its design cost effective and, importantly, effectively engage industry as the owners and operators of the subsequent ABR fleet.

It is also not obvious why, at least for a transition period of multiple decades, a two-tier strategy is not envisioned to allow a fast reactor concept to be designed and tested. One such strategy would recycle the plutonium plus the other actinides in fertile free pins which comprise a fraction of a LWR core. Although final passes in a fast spectrum are likely needed because of curium buildup in a thermal spectrum, thermal recycling has been determined to destroy significant quantities of TRU. The benefit of this scheme is the existing availability of operating LWRs to do this transmutation function.

The final facilities in GNEP are Small-Scale Reactors for developing economies for which fresh fuel would be provided and spent fuel returned to the supplier states. The small scale is not necessitated by the fuel cycle but rather the electrical grid and capital structure of the developing economy. Such a supply and spent fuel return arrangement would provide adequate proliferation safeguards in an era of worldwide expansion of nuclear technology. It is, however, by no means certain that the capital and fuel cycle costs of these small-scale reactors would yield an attractive cost of electricity (COE) for these economies. Considerable R&D needs to be supported by DOE to refine such designs to a level where realistic COE can be projected and proliferation resistant effectiveness assessed especially if fast spectrum design options are to be considered. There are, however, some innovative LWR designs already existing and pebble bed reactors being developed in South Africa and China that offer considerable advances in reactor safety features which bode well for introduction of nuclear power into technically unsophisticated nuclear economies, if competitive COE can be achieved.

Two important topics remain – first, the proliferation dangers of diffusion of reprocessing technology and second, the readiness of the U.S. educational infrastructure to sustain the

GNEP. The first involves the proposition that these dangers are so serious that all work should be avoided, especially since the practical need for deployment of reprocessing is so distant. The alternate view is that U.S. R&D is necessary to maintain U.S. credibility and influence in international affairs.

Quoting from a working paper of the MIT Study (Deutch, 2/03), "There are basically three costs of the U.S. not supporting separation technology going forward. First, and most importantly, we will lack the technical knowledge to be credible and influential in the evolution of commercial nuclear power. Second, we will not acquire the knowledge necessary to develop effective safeguards for operating reprocessing facilities in other nations. Third, we will not acquire the knowledge to permit us to make timely and informed judgments about long-term options for closed nuclear fuel cycles that may be of importance in future generations." These costs dictate that we pursue such R&D.

In closing, let me remind you that this Partnership is a very technically intensive and long-term undertaking. Its execution and certainly its probability of success will depend heavily on the technical strength of the new generation of nuclear professionals recruited to its ranks. The U.S. nuclear academic community today lacks depth in faculty skilled in recycling and particularly reprocessing as well as fast reactor analysis and design technology. Consequently, the stream of graduates in these areas is very small. The Department's AFCI program has started an education assistance initiative which I presume will be subsumed by a GNEP program. However, these very limited actions need the existence of the broader program of Department nuclear education support to build and sustain the infrastructure necessary for the success of these limited, targeted AFCI/GNEP fellowship programs. University administrators look to government and industry support of such programs for indication that the nuclear renaissance is real. It is ironic and self-defeating that, coincident with the launching of GNEP, the Department has proposed termination of its University Reactor Fuel Assistance and Support Program, which is a primary vehicle for supporting nuclear engineering graduate students and university faculty research.

In summary, GNEP is worthy of pursuit; however, there are serious decisions about its possible and optimum pace to be resolved which involve technical readiness, facility processes and scale, and the consequences of redirecting essentially most of the available funding for nuclear energy to this effort.

Appendix A

Sources Consulted

1. DOE websites
   www.gnep.gov   or
   www.gnep.energy.gov

2. Advanced Fuel Cycle Initiative, FY 2007 Congressional Budget Request

3. Statement of Clay Sell to FY 2007 Appropriations Hearing on the Global Nuclear Energy Partnership, March 2006

4. GNEP Presentation to Nuclear Energy Research Advisory Committee (NERAC) on February 22, 2006 by R. Shane Johnson, Acting Director, Office of Nuclear Energy, Science and Technology, US DOE

5. Presentation on March 10, 2006 by Phillip Finck, Argonne National Laboratory, "The Benefits of the Closed Nuclear Fuel Cycle"

6. EPRI-INL, Nuclear Energy Development Agenda, January 4, 2006

7. Report of NERAC's ANTT Subcommittee of March 22, 2006 transmitted to NERAC for review

Appendix B

GNEP Facilities*

Facility	Mission	Schedule
Advanced Simulation Laboratory	Computer simulations and visualizations in support of the design of facilities and processes	Operational by 2008
Engineering Scale Demonstration (ESD)	• "Large scale" demonstration of UREX+1 separation process (100 to 500 MT/yr) sized to provide insights for designing a 2500 MT per year facility in the next 15-20 years • Provide "required" TRU* for ABR fuel (assumes deployment of commercial-scale ABRs will start in 2022 – 4 module units with each module 840 MWt (320 MWe)	Operational by 2011.
Advanced Burner Test Reactor (ABTR)	Burner demonstration reactor for: • TRU-bearing fuel multi-cycle demonstration • ABR licensing • ABR TRU-bearing fuel qualification.	Operational by 2014.
Advanced Fuel Cycle Facility (AFCF)	Four-module facility to develop and demonstrate advanced fuel cycle technologies at engineering scale • Remote TRU-bearing transmutation fuel fabrication (rod and subassembly scale; ≤8 LTA/yr) • Integrated aqueous separation process development and demonstration using LWR spent nuclear fuel (≤25 MT/yr) • Integrated dry process development and demonstration using fast reactor spent fuel (≤1 MT/yr) • Advanced safeguards instrumentation for materials protection, control, and accountability, and advanced control and monitoring systems.	Facility operational by 2016 (first module) Fuel fabrication module: 2016 Aqueous separation processing module: 2017 Pyroprocessing module: 2019
Advanced Burner Reactors (ABR)	Reactors for actinide treatment and Pu burn up.	Wide-scale deployment of 4-module plants (each module 840 MWt/320 MWe) beginning in 2023.
Small-Scale Reactors	To be made available to emerging economies for safely expanding nuclear energy without increasing proliferation concerns.	Deploy demonstration plants in parallel with advanced fuel cycle demonstrations.

*Adapted from NERAC ANTT Subcommittee report and GNEP website