Nuclear Power Partnerships

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DOE Perspectives on
Global Nuclear Energy Partnership Implementation

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Although introduced as Assistant Secretary for Nuclear Energy, I am designated as the GNEP Program Manager and it is with that hat that I am speaking to you today. GNEP is not just an Office of Nuclear Energy program. NNSA, Office of Science, and Civilian Radioactive Waste Management all have major roles. It is also more than just a DOE program, with the Department of State also having a major role. GNEP is a Presidential Initiative.

It is important to note, however, that we do not have an FY'07 appropriations bill. We are operating under a continuing resolution that makes no provision for new starts. Following the results of last Tuesday, it is anybody's guess as to when we will have an appropriation bill. The total of new money currently available for GNEP implementation is $0.

With that in mind, everything I say today that pertains to GNEP implementation needs to carry the qualification, "DOE Proposal."

Global Nuclear Energy Partnership Statement of Principles

The goal of the Global Nuclear Energy Partnership (GNEP) is the expansion of nuclear energy for peaceful purposes worldwide in a safe manner that supports clean development without air pollution or greenhouse gases, while reducing the risk of nuclear proliferation.

To ensure that nuclear energy makes a major contribution to global development into the 21st century consistent with non-proliferation and safety objectives, cooperation among GNEP partners will include the following objectives:

• Expand nuclear power to help meet growing energy demand in an environmentally sustainable manner and in a way that provides for safe operations and management of wastes.

• Develop, demonstrate, and deploy advanced technologies for recycling spent nuclear fuel that do not separate plutonium, with the goal over time of ceasing separation of plutonium and eventually eliminating stocks of pure plutonium and drawing down existing inventories of civilian spent fuel. Such advanced fuel cycle technologies, when available, would substantially reduce nuclear waste and simplify its disposition.

- Develop, demonstrate, and deploy advanced reactors that consume transuranic elements from recycled spent fuel.
- Establish international supply frameworks to enhance reliable fuel supplies to the world market for the purpose of generating nuclear energy, by providing nuclear fuel which would be taken back for recycling, without spreading enrichment and reprocessing technologies.
- Promote the development of advanced, proliferation resistant nuclear power reactors appropriate for the power grids of developing countries and regions.
- In cooperation with the IAEA, continue to develop enhanced nuclear safeguards to effectively and efficiently monitor nuclear materials, to ensure nuclear energy systems are used only for peaceful purposes.

International cooperation among GNEP partners will be carried out under existing and, where appropriate, new bilateral arrangements as well as existing multilateral arrangements such as the Generation IV International Forum and the International Project on Innovative Nuclear Reactors and Fuel Cycles.

Commitments and international obligations, including IAEA safeguards and the requirements of UN Security Council Resolution 1540 will be strictly observed. The highest levels of nuclear safety and security will be maintained.

States which share these goals will be welcome to participate. Through international cooperation, partners aim to accelerate development and deployment of advanced fuel cycle technologies to encourage clean energy development and prosperity worldwide, improve the environment, and reduce the risk of nuclear proliferation. Participating States would not give up any rights, but voluntarily engage to share the effort and gain the benefits of economical peaceful nuclear energy.

We have discussed these principles with the major fuel cycle states and have incorporated comments received to date.

IMPLEMENTATION

The need for nuclear energy to play a major role in meeting base load electrical energy requirements is now recognized by most of the world's industrialized nations. Similarly, in the United States there is growing recognition of the need to start building new nuclear power plants as soon as possible and to rebuild our national nuclear infrastructure – needs supported by both the Energy Policy Act of 2005 and DOE's Nuclear Power 2010 program. What I will discuss today is a proposed implementation strategy to enable a world-wide increase in the use of nuclear energy safely, without contributing to the spread of nuclear weapons capabilities, and in a manner that responsibly disposes of the waste products of nuclear power generation.

Criteria

Proliferation/Safeguards Risk

Two parts of the nuclear fuel cycle that have the greatest potential of misuse for the purpose of developing nuclear weapons are the enrichment process and the spent fuel reprocessing/refabrication process. Enrichment facilities typically separate uranium with a U235 content of 2.5% to 5% for use in a nuclear power plant, which is not weapons useable. However, the same enrichment technology could be used to produce highly enriched uranium that would be weapons useable. Similarly, a reprocessing plant using solvent extraction technology takes used fuel from a reactor and separates the remaining useable nuclear fuel (plutonium and uranium) from other waste products. As long as the fissile materials remain combined with sufficient quantities of non-fissile materials the product is not directly useable as a nuclear weapon. However, the same technology can separate plutonium and could be used for weapons purposes. Safeguarded nuclear power plants do not by themselves present a significant proliferation risk.

The risk of non-peaceful use of the civilian nuclear fuel cycle comes from two principal sources: (1) a nation wanting to advance toward the capability to build nuclear weapons in a shorter period of time and (2) a terrorist group wanting to divert nuclear materials to quickly fabricate and explode an improvised nuclear device or a dirty bomb. GNEP aims to address both of these issues by providing incentives to forego enrichment and reprocessing facilities, and by eliminating over time excess stockpiles of civil plutonium.

Proliferation Prevention

Preventing the spread of commercial nuclear technology does not by itself prevent the spread of weapons capability. Several countries that have no commercial nuclear reactors have either developed or sought to develop nuclear weapons. The plutonium contained in spent fuel discharged from a Light Water Reactor is not considered “weapons grade.” However, plutonium separated from spent nuclear fuel could be fashioned into a weapon and achieve a nuclear yield of some magnitude. Further, both centrifuge enrichment plants and chemical reprocessing plants can be adapted from commercial use to weapons use.

For the past 30 years the United States has conducted research to develop advanced methods of reprocessing spent commercial nuclear fuel that might make reprocessing easier to safeguard and more proliferation- resistant. Advances have been made in developing processes that are easier to safeguard, allow improved materials accountability, are more resistant to terrorist threat, and offer the possibility of placing a much reduced burden on our waste disposal facilities.

However, there is no technology “silver bullet” that can be built into an enrichment plant or reprocessing plant that can prevent a country from diverting these commercial fuel cycle facilities to non-peaceful use. From the standpoint of resistance to rogue-state proliferation there are limits to the nonproliferation benefits offered by any of the advanced chemical separations technologies, which generally can be modified to produce plutonium if a nation is willing to withdraw from the Non-Proliferation Treaty (NPT) or violate its NPT or safeguards obligations.

One challenge we face is that all nations that have signed the NPT retain the right to pursue enrichment and reprocessing for peaceful purposes in conformity with article I and II of the Treaty. GNEP seeks to develop advanced fuel cycle technology for civil purposes, centered in existing fuel cycle states that would allow them to provide fuel services more cheaply and reliably than other states could provide indigenously.

Terrorist Threat Reduction

In the most general terms, GNEP seeks to eliminate over time excess stocks of separated plutonium and reduce stocks of spent fuel worldwide, thereby strengthening nuclear security worldwide.

In more specific terms, a key objective with respect to any GNEP recycling facility is to deny access to fissile nuclear materials of critical mass that could be readily made into a nuclear device. Supportive policies can be implemented in this regard: (1) minimize transportation; keep fissile materials inside one integrated facility from the time used fuel enters until recycled material leaves; (2) maintain a mixture of fissile material with non-fissile material in a ratio that is not easily useable as a weapon; (3) use advanced safeguards and security techniques; and (4) maintain a goal of minimizing the buildup of, and eventually eliminating, stockpiles of separated civilian plutonium.

Reduce Repository Burden

Commercial spent nuclear fuel can either be disposed of directly into a repository (e.g., Yucca Mountain in the U.S.) or reprocessed/recycled and the byproduct high level waste sent to a repository.

The PUREX reprocessing technology currently in use in France and the U.K., for example, has three basic product streams: uranium, plutonium, and vitrified high level waste that includes fission products and minor actinides. Other residues include the cladding hulls, process wastes and some noble gases. (Japan mixes some uranium with the plutonium at the end of their process so no pure plutonium exits in the final reprocessing stage. Both France and a U.S. company have proposed a variant of their process that does not result in a pure plutonium product stream.)

The vitrified waste product can be uniform, well characterized and robust. Repository capacity would also be increased through this recycling method (because of the change in the waste form) and the amount of spent fuel to be disposed of would decrease, thus resulting in a double benefit to our waste disposal obligations. The actual volume of that benefit could vary substantially depending on factors such as the length of time the spent fuel is cooled prior to reprocessing. Reprocessing using this proven and currently available technology (light water reactor with a mixed oxide fuel) would offer some minor benefit to the repository but would not meet the GNEP objectives.

The full benefit envisioned for the separations process in GNEP anticipates substantial repository benefits (by separating out all the actinides) and a reduction in liquid process waste. The most significant repository benefits can be achieved by removing the very long-lived minor actinides and recycling them as part of the fuel for fast reactors. To obtain a repository capacity increase ranging from one to two orders of magnitude and allow Yucca Mountain to satisfy our repository needs for the remainder of the 21st century it will be necessary to remove and fission through recycle the very long-lived minor actinides.

Further repository benefit can be achieved by removing the fission products cesium and strontium from the high level waste stream and allowing them to decay separately. These elements have a relatively short half life and after decay could be disposed of as low level waste. Additionally, removing the technetium and fixing it in a matrix with the cladding hulls could reduce the possibility of this fission product migrating away from the repository area. DOE has been conducting work on processes to achieve all of these additional advanced partitioning objectives as well as work on how to recycle and consume these materials in a fast spectrum reactor. To date these efforts have been carried out as part of the Advanced Fuel Cycle Initiative, and it is proposed to continue this work as part of the broader GNEP initiative. Similar work is being carried out in Japan, France and Russia with promising results.

Assured Fuel Supply

The implementation of a regime by which nations wanting to enjoy the benefits of nuclear energy without needing to develop the expensive indigenous capability to enrich or reprocess spent nuclear fuel was the subject of an IAEA Special Event on Assurances of Nuclear Supply and Nonproliferation on September 19-22, 2006. This event attracted 300 international participants from 61 countries and organizations. A number of proposals were put forward, all having in common that a country choosing to obtain enrichment and reprocessing on the international market should be able to have international assurance that its nuclear fuel cycle requirements will be met. The six-country concept for reliable access to nuclear fuel, the U.S. commitments to support an enriched uranium reserve, and President Putin's initiative on international nuclear fuel service centers are all paths to a common objective of assuring that all nations should be able to enjoy the benefits of nuclear energy without the burden of investing in expensive enrichment and reprocessing facilities.

The implication for the U. S. is that if we are going to participate in assuring access to nuclear fuel, and in the longer term, spent fuel services, to these countries as they enter the nuclear arena, the U.S. must have the capability to provide the needed fuel cycle services — capability that we do not currently possess. Our fuel cycle technology should also build our ability, and those of our partners, to establish and sustain "cradle to grave" fuel service or leasing arrangements over time and at a scale commensurate with the anticipated expansion of nuclear energy by helping in a major way to solve the nuclear waste challenge.

Capability and Leverage

The GNEP vision has been well received by the international nuclear community, particularly among the leading fuel cycle states. Sustaining and building on that enthusiasm depends upon the U.S. ability to get back in the commercial nuclear business and assume an active role. Participating fully in that business is essential in order to shape the rules that apply to it. The nuclear capability of the U.S. has atrophied over the past 30 years since the last nuclear plant construction permit was issued. We no longer have the capability to forge the heavy ingots needed to fabricate major nuclear reactor components. Whereas, the U.S. was once the unquestioned leader in enrichment technology we currently meet only a portion of our domestic demand with outdated technology, and we depend on foreign sources for more than 80% of our enriched uranium requirements. We have no domestic commercial fuel recycling facilities, no operating fast- or gas-cooled reactors and no operating high level nuclear waste repository. Further, each year less and less of the nuclear material in international commerce is of U.S. origin and therefore subject to U.S. consent over its transfer and use.

However, we still have more operating nuclear reactors than any other nation; we have a vision of a future world that can universally enjoy the benefits of safe, economical, emission-free energy; and we have programs and plans to put the U.S. back in the nuclear energy game in a leadership role. Much of the international interest in GNEP is predicated on the assumption and belief that the United States will follow its words with concrete actions. Prospective partners await congressional action on the GNEP budget and will in part gauge the responsiveness of their actions by it. Funding for GNEP is absolutely essential; how we spend those funds and how we leverage them to achieve the greatest effect is an equally important issue. GNEP must be more than an R&D program. No matter how successful our laboratories and universities may be in solving the remaining fuel cycle technology issues, GNEP must build facilities that have true *commercial* value in order to succeed.

Nuclear Technology: Government and Industry Role

Required Technology and Facilities

There are three facilities required to implement and thus affirm our commitment to GNEP: (1) an advanced separations facility to separate the components of spent fuel required by GNEP (here termed a Consolidated Fuel Treatment Center [CFTC]); (2) a fast reactor to burn the actinide based fuel (here termed an Advanced Burner Reactor [ABR]); to transform the actinides in a way that makes them easier to store as waste and produces electricity; and (3) an Advanced Fuel Cycle Facility (AFCF) to serve as an R&D center of excellence for developing transmutation fuels and improving fuel cycle technology.

The pursuit of these three facilities constitutes a pathway with two complementary components. The first component, the CFTC and the ABR, would be led by industry with technology support from laboratories, international partners, and universities. The second component, research and development led by the national laboratories, would include the AFCF funded by the Department and located at a government site. The two components would work closely together to move GNEP forward by integrating the national laboratories' capabilities with the needs of industry.

Fast reactors already exist and there are proven separations processes. But there is a great deal of new technology that is needed to fully implement GNEP, and much of that technology can and must be developed at our national laboratories and universities in cooperation with similar international institutions. However, to effectively bring GNEP into the commercial application we need to engage industry now. Through submittal of Expressions of Interest, industry has indicated not only its support for GNEP, but a potential willingness to invest very substantial sums of private money to build and operate GNEP fuel cycle facilities.

At this early point, it should be recognized that potential industry participants have expressed interest, but certainly have made no commitments or fully explained what strings they might wish to attach to their participation. Nonetheless, a GNEP goal is to develop and implement fuel cycle facilities in a way that will not require a large amount of government construction and operating funding to sustain it. However, GNEP will also require a significant federal investment in supporting R&D and incentives to ensure that the long-term goals are sustainable.

GNEP Program Technology Action Plan

The objective of this GNEP technology and facilities implementation plan is to harness and coordinate the strengths, capabilities and resources of industry, national laboratories, universities, and international partners with the clear objective of getting commercial scale facilities that accomplish our GNEP vision into use as quickly and economically as possible. At the core of this effort will be the development of a sound, achievable business plan. The task for the next two years is to assemble the requisite technology, economic and environmental information that can present a convincing case for a path forward to commercial scale facilities that can be approved by the Secretary of Energy in a Record of Decision. Specific programmatic actions proposed include:

- **Obtain input from U.S. and international industries and governments on how best to bring the needed GNEP facilities into being, what technology and policy issues must be resolved, and what business obstacles must be overcome.** This process has already begun with the receipt of responses to DOE's request for Expressions of Interest in commercial scale fuel treatment and fast reactor facilities. These initial responses suggest that there is substantial industry interest in building and operating such facilities, and in doing so with private money and at their own risk under the proper circumstances. Separately, there appears to be genuine interest in an international fast reactor construction program.
- **Develop a detailed GNEP technology roadmap for demonstrating solutions to the remaining technical issues in order to support commercial GNEP facilities. Inform and adjust this roadmap with input received from industry, international partners, and the policy community.** Carry out the technology development work principally in existing U.S. national laboratory facilities, universities, in the proposed Advanced Fuel Cycle Facility and in the facilities of our international partners. Internationally, we will use existing Generation IV International Forum agreements, I-NERI agreements and new bilateral or multilateral agreements as appropriate.

- **Pursue industry participation in the development of conceptual design and other engineering studies that support both the Consolidated Fuel Treatment Center (CFTC) and the Advanced Burner Reactor (ABR).** For the CFTC, the designs would be expected to show, for example, not only what can be built with proven technology (no pure plutonium) but also how the facility would be designed to operate, incorporate and expand using advanced separations modules as they are proven (i.e., minor actinide recycle, Cs and Sr separation, Tc stabilization, etc.). Further, the designs would be expected to meet proliferation resistance, security, waste management, and other important requirements.
    - A majority of the construction cost and schedule (site preparation, fuel receipt and storage, shearing, dissolution, waste treatment, effluent control, etc.) of the CFTC is associated with known technology. The processes yet-to-be-proven involve small volumes of material but also define the components of programmatic risk. Further, in a chemical separations plant it is possible to make provision to insert new or modified separations modules.
- Prepare a programmatic GNEP Environmental Impact Statement. Fund several siting studies at locations that submit proposals to host the CFTC and/or the ABR facilities and develop environmental data for these sites.
- No later than June of 2008, prepare a decision package for the Secretary of Energy to proceed with a government-industry partnership to building a CFTC and prototype ABR, assuming that:
    - A credible technology pathway has been developed and satisfactory progress has been made in its implementation;
    - A credible business plan exists;
    - there is reason to believe that a government private partnership can be formed to build the GNEP facilities that is in the best interests of all parties;
    - Relevant NEPA requirements are satisfied; and
    - Nonproliferation criteria are defined and met.

CONCLUSION

In sum, we propose to proceed in parallel to: (1) build and operate the CFTC and ABR facilities using the latest commercial technology available after final designs are validated (as soon as possible after the Secretary of Energy's decision in 2008), and (2) continue an aggressive R&D program to complete development of advanced spent fuel separations techniques and transmutation fuel fabrication and recycle technologies and develop validated simulation and computation techniques to advance the development and approval of fuel cycle technology. The parallel activities will have strong cross-connections with industry-requested technical information provided by R&D according to the technology roadmap.

The CFTC would be designed to incorporate the advanced separations and fuel fabrication modules, with construction scale paced by success in the R&D validating these modules and the prospect for use of separated product as fuel in fast reactors. The output of CFTC would be fuel including transuranics for fast spectrum reactors. It is not intended to produce MOX for Light Water Reactors. Once the CFTC is approved to accept spent fuel, shipments of fuel could begin from utilities, which would be a significant step in providing confidence in our nation's ability to meet its nuclear waste management responsibilities.

The ABR project would aim to reduce capital and operating costs in order to economically produce electricity while consuming plutonium and other transuranics. R&D would continue on technology for recycling used ABR fuel for further burning in an ABR.

It is reasonable to expect that in the decade or more that design, approval and construction of these "base technology" facilities would take place, we can successfully prove and incorporate the vital actinide separations steps and develop and qualify a minor actinide bearing fast reactor fuel. Even if the advanced R&D effort was not fully successful or is delayed, we will still have made proven advancements over facilities in operation elsewhere in the world and could make a policy judgment at that time how best to proceed. Our current focus is on making the integrated GNEP system work.

The advantage of the parallel approach is that the U.S. could save nearly a decade in time and a substantial amount of money, while still engaging and reinvigorating the nuclear community with new facilities and continued long- term R&D. Development by the U.S. of a credible program for construction of commercial fuel cycle facilities is a critical element of a strategy to convince any other nation considering beginning a nuclear energy program that they can rely on the U.S. for any of their fuel cycle needs. Making the U.S. a player in fuel cycle technology is vital to fulfilling the GNEP vision.

I want to thank you again, Dr. McFarlane, for organizing this session on GNEP. We will move forward in our shared goal to advance nuclear power as a reliable, economical and environmentally friendly energy source. My best wishes to everyone here for a productive conference this week.