



Pacific Northwest Center for  
**Global Security**

**Cradle-to-Grave Nuclear Fuel Supply Assurance Workshop:  
Industry's Potential Role**

**Pacific Northwest National Laboratory Office  
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Washington D.C.**

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**WORKSHOP REPORT**

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*Note: Prior to his illness and death, Harold D. Bengelsdorf of Bengelsdorf, McGoldrick and Associates, LLC. made important contributions to the organization of and preparation of materials for this workshop.*

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### ***Disclaimer:***

*This document reports the discussion of a workshop in which representatives from government, industry, non-governmental organizations (NGOs), national laboratories, and other organizations participated. As such, views expressed within this report are **not** the consensus views of PNNL, industry or government. The three sections of the report represent an attempt to convey key themes discussed and specific concerns that emerged as part of this discussion.*

*Section 1.0 offers a summary of the workshop, especially key themes, and is an attempt to convey the overall feel of the workshop. The questions found in Section 2.0 are similar to those questions found in Appendix C (which were provided to workshop participants in order to frame workshop discussion), however, the questions in Section 2.0 were tailored to more closely align with the flow of discussion during the workshop. This section takes ideas and individual statements from participants that emerged during the workshop, and catalogues them in an attempt to convey more of the detailed discussion of the workshop discussion. Ideas and statements included under a question are not necessarily answers to the questions, but were relevant to the topics, including cradle-to-grave fuel services regime (CTG) and the Global Nuclear Energy Partnership (GNEP), discussed during the workshop. None of these statements are attributable to any particular organization or individual. Section 3.0 offers the ideas of the PNNL authors on key themes resulting from the workshop, and recommendations for addressing some of the issues and concerns that emerged throughout the day.*

## **1.0. Workshop Summary**

### **1.1. Introduction**

The Pacific Northwest Center for Global Security hosted a workshop on June 6, 2007 in Washington D.C. to discuss the feasibility, merits and implications of the United States offering cradle-to-grave nuclear fuel cycle services to other countries. The workshop consisted of a small group of senior individuals from the private sector, government and the national laboratories. (Attendees are listed in Attachment 1.)

In a February 2004 speech to the National Defense University, President Bush proposed that the major nuclear suppliers offer improved nuclear fuel assurances to states that forego enrichment and reprocessing. In addition, in unveiling the Global Nuclear Energy Partnership (GNEP), the Department of Energy (DOE) offered a proposal in which a limited number of so-called “fuel cycle” or “supplier” countries or states (i.e., those having either enrichment or reprocessing plants) would ultimately provide commercial power reactor fuel to so-called “reactor” or “consumer” countries (i.e., those having neither enrichment or reprocessing plants) on a leased or cradle-to-grave basis. Under this proposal the fuel cycle states would assume responsibility for the management and disposition of the spent fuel produced from the supplied fuel in the so-called reactor states.

The workshop was an informal brainstorming session designed to obtain the reactions of experts from the private sector concerning the implications of, potential for, and obstacles to moving forward to offer a nuclear fuel leasing or cradle-to-grave fuel cycle service. Explanations were given by DOE officials of U.S. fuel assurance initiatives and of GNEP. In addition, there was a presentation of a paper prepared by Bengelsdorf, McGoldrick and Associates (Attachment 2) as well as a slide presentation of a paper prepared by James Malone, Exelon Corporation, James Glasgow, Morgan Lewis, Stephen Goldberg, Argonne National Laboratory, and Peter Heine, Argonne National Laboratory (Attachment 3). Finally, a graphic description of the cradle-to-grave concept was presented by PNNL (Attachment 4).

Bengelsdorf, McGoldrick and Associates and PNNL prepared a number of questions for discussion by the group. The following summary is based on the discussions that informed the answers to these questions. Several major themes emerged from the discussions.

### **1.2. Fuel Assurances**

Several participants indicated that the market was working well and that consumers saw little need for an emergency fuel reserve or international fuel bank. Several participants expressed the view that states party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) are not likely to give up their rights under Article IV of the Treaty in exchange for any kind of fuel assurances, and that fuel assurance schemes are not likely to persuade countries like Iran and North Korea to abandon their enrichment and reprocessing facilities. The U.S. Government officials present explained that the U.S. proposals for improved fuel assurances were not directed at the hard cases of North Korea or Iran, but were aimed at setting a general international norm to convince states that they had realistic alternatives to national reprocessing and enrichment plants. Participants at workshop noted that, while consumer countries have not expressed a need for improved nuclear supply assurances, there may be merit in strengthened fuel guarantee schemes since they would help establish global nonproliferation norms for the nuclear fuel cycle. These

norms would help remove excuses for countries to pursue their own enrichment and reprocessing facilities.

However, one participant noted that the U.S. was proposing to spend most GNEP money on activities related to the Advanced Fuel Cycle Initiative (AFCI) and was not really spending much money or effort on the fuel assurance aspects of GNEP. In addition, several participants noted that they did not perceive widespread movement among states to acquire enrichment and reprocessing capabilities at this time.

The attendees at the workshop seemed to see merit in the idea of a fuel trust, as proposed by James Malone et al, since it offered financial benefits and reduced risks to utilities in their efforts to acquire uranium and enrichment services on a reliable basis with minimum cost. It also offers a mechanism for utilities to partner to achieve economies of scale. It would also provide for flexible back-end solutions since the trust would allow for the lessor to retain title after discharge without any predetermination of further processing and disposition. By itself, however, the trust as proposed by Malone et al, did not offer a solution to the problems faced by countries with spent fuel or waste management problems that exist today.

### **1.3. Cradle-to-Grave Services**

Participants generally felt that a cradle-to-grave policy would provide a strong incentive for countries to forego the acquisition of their own enrichment and reprocessing facilities. However, industry representatives spent considerable time expressing their strongly held views about the inability of the U.S. Government to meet its responsibilities under Nuclear Waste Policy Act to take spent fuel off the hands of American utilities. They stressed that the United States would have no credibility in offering a cradle-to-grave policy to foreign countries unless and until it could move to solve its own waste management problems. There was considerable support for some interim spent fuel storage arrangements until the Yucca Mountain Project could get underway. One suggestion that received considerable support among attendees was to make Yucca Mountain a retrievable storage site that would be licensed for 200 years. The main theme, however, was that the United States was in no practical or credible position to offer nuclear fuel leasing or cradle-to-grave proposals to other countries until it got its own house in order.

One suggestion was that the U.S. Government should try to pursue an interim regional spent fuel storage approach rather than deal with the U.S. spent fuel problem in its entirety. Participants felt that, in the case of some U.S. utilities, it would be very difficult to take substantial steps toward building a new nuclear power plant until the Government demonstrated its ability to assume responsibility for taking the spent fuel. Some pointed to the interim spent fuel storage project proposed by Private Fuel Storage (PFS) as an indication that private industry could itself take steps to provide temporary spent fuel storage. Still the Department of Interior decision to prevent the transport of spent fuel to the PFS facility in Utah demonstrates that even private industry efforts to establish a spent fuel storage facility in the United States will require U.S. Government support in the form of regulatory approval.

One participant stressed that such interim storage need not be built underground and that spent fuel in dry casks above ground is safe and secure. If the U.S. Government could establish an interim spent fuel storage facility in the United States, it would set an important example for other countries to follow, and help dissuade others of the need for a reprocessing facility. Some stressed that there is a pressing need for interim spent fuel storage until new technologies for waste management are developed.

It was noted that there has been a tepid industry endorsement of GNEP, particularly among utilities, since it is not at all clear that fast burner reactors will prove to be economically viable. Moreover, it will require decades to develop and demonstrate the economic efficiency and commercial viability of fast burner reactors as well as other proposed GNEP facilities. GNEP will require substantial funding and sustained political support from one Administration and one Congress to another. Hence, if offering cradle-to-grave services depends on the development, demonstration and commercialization of the fuel cycle facilities and fast burner reactors proposed by GNEP, it will be decades before the United States is in a position to propose this incentive to foreign countries. In general the participants expressed a great deal of skepticism about the prospects for GNEP and some felt that the United States was putting the wrong technology on a fast track.

The question was raised whether it might be possible to adopt a policy to take back spent fuel to the United States in a few limited cases where there were compelling national security reasons. This suggestion elicited little or no reply from industry representatives.

#### **1.4. Prospects for Other Suppliers Offering Cradle-to-Grave Policies**

With few exceptions, it was generally agreed that none of the major nuclear exporters were prepared to offer fuel leasing or cradle-to-grave services.<sup>1</sup> The primary exception to this general characterization of other suppliers is Russia, which is establishing an international enrichment center eligible for IAEA safeguards in Angarsk.<sup>2</sup> The Russians have invited foreign countries to become partners in this enterprise, particularly countries that are uranium producers. The Russians have also suggested that Moscow might be prepared to take back spent fuel produced from the fresh fuel Russia supplies to countries beyond the ex-Soviet bloc. There was some speculation that Russia might use the profits from the first Angarsk facility to build additional enrichment facilities and might eventually be willing to take back not only spent fuel from the fresh fuel Moscow sells but to take back non-Russian origin spent fuel in exchange for new enrichment contracts.

Russia already make considerable profit from enrichment services it presently sells on the international market, and the reason that it may offer to take back spent fuel from the fresh nuclear fuel they supply is to push the West out of the international market altogether. There seems to be a general consensus that the Russians are moving out aggressively to market enrichment services internationally. If they also decided to offer some form of cradle-to-grave services, they would pose formidable competition in the international market. They would have the additional advantage of their nuclear industry enjoying government involvement and backing.<sup>3</sup>

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<sup>1</sup> France has recently adopted a partial cradle-to-grave service to Italy where it provides reprocessing services and does not return the plutonium or uranium to Italy and sells these materials to its own utilities or other utilities in Europe. However, it does require the return of the reprocessed wastes to Italy.

<sup>2</sup> This facility has been made available for IAEA safeguards. For more detail, see the PNNL paper prepared for NA-243 on "International Fuel Service Centers: Angarsk International Uranium Enrichment Center" (Elkhamri).

<sup>3</sup> For more detail, see the PNNL paper prepared for NA-243 on "Reforms in Russia's Nuclear Industry: Challenges and Implications" (Elkhamri, et al.)



The question was even raised as to whether U.S. utilities might be persuaded to purchase enrichment services from Russia and to transfer the resultant spent fuel to Russia for eventual disposition. It was pointed out that Russia was already fabricating fresh nuclear fuel for German and Swiss utilities, which meets Western states standards. However, in order to sell nuclear fuel in the United States, the Russian fuel would have to be licensed by the NRC.

### **1.5. Roles of Government and Industry in Implementing a Cradle-to-Grave Policy**

Industry representatives emphasized that they would require at least two fundamental actions by the U.S. Government in order to participate in a cradle-to-grave policy. The first would be for the government to establish a system to limit the risks and liabilities of private industry in carrying out whatever tasks would be required. Companies could be reluctant to lease nuclear fuel to other countries because of the liabilities such leasing would entail. Who actually owns the fuel at the back end of the fuel cycle is not a trivial question, because whoever owns the spent fuel or wastes assumes the responsibility and the liability for handling such spent fuel. The idea of establishing a trust that would lease fuel might help alleviate the liability concerns of private companies. It is possible to conceive that the government itself could lease fuel to other countries; it is also possible that an international organization could do so. However, participants in the workshop argued that private American companies will not act alone without some form of risk mitigation. Industry representatives emphasized the importance of the United States implementing the Supplementary Convention on Nuclear Liability. However, it was pointed out that the Congress has not yet passed legislation required to implement the Convention in the United States, and that industry's pressure on Congress was necessary to accomplish this objective. It was also pointed out that many small states do not adhere to the various international liability conventions and that they would need to participate in a liability regime, if American industry were to offer fuel leasing or cradle-to-grave fuel cycle services to such countries, or the U.S. Government would have to take appropriate actions to limit the liability of private industry if they were to operate in these countries.

One industry representative pointed out that an important consideration for private industry is whether there would be an economic incentive to lease nuclear fuel rather than to sell it. He pointed out that private companies are in business in order to make a profit and that they cannot be expected to assume nonproliferation responsibilities which are namely a government function. GNEP may require the establishment of a government corporation or similar entity in order to build the facilities that GNEP is proposing, e.g., for recycling spent fuel.

Several participants also pointed out that U.S. private industry was not on a level playing field in its competition with foreign countries. Most nuclear industries in other countries were owned or part-owned by their governments, giving them great advantages in liability. Others received heavy government financial support, including concessionary financing. Foreign industries are also integrated vertically with heavy government involvement. U.S. industry is operating on a different model and simply can not compete internationally under such circumstances. At a minimum the U.S. nuclear industry needs strong financial, liability and regulatory support from the U.S. Government if it is to maintain a presence in the international market and to be in a position to play the kind of roles envisioned by the initiatives outlined in GNEP.

It was also pointed out that the ability of the American nuclear industry to compete abroad is rapidly diminishing. Furthermore, many companies have become multinational; of the three major Western manufacturers of reactors, one is French owned (Areva), one is owned by Japan (Westinghouse) and the other is under part ownership by Japanese and U.S. interests—Hitachi

and General Electric. The United States presently imports fifty percent of its enrichment service needs, and serious questions were raised about the ability of the United States to export enrichment services on a significant scale in the future.

Thus the ability of the U.S. private industry to participate in a nuclear fuel leasing or cradle-to-grave fuel cycle services will depend on a revival of the U.S. industrial capacity and its ability to play a competitive role in international nuclear affairs.

#### **1.6. The Ability to Import Power Reactors Spent Fuel from Abroad**

Several of the participants stated that the United States Government would face formidable public and congressional acceptance problems if it were to try to initiate a program to take back foreign power reactor spent fuel and, as previously noted, such a program would not be credible unless and until the U.S. Government moved to solve its own domestic spent fuel disposition and waste management problems. Moreover, as one participant pointed out, NRC does not have the personnel or regulatory capacity to handle anticipated increased demand for licenses for new nuclear power plants, much less for the facilities planned under GNEP, including those that might accept power reactor spent fuel for storage, processing or disposal.

#### **1.7. International or Regional Spent Fuel Storage or Disposal**

The question was raised as to whether new emphasis should be placed on efforts to establish regional or international facilities for interim spent fuel storage or a nuclear waste repository. It was noted that historical efforts to establish such a facility were unsuccessful due (among other things) to the lack of an economically compelling market for such facilities. Most countries that have expressed interest in offering to store other countries' wastes such as China, North Korea, and the Marshall Islands as well as the U.S.-Japan efforts in the late 1970s to establish a spent fuel storage facility on Palmyra Island in the Pacific Ocean have either been withdrawn or were otherwise not realized. One country that was identified as a potential site for an international or regional spent fuel storage site or waste repository was Kazakhstan, although it has made no such formal or informal offer.

## 2.0. Key Questions and Answers Resulting from the Workshop Discussions

*Note: These are not the questions that were given to meeting participants before the meeting; rather, they were developed to capture major parts of the discussion around certain key topics. These statements by workshop participants are included here because if the recommendation to create a working group is agreed, the more detailed comments of workshop participants may be useful to identifying issues for the working group to address.*

### 2.1. Big Picture Issues

- *If Cradle-to-Grave (CTG) is a desirable goal that the United States should promote in collaboration with other suppliers, what steps must be taken to accelerate implementation of the CTG concept?*

Workshop discussion indicated that the question of whether cradle-to-grave is desirable is less relevant than whether it is feasible. Industry (and government) argued that it would be publicly and politically unacceptable for the United States to offer take back of foreign spent fuel on U.S. soil until the US begins to solve its own waste management problems. A more appropriate question would be: “What steps can be taken to work toward effective management and disposition of spent fuel from U.S. utilities?”

- *Should implementation of the CTG concept be tied to the ambitious goals relating to the demonstration and deployment of advanced separations and reactor technologies?*

There was consensus that the time-frame for development of new GNEP technologies was significantly longer than currently stated – closer to 50 years. Industry noted that “if GNEP is going to survive, there needs to be an industry consensus on what GNEP principles are of value, and why. Broad consensus on principles will help GNEP transition into the next administration.”

To work toward both short- and long-term goals for expanding nuclear power, it was noted by some that dual paths should be simultaneously pursued:

- Build and license long-term spent fuel storage facilities to address U.S. waste management over the next 50 years, and
- Pursue GNEP technologies for proliferation-resistant advanced reactors and spent fuel recycling on an R&D basis to minimize waste.

Having a geological repository and/or long-term storage as near-term options would be necessary but not sufficient conditions for CTG because the question of management of the spent fuel still begs many questions. For instance, if the United States were to pursue a license for Yucca Mountain as a Monitored Retrievable Storage facility, there might not be capacity for storing even U.S. spent fuel, much less capacity for storing international spent fuel. So some further processing of the spent fuel may be needed. Congressional, regulatory, and public support for transporting U.S. spent fuel to Yucca Mountain also remains necessary in this scenario. The State of Nevada is also strongly opposed to using Yucca as a Monitored Retrievable Storage Facility.

## 2.1. Arrangements and Options for Spent Fuel Management

### ■ *What are the major options for developing and implementing a CTG policy?*

No country has yet announced that it will offer cradle-to-grave fuel management. The status of countries attitudes and activities related to CTG include:

- **U.S.:** U.S. law requires explicit Congressional funding and appropriations for any import of foreign power reactor spent fuel. Although there is provision for takeback of spent fuel in “emergency” situations, it is unclear what constitutes an emergency situation, and whether the United States would exercise this option. Any attempt to import foreign power reactor spent fuel would meet with strong public and Congressional opposition.
- **Europe:** At the Le Hague reprocessing facility, France has been reprocessing foreign spent fuel for many decades. France, however, requires the return of the reprocessed waste to the country of origin. Historically France has also returned the recovered uranium and plutonium to the country of origin. Recently an Italian consortium has decided to sell the plutonium and uranium recovered through reprocessing Italian spent fuel on the European market it. Vitrified waste would be returned to Italy for storage.
- **India:** India has existing enrichment and reprocessing facilities which it does not intend to submit to international safeguards. However, it has recently agreed to construct a facility dedicated to reprocessing safeguarded spent fuel produced from imported enriched uranium. India has not indicated any intention of importing foreign spent fuel for storage or disposition. What role (if any) that India will play in GNEP has not yet been determined.
- **China:** China is pursuing its own civil nuclear fuel cycle. In the 1980s, it gave some indications that it would be prepared to take back spent fuel for reprocessing and disposition in China, but subsequently withdrew that offer, citing public opposition as well as other reasons. .
- **Russia:** Russia is establishing an international facility at Angarsk that would provide enrichment services. The facility and technology are Russian-owned; partners would buy into the facility and receive rights to enrichment services from that facility. It was mentioned that at some point in the future, Russia might also develop a second international facility, which would be located in Kazakhstan, which would provide long-term storage for fuel sold through Angarsk.

Additionally, a proposal was put forward for a consortium that could facilitate an aspect of CTG. Exelon described their concept for a nuclear fuel leasing arrangement, called Terms for Reliable Uranium Service Transactions (TRUST).<sup>4</sup>

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<sup>4</sup> Presentation on TRUST can be seen in Appendix E.

## 2.2. Implementation Issues

### 2.2.1 Institutional Issues: Regulatory, Policy and Public Acceptance

- *What are the major legal, regulatory, policy and public acceptance impediments to adoption of the CTG concept at this time?*

The key hurdles for both CTG and GNEP include financing, public acceptance, and political will. Technology development is also a significant problem. It was noted that it would be extremely unlikely (if not impossible) for CTG to take place in the United States *without* GNEP – although variations on CTG, to include takeback of spent fuel to a facility not on U.S. soil, were considered possible. These, and additional themes that were discussed included:

- **Successful Management of U.S. Spent Fuel:** Moving forward with a long-term storage facility and the licensing of Yucca Mountain will be crucial to mitigate the U.S. spent fuel problem until GNEP technology is developed. CTG in the United States will not be feasible until the United States successfully takes steps to solve its own spent fuel management problems; further, industry will have a difficult time trusting government in other nuclear-related matters until these steps are taken.
- **Political Will and Industry Advocacy:** Due to the long timeframe required for nuclear technology development, enduring political will and industry advocacy for development of advanced nuclear technology will be critical for sustained pursuit of recycling technology. Industry leadership will be important to raise key technical, legal, financial, energy security and nonproliferation issues on Capitol Hill.
- **Public Acceptance of Spent Fuel Takeback:** The United States has taken back spent research reactor fuel justified on nonproliferation grounds. However, Congress has established major legal barriers to taking back power reactor spent fuel. It is highly likely that both Congress and the general public would strongly object to any attempt to institute a cradle-to-grave policy on any broad basis. This political opposition is made all the more difficult since the U.S. Government has not effectively managed its own nuclear waste problem. Spent fuel generated by U.S. utilities is being stored at reactor sites and the USG has failed to meet the requirements of the Nuclear Waste Policy Act to assume responsibility for spent fuel at U.S. utilities. The United States needs to move forward aggressively in solving its own spent fuel problem before a CTG policy could become a reality.
- **U.S. Ability to Compete in the International Market:** U.S. companies face considerable obstacles in competing on the international market. Their foreign competitors are often government-owned or subsidized. Moreover, U.S. nuclear manufacturing capability has diminished significantly. The United States lacks a robust fuel fabrication capability. Of the three companies that supply reactors, Areva is French, Westinghouse is Japanese, and GE is owned 60/40 by Japanese and U.S. interests. Additionally, lack of sufficient NRC personnel to license new facilities will be a challenge, as will the long-time frame for licensing the facilities. (Note: building new reactors on existing reactor sites or reactors on previously licensed sites is anticipated to be easier than building entirely new facilities on new sites.)
- **Infrastructure for Acceptance of Spent Fuel:** Lack of spent fuel storage facilities and disposal facilities and public acceptance mean that the United States cannot implement

CTG in the near-term in the United States. For any other country to implement a CTG solution, whether on a single-country basis or through a multinational facility or supplier consortium, a similar problem must be faced –namely, some country has to be willing to accept foreign spent fuel. If some country were to volunteer to host such a facility, for U.S. companies to participate, additional legal infrastructure would be necessary, including: a 123 agreement with the prospective country, agreement on the Supplementary Compensation Convention, and possibly Carbon Caps.<sup>5</sup>

- **Liability in Pursuing Spent Fuel Takeback:** Industry would not be willing to expose itself to significant risk by accepting foreign spent fuel (or sending U.S. spent fuel overseas) without additional legal protections. A number of mechanisms were suggested, including:
  - U.S. implementation of the Convention on Supplemental Compensation for Nuclear Liability/Damage. It would give the United States credibility in convincing other countries, particularly small states, to do the same.
  - TRUST or other shell organization: Using TRUST or another protective mechanism – organized through the government, an international organization, or a state that is part of an international organization -- to shield from risk.
- **Protection from Financial Risk from GNEP:** Industry representatives expressed concern about offering support to GNEP. It was noted that 1) new nuclear technology (i.e. GNEP technology) needs to be proven before industry will invest in it, and 2) there need to be financial loan guarantees in order to encourage utilities to take the first step towards building new reactors in the United States.

### 2.2.2 *Economic Issues*

- *What is the economic feasibility of implementing CTG services in the United States? Internationally?*

The economic competitiveness of nuclear energy is still uncertain. Considering developing nuclear energy programs, shifting global regimes, questions regarding carbon caps, and potential development of new technologies; it is unclear what the economics of CTG would be once GNEP is implemented. It was noted that the acceptance of CTG services could be more economic for most countries than building their own enrichment and reprocessing facilities. Still, it was noted that CTG will require new and unproven technologies which present a substantial economic risk. Based on nonproliferation benefits, these new technologies may be attractive or necessary, but they will substantially increase the cost to the U.S. of offering CTG services [as costs of technology development would be included in CTG cost.] Additionally, U.S. industry representatives indicated that industry “cannot be expected to pay for nonproliferation, which is a legitimate government function.” Government subsidies, economic incentive packages, and loan guarantees were all suggested as mechanisms to promote industry engagement with GNEP.

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<sup>5</sup> Since carbon caps would put limits on U.S. (and/or) world carbon emissions, this would act as an incentive to nuclear industry, as it could make nuclear power more attractive relative to oil and gas energy.

- *If other supplier state(s) offered CTG services to foreign customers, would this put the U.S. nuclear industry at a competitive disadvantage? What would be the implications for U.S. nuclear exports if Russia, for instance, were to provide full cradle-to-grave fuel supply services for other countries?*

It is not likely that the United States will be a first mover in this regard, or that any state will initiate a CTG program in the near-term. The Angarsk facility is conceptually closest to providing cradle-to-grave services, as it may offer spent fuel disposition services for fuel sourced through this facility.<sup>6</sup> Industry indicated that Russia has a sizeable cash flow from other areas of its nuclear industry, so there is no current economic driver to offering cradle-to-grave services.

If at some point Angarsk did offer CTG, this would have a significant impact on its competitors. At the workshop, U.S. industry indicated that if U.S. utilities could discontinue their contract with the USG and avoid paying into the Nuclear Waste Fund by leasing fuel through the Angarsk facility, they would “do it in an instant”. Overall, it was conjectured that there would be a high demand for such a service, and U.S. industry would most likely be at a substantial competitive disadvantage.

Although Russia’s revenue from enrichment services may mean that it does not need CTG financially right now, if it did implement CTG, it will have the advantages of speed and efficient response to engage countries interested in nuclear power. The United States should identify specific actions that both government and industry can take to engage the international community and ensure a seat at the table. Interim steps might include:

- Pursue government-sponsored interim storage to address spent fuel needs until Advanced Burner Reactors (ABRs), also known as Advanced Recycling Reactors (ARRs) become available
- Consider a public-private partnership that could develop a waste management system using money from the Nuclear Waste Fund
- Minimize constraints for U.S. industry to participate in the international market (e.g. put 123 agreements in place with potential partner countries, consider economic incentives so that U.S. industry is competitive with foreign competitors that are often government-owned or subsidized, address challenges facing the NRC including a lack of personnel to license new facilities and the long timeframe for licensing of new facilities, etc.. )
- Address domestic challenges faced by U.S. industry, such as storage, transportation, regulatory constraints, and lack of infrastructure, to help prepare industry for future growth

### **2.2.3 Technical Issues**

- *What are the key technical impediments to adoption of the CTG concept at this time?*

One participant noted that the DOE estimated timeframe (2035) for Advanced Burner Reactors (also known as Advanced Recycling Reactors) is too aggressive, for technology development,

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<sup>6</sup> Additionally, it is believed that for every 4 cores of Angarsk-sourced fuel, the facility would take back a 5<sup>th</sup> core of legacy fuel, which will help states reduce their stockpiles of spent fuel.

testing, building and deployment. The move from a Generation IV reactor to a fast burner reactor is a significant leap; if it takes 15 years to develop the next generation PWR, it will take longer to develop fast burner reactors. Considering technical, institutional, and economic constraints, a 50 year time-frame would be more reasonable. Finally, the U.S. Government will have to provide sustained leadership and economic support in order to promote development of GNEP technologies over this time frame.

### 2.3. Government and Industry Roles

- *What roles should be played by the U.S. Government and private industry in putting a CTG scheme into effect?*

Industry is not interested in taking responsibility in a U.S. program to provide CTG fuel cycle services to foreign customers. The current feeling is that industry is currently storing its own spent nuclear fuel, despite having paid money into the Nuclear Waste Fund for disposal and is not in a position to assume further responsibility or liability. Participants felt that in order to establish a CTG program, government would need to:

- Provide regulatory assurances for industry
- Assume responsibility for spent nuclear fuel (i.e. establish a place for interim spent fuel storage and long-term waste storage)
- Re-establish credibility through providing that they will assume responsibility for U.S. spent fuel in the near-term
- Provide financial incentives that would help restore industry confidence that government support will be available to license reactors and manage the spent fuel.

- *In the case of spent fuel takeback, who would actually hold title to and lease the fuel? Where would fuel be located?*

Industry indicated that while a U.S. commercial consortium might take on an operational aspect of a fuel leasing scheme, no private U.S. company – or any private supplier -- could take full responsibility for long-term storage or disposal. Providing the “hole in the ground” to manage the nuclear waste is the government’s responsibility.

The discussion of title and ownership is an important one; receiving reactor operators take title to the fuel. Discussing ownership will help establish responsibility for disposal, as it will decide the extent of the public-private partnership. What does industry want? What does government want?

- *While the government would have the lead in formulating policy for both CTG and GNEP, what kinds of roles should industry assume?*

It was noted that industry should take a more active role in communicating its needs and concerns to Congress and that increased industry pressure would be helpful in effecting intermediate steps for spent fuel management, such as long-term storage. It was noted that while the U.S. Government has the ultimate responsibility for spent nuclear fuel management and disposal, including licensing the relevant facilities, industry needs to actually manage the fuel right now.



### **3.0. Conclusions and Recommendations**

The conclusions were based on closing comments heard during the workshop from workshop participants. The recommendations presented below were developed by PNNL in response workshop discussion and in attempt to integrate key themes and concerns that emerged throughout the day.

#### **3.1. Conclusions**

Key takeaways and conclusions from the workshop included:

- The inability of the U.S. Government to meet its responsibilities under the Nuclear Waste Policy Act and take responsibility for spent fuel has caused considerable industry frustration. Industry noted that the United States would have no credibility in developing a cradle-to-grave nuclear fuel management policy until it can solve its own waste management problem.
- Industry is concerned about the impact that the new Russian Angarsk enrichment consortium facility will have on the nuclear industry. It appears for example, that Russians may be planning to eventually offer long-term storage of spent fuel or other back-end fuel services as well. Russia's nuclear policies indicate that they are strategically positioning their industry to be the first full fuel cycle services international player.
- Industry also noted a need to develop cohesive, effective, and technically feasible U.S. policies that will support continued growth and competitiveness of the U.S. nuclear industry through the next administration, and beyond. How GNEP is perceived by the next administration will have a significant impact on the future of the cradle-to-grave fuel management assurances.
- A very real issue is that developing new nuclear technology and managing spent fuel is a long-term proposition, while the U.S. government operates on shorter time horizons. This lack of government policy and program stability increases the risk to industry in evaluating whether it can support and invest in new USG nuclear programs, such as GNEP.

#### **3.2. Recommendations**

One key recommendation is that the Center establish a public-private working group to discuss issues related to fuel supply, nuclear waste management, emerging technology, and nonproliferation issues for NNSA. This group would be one means of enhancing trust, credibility, and communication between government and industry. Such a group would have the ability to examine technical, political, and economic issues that can affect the viability of the nuclear industry over the next 3-50 years. Such a group could address both short- and long-term issues that will impact the sustainability of the U.S. nuclear industry. Efforts conducted through this

working group could contribute to a U.S. roadmap for cradle-to-grave fuel management, as well as other issues.<sup>7</sup>

***It is recommended that short- and long-term industry concerns be examined and addressed through this working group.*** These concerns are listed below under policy, economic, and technical issues. The recommendation for this working group is not a direct step toward CTG; rather, it creates a collaborative forum in which government and industry can discuss issues and concerns informally, such as those identified below.

### **3.2.1. Policy**

- **Nuclear Infrastructure:** Due to a variety of factors, including the internationalization of the nuclear industry, and the lack of recent U.S. investment in nuclear power, the U.S. nuclear industry needs U.S. Government support to become capable of sustaining significant future growth. Indeed, there was concern that existing human and technical resources in the U.S. Government and industry are not sufficient to maintain the industry at its current level, much less expand in a nuclear renaissance or under CTG. Specific challenges noted by industry included ensuring that the NRC has sufficient resources for licensing new facilities especially beyond reactors, and ensuring that there are sufficient trained U.S. personnel in all areas of the nuclear industry (including engineers, technicians, etc) to support the renewed U.S. nuclear program. In addition to human resources, the lack of technical resources, such as the United States not being able to build a new reactor without relying on specialized manufacturing capacity from other countries, was also considered a problem for revitalizing U.S. industry. A government-industry working group may be one venue for developing possible means to address this challenge.
- **Long-term Storage:** Industry's perspective is that U.S. government cannot credibly promote U.S. involvement in cradle-to-grave fuel management without first addressing U.S. government national obligations for spent fuel management. Several options for long-term storage were discussed. It was explicitly noted that continuing to pursue Yucca Mountain as a final repository facility was unrealistic, and that the United States consider other more immediately viable options, such as licensing Yucca Mountain for medium-term removable storage, or constructing a spent fuel storage facility at the Waste Isolation Pilot Project (WIPP) facility in Carlsbad, New Mexico. New Mexico has explicitly noted its interest in licensing such a facility. Industry also noted licensing such a facility would be an appropriate use for funding that remains in the U.S. Nuclear Waste Fund.
- **Administration Transition Issues:** Industry noted that it is difficult to plan for future growth without a clear indication of what U.S. nuclear policy will be post-2008. Developing an industry consensus on the principles behind GNEP, new reactor development, and nonproliferation, would be a useful exercise that would help ensure continuity through the next administration.

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<sup>7</sup> Note: In this paper, "working group" is used to describe some venue for sustained communication that would enable sustained informal discussion between government and industry. The most effective arrangements for such a group would need to be determined by NNSA.

### **3.2.1. Economic**

- **Industry Competitiveness:** There is an uneven playing field in the international nuclear fuel market. The nuclear industry in most (if not all) other countries is state-owned or partially so. U.S. industry faces increased costs and regulatory challenges which put it at a competitive disadvantage in the international market as it must pass on these costs to enable a profit. Some of these challenges were identified during the workshop, such as differences in nuclear liability coverage. Further effort to discern and address these issues would be another useful activity for a public-private working group.
- **Angarsk:** Although there are no nuclear facilities that offer international spent fuel-takeback, Russia's new Angarsk International Uranium Enrichment Center could be gearing up to do so which concerns U.S. industry. Combined with the restructuring of Russia's nuclear industry, Angarsk represents a move toward a comprehensive and vertically integrated nuclear industry that could represent a significant competitive threat to U.S. industry. Despite potential concerns, some U.S. utilities would consider the purchase of nuclear fuel services from Angarsk if this would alleviate some of their burden for spent fuel storage. However, industry is already paying the U.S. government for spent fuel management and storage, and does not want to pay for these services twice.
- **Financial Incentives:** U.S. utilities face challenges in planning for new reactor construction in unclear economic and political circumstances. Clarification of U.S. policy on possible U.S. Government investment support, carbon caps, tax and other financial incentives would help industry better evaluate such investments. U.S. industry will be reluctant to expose itself to the substantial risk involved in new reactor construction without some option for financial assurance, such as government loan guarantees.
- **Liability Risk:** U.S. fuel, services and reactor/parts manufacturers want the U.S. Government and Congress to complete bringing the Supplementary Compensation Convention into force so they can have improved liability protection.

### **3.2.1. Technical**

- **New Technology Development:** Industry considered government timelines for development of new GNEP technology to be overly optimistic. Due to the long time-frame and the risks involved in developing new technologies, industry has no current incentive to participate in the development or launch of GNEP-envisioned fast reactors. A public-private partnership could be a venue for exploring industry's role in support of new proliferation resistant reactors.

## Appendix A: Attendees

### I. INDUSTRY

- **AREVA:** Alan Hanson  
*Executive Vice President, Technologies and Used-Fuel*
- **AREVA:** Stefano Ratti
- **Babcock & Wilcox** Craig Hansen  
*Fuel Services*
- **Constellation Energy Group**  
Jeanne Shobert
- **Exelon Generation Company, LLC**  
James Malone  
*Vice President, Nuclear Fuels*
- **Nuclear Assurance Corporation (NAC)**  
Craig Seaman
- **URENCO (UEF)** Kirk Schnoebelen  
*President URENCO U.S.*

### NGO/Other

- **American Council Global Nuclear Competitiveness**  
Scott Campbell  
*President*
- **Environmental Business International**  
Andrew D. Paterson  
*Principal / Energy Issues Editor*
- **Energy Resources International (ERI)**  
Mike Schwartz  
*Principal*
- **National Association of Regulatory Utility Commissioners**  
Brian O'Connell  
*Director, Nuclear Waste Management Program*
- **Nuclear Energy Institute (NEI)**  
Steven P. Kraft  
*Senior Director, Used Nuclear Fuel*
- **Shaw Pittman** Charles Peterson  
*Partner*

- **Bengelsdorf and McGoldrick and Associates:**  
Fred McGoldrick

## II. GOVERNMENT

- **NA-243:** **Rich Goorevich**  
*DOE, Export Control*
- **NA-243:** **Sean Oehlbert**  
*DOE, Export Control*
- **NA-243:** **Ingrid Bruns**  
*DOE, Export Control*
- **NA-24:** **Mark Goodman**  
*DOS, on assignment to DOE*
- **DOE:** **William Szymanski**  
*DOE*
- **DOS:** **James Timbie**  
*U.S. Department of State*
- **DOS:** **Dick Stratford**  
*U.S. Department of State*
- **NRC** **Paul Dickman**  
*Nuclear Regulatory Commission  
Office of the Chairman*

## III. LAB REPRESENTATIVES

- **PNNL Staff** Carol Kessler  
Gretchen Hund  
Heidi Mahy  
Amy Seward
- **ANL:** Peter Heine  
Nuclear Engineering Division (NE)
- **ANL:** Steven Goldberg
- **LLNL** Jonathan Essner

## Appendix B: Agenda

**Note:** Agenda was provided as a read-ahead to workshop participants



### **Cradle-to-Grave Nuclear Fuel Supply Assurance Workshop: Industry's Potential Role**

**Pacific Northwest National Laboratory Office  
901 L'Enfant Plaza  
Washington D.C.  
June 6, 2007**

- 8:30 a.m. Registration (Coffee provided)
- 9:00 a.m. Welcome, Agenda, Workshop Goals, Objectives, and Introductions  
*Carol Kessler, CGS*
- 9:20 a.m. U.S. Government Assured Nuclear Fuel Programs
- Assured Fuel Supply (10 Min) *Rich Goorevich, NNSA, DOE*
  - International. Reactions to Fuel Services Proposals (10 min) *Mark Goodman, NNSA, DOE*
  - Discussion (20 min)
- 10:00 a.m. Presentation of Cradle-to-Grave Strategies Paper (25 min) and Discussion (20 min)  
*Fred McGoldrick  
Bengelsdorf, McGoldrick & Associates*
- 10:45 a.m. Break
- 11:00 a.m. Arrangements for Considering Cradle-to-Grave Management  
*Gretchen Hund, PNNL*
- 11:30 a.m. General Discussion of Implementation Issues: Legal/Regulatory, Economic, Technical
- 12:30 p.m. Working Lunch: Industry Presentation on TRUST Nuclear Fuel Leasing Arrangement and Questions (Lunch will be provided)  
*James Malone, Exelon*
- 1:15 p.m. Discussion of Government and Industry Roles in CTG
- 3:15 p.m. Break
- 3:30 p.m. Discussion of Possible Next Steps
- 4:00 p.m. Big Picture: Conclusions and Recommendations for U.S. Government
- 4:30 p.m. Adjourn

## **Appendix C: Questions Used to Frame Workshop Discussion**

Note: These were the original questions were provided ahead of time to workshop attendees. They were used during the workshop as a means to frame discussion; however, the revised questions found in Section 2 are closer to presenting the subjects that were actually discussed. .



### **Pacific Northwest Center for Global Security**

#### **Cradle-to-Grave Nuclear Fuel Supply Assurance Workshop: Industry's Potential Role**

**Pacific Northwest National Laboratory Office  
901 L'Enfant Plaza  
Washington D.C.**

June 6, 2007

#### **FRAMING THE CRADLE-TO-CRAVE CONCEPT**

##### **I. INTRODUCTION: BIG PICTURE ISSUES**

- Terminology: What is the difference between CTG, fuel leasing and other fuel services concepts?
- Is CTG a desirable goal that the United States should promote in collaboration with other suppliers? Should steps be taken to accelerate implementation of the CTG concept? What are the essential elements of a CTG policy?
- Under what conditions would the United States be in a position to implement a CTG policy? What conditions do you believe must be applied to make any fuel-leasing or CTG concept a viable proposition for industry to support and participate in?
- Under what circumstances would a policy of nuclear fuel leasing and/or acceptance of foreign spent fuel in the United States being advantageous to industry?
- Are there steps that the federal government could take that would enhance the attractiveness of CTG fuel management in the United States? In the near term? In the long term?

- What are the likely reactions of the major “fuel-cycle” countries (e.g., France, Japan, Russia, the United Kingdom and China) to the U.S. CTG proposal in the near and long term? What would be the reactions if another country were to implement a CTG policy?
- Should implementation of the CTG concept be tied to the ambitious goals relating to the demonstration and deployment of advanced separations and reactor technologies?

## **II. ARRANGEMENTS**

- What are the major options for developing and implementing a CTG policy?

## **III. IMPLEMENTATION ISSUES**

### **B. INSTITUTIONAL: LEGAL, REGULATORY, POLICY, & PUBLIC ACCEPTANCE**

- What are the major legal, regulatory, policy and public acceptance impediments to adoption of the CTG concept at this time?
- What basic institutional conditions would have to be established to enable the United States to offer CTG services to foreign countries?
- Who would actually hold title to and lease the fuel? Where would fuel be located?

### **C. ECONOMIC**

- What is the economic feasibility of implementing CTG services in the United States? Internationally?
- If other supplier state(s) offered CTG services to foreign customers, would this put the U.S. nuclear industry at a competitive disadvantage?
- What would be the implications for U.S. nuclear exports if Russia, for instance, were to provide full cradle-to-grave fuel supply services for other countries?

### **D. TECHNICAL**

- What are the key technical impediments to adoption of the CTG concept at this time?
- What steps have to be taken in order to make a CTG policy technically feasible?

## **IV. GOVERNMENT AND INDUSTRY ROLES**

- Are there sectors in private industry that might be interested in participating in a U.S. program to provide CTG fuel cycle services to foreign customers, i.e., make arrangements for fuel to be taken back in the United States or sent to another country for further management?
- What roles should be played by the U.S. Government and private industry in putting such a scheme into effect?
- While the government would have the lead in formulating policy, what kinds of roles should industry assume?



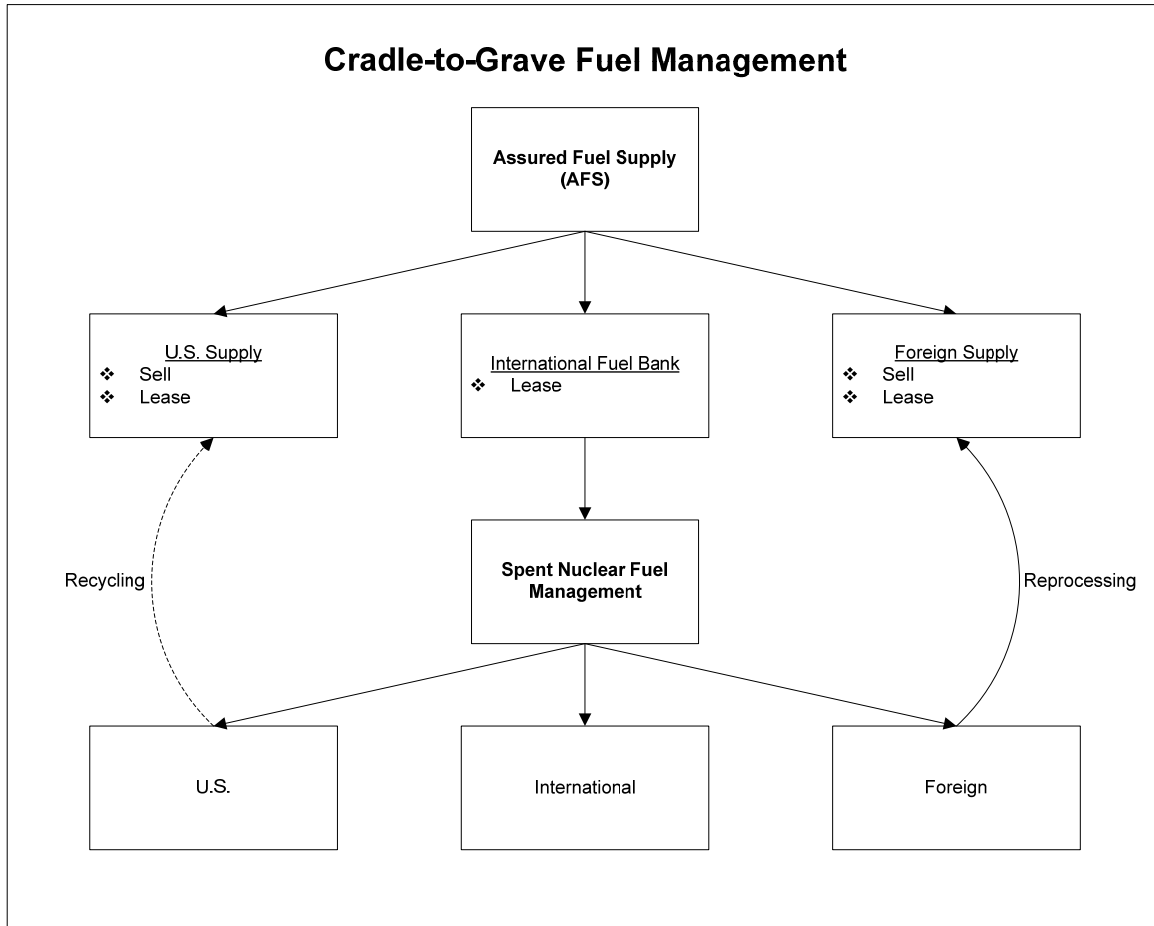
## **V. POSSIBLE NEXT STEPS**

- What steps would the U.S. Government have to take in order to make a CTG policy politically, legally, socially, economically and technically feasible?
- Could some circumstances develop that might make it feasible to implement the CTG concept on a more rapid schedule than currently envisioned? If so, what are they?
- What possible partial steps can you envision towards adopting the CTG concept that supplier states could credibly take in the near term, pending adoption of generic cradle-to-grave programs? For example, providing for management of a limited amount of foreign spent fuel in emergency situations or offering CTG services in cases of serious proliferation risk?
- If the direct return of spent nuclear fuel to the United States is not a near-term option, how feasible might it be for the United States, as an interim measure, to persuade any third countries to accept spent fuel for interim storage or disposal?

## **VI. CONCLUDING DISCUSSION: REVISIT BIG PICTURE ISSUES**

## Appendix D: Arrangements for Considering Cradle-to-Grave Management

**Note:** Graphic was used as a means to frame discussion of possible arrangements for cradle-to-grave fuel management.



## Appendix E: Presentation on TRUST Fuel Leasing

**Note:** Presentation was given during the workshop by Jim Malone, Exelon.

### "TRUST," AN INNOVATIVE NUCLEAR FUEL LEASING ARRANGEMENT

James Malone, Exelon Corporation  
James Glasgow, Morgan Lewis  
Stephen Goldberg, Argonne National  
Laboratory  
Peter Heine, Argonne National Laboratory

June 6, 2007

### Topics

- Introduction – Apply Free Market Principles while Enabling Deployment of Nuclear Energy Worldwide
- Background
  - Fuel Assurance Arrangements (GNEP)
  - Specific Issues Impacting Utilities in Emerging Nuclear Energy Countries
- Terms for Reliable Uranium Service Transactions Through Leasing
  - Description
  - Role of International Agreements
- Benefits – Comparison with Various Structures
  - Economic
  - Nonproliferation
  - Budgetary
- Conclusions

### Fuel Assurance Arrangements

#### Introduction

- Objective: Create an entity that can serve the important function of supply assurance to emerging nuclear utilities at competitive prices, without disrupting the already existing, functioning nuclear fuel supply chain

#### GNEP:

- Seeks to develop worldwide consensus on enabling expanded use of economical, carbon-free nuclear energy to meet growing electricity demand
- Arranges for nations with secure, advanced nuclear capabilities to provide fuel services to emerging nuclear energy countries
- Limits the number of countries engaging in enrichment and reprocessing to remain small
- Uses a closed fuel cycle model

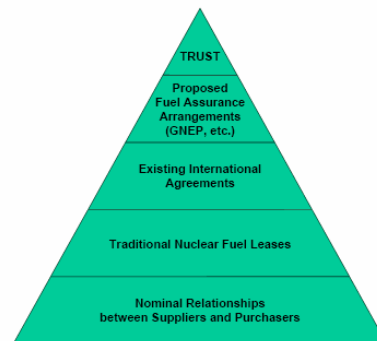
#### TRUST

✓  
  
✓  
  
✓  
  
✓

#### Current Issues Facing Utilities in Emerging Nuclear Energy Countries

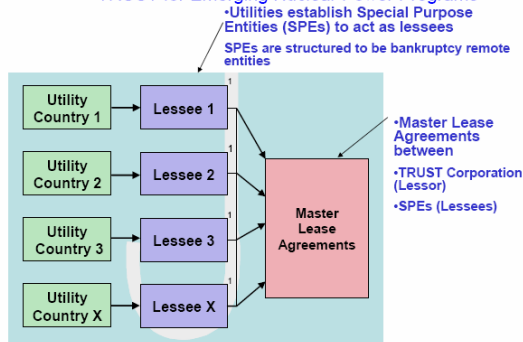
- Without sophisticated risk management tools, these utilities would be sensitive to price spikes and/or market imbalances
- Managing market risks has historically been accomplished by inventory – expensive for these utilities to dedicate capital to maintain inventory
- Loan rate for uranium has risen significantly – close to the peak of 1974
- Cost of borrowing for such utilities in the developing world is significant – could be as high as 17 percent

### TRUST Approach Based on Traditional Arrangements

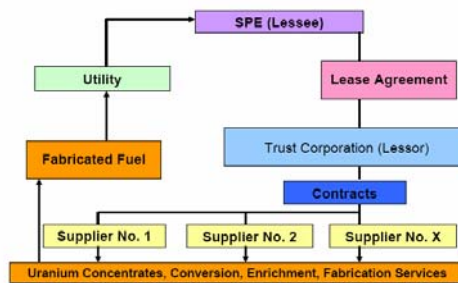


### Terms for Reliable Uranium Service Transactions ("TRUST")

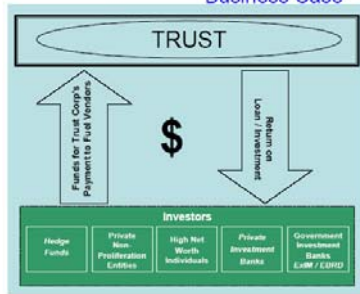
#### TRUST for Emerging Nuclear Power Programs



### Terms for Reliable Uranium Service Transactions ("TRUST") TRUST for Emerging Nuclear Power Programs



### Terms for Reliable Uranium Service Transactions ("TRUST") TRUST for Emerging Nuclear Power Programs Business Case



- TRUST's cost of capital is significantly lower than the cost for utilities in emerging nuclear energy countries

### Terms for Reliable Uranium Service Transactions through Leasing (TRUST) – Cradle-to-Cask

- Modified bundle: scope would encompass procuring the fuel and services, assembly of the fuel components, use of the fuel, and storage of the spent fuel at facilities owned by the nuclear utility, with the lease ending when and if the spent fuel is removed from the site
- TRUST allows for lessor retaining title after discharge without any predetermination of further processing and disposition (flexible back-end arrangement)
- TRUST concept could be expanded to allow for the possibility of some of the lessor holds title to spent fuel for a very long period (decades or longer) during the period where the spent fuel could be held in a third country for long-term storage

## Economic Benefits

- For nuclear utilities in emerging nuclear energy countries, pooling of nuclear fuel purchases and attendant services by one large entity (lessor) will likely produce a competitive market for fueling their reactors
  - TRUST could be in a significant bargaining position to negotiate competitive prices by pooling the requirements of small purchasers
  - TRUST's larger portfolio can serve as a buffer to mitigate shifting policies of countries possessing raw materials
  - TRUST would provide stability in supply and prices
- For suppliers, more easily manage their supply decisions with a predictable demand from a pool of utilities that are in emerging nuclear energy countries

## Nonproliferation Agreements

- Agreements Between Supplier/Recipient Governments
  - Agreements for Cooperation: §123 Agreement for U.S.
  - Such agreements include: advance consent provisions to facilitate import/export and retransfer of fuel
- Recipient Government Assurances to Trust Corporation (Lessor)
  - Long-term import/export assurance
  - No Government expropriation
  - Legal opinion on legality of contract
  - No trade barrier
  - Compliance with antitrust laws

## Nonproliferation Benefits

- TRUST Mechanism Will Encourage Prompt Negotiation and Entry Into Force of Agreement for Cooperation
  - Agreement should include advance consent long-term programmatic consents and licenses for export and retransfer of fresh fuel and used fuel
- TRUST Corporation's Lease Will Include Nonproliferation Assurances:
  - Guarantees by Lessee (and utility)
  - Peaceful use of fuel and reactors
  - Compliance with IAEA safeguards agreement and facility attachment
  - No retransfer, reprocessing or alteration in form or content of fuel, except with lessor's consent

## Nonproliferation Benefits (contd.)

- Noncompliance With Nonproliferation Assurances Will Be an "Event of Default"
  - Lessor's remedies include:
    1. Termination of lease
    2. Repossess fresh fuel
    3. Forfeiture of lessee's advance payment
- Lessor's Remedies will be enforceable through dispute resolution procedures specified in the lease

## Budgetary Benefits

- Establishment of TRUST would not be subject to "availability of funds clause"
- Excellent model – the 1994 HEU agreement between the USG and the Russian Federation – Accomplished in a budget neutral fashion

## Conclusions

- Compatible with proposals advanced by the IAEA six party group, WNA experts Panel, and other entities
- Market-based
- Facilitates intergovernmental agreements
- Budget neutral
- Compatible with various back-end strategies

## **Appendix F: Background Paper by Bengelsdorf, McGoldrick & Associates**

**Note:** Paper was given to attendees before the workshop in order to provide additional background and context for discussion.

### **Background Paper: Cradle-to-Grave Fuel Cycle Concept**

**For  
Cradle-to-Grave Nuclear Fuel Supply Assurance Workshop:  
Industry's Potential Role**

**Hosted by the Pacific Northwest Center for Global Security  
June 6, 2007**

#### Introduction

On February 11, 2004, President Bush proposed that a) the world's leading nuclear exporters should ensure that states have reliable access at reasonable cost to fuel for civilian reactors, so long as those states renounce enrichment and reprocessing, and b) the members of the Nuclear Suppliers Group should refuse to sell enrichment and reprocessing equipment and technologies to any state that does not already possess full-scale, functioning enrichment and reprocessing plants. In addition, Mohamed El Baradei, the Director General of the International Atomic Energy Agency, has suggested placing all enrichment and reprocessing facilities under some form of multinational control.

In February 2006 the Department of Energy announced the launching of the Global Nuclear Energy Partnership (GNEP). Among other goals, GNEP seeks to ultimately establish a new nuclear fuel assurance regime that would include working with other major supplier states in order to discourage the spread of enrichment and reprocessing facilities. A major long-term aspect of this objective is a proposal that those supplier states with industrial enrichment and fuel recycling capabilities should work through the demonstration of advanced separations and reactor technologies to provide so-called "cradle-to-grave" services to states who agree to refrain from acquiring enrichment and reprocessing facilities. Under this approach the supplier states would lease enriched uranium to consumer nations and would accept responsibility for recycling or disposing of the spent fuel. As expressed in the GNEP proposal, achievement of this goal will take several years since such cradle-to-grave services would be put into place once the proposed advanced recycling technologies have been proven and have become commercially operational.

#### Advantages of Fuel Leasing or Providing Cradle-to-Grave Fuel Cycle Services

This aspect of GNEP contemplates that a limited number of so-called "fuel cycle" or "supplier" countries or states (i.e., those having either enrichment or reprocessing plants) would provide commercial power reactor fuel to so-called "reactor" or "consumer" countries or states (i.e., those having neither enrichment or reprocessing plants) on a leased or cradle-to-grave basis.

The concept rests on the premise that the fuel cycle states would assume responsibility for the management and disposition of the spent fuel produced from the supplied fuel in the so-called reactor states. Supplier states would provide power reactor fuel to the consumer states with the

understanding that the resultant spent fuel would be returned to one of the supplier countries or to suitable alternative locations for treatment, recycling and ultimate disposal of the residual wastes. The services could involve the agreement by the supplier state to take back the spent fuel to its territory or conceivably to remove it to another country if such country should ever become host to a regional or international spent fuel storage facility or waste repository. The key point is that the supplier country would have the responsibility for disposing of the spent fuel.

The basic premise is that, if the United States and other supplier states can successfully demonstrate and commercialize the advanced nuclear systems contemplated by GNEP, it should be more physically and politically feasible than it is today for supplier countries to lease nuclear fuel or to offer a spent fuel take-back arrangement to consumer countries. This view is predicated on the expectation that these technical advancements would greatly reduce the burden on the supplier countries in managing and disposing of the returned spent fuel. GNEP also appears to be based on the premise that, in time, interested supplier countries would be prepared to develop and deploy similar advanced technologies and that each participating supplier fuel cycle country would be prepared to support some form of cradle-to-grave fuel cycle service.

A major stated objective of nuclear fuel leasing or the provision of cradle-to-grave services to designated consumer countries would be to discourage the spread of enrichment and reprocessing facilities beyond the fuel cycle or supplier countries. The United States has taken the position that, if the major supplier countries could ever implement such new supply arrangements, they could greatly reduce, if not eliminate in some cases, the aspirations of consumer countries to acquire their own national enrichment and reprocessing facilities. In addition, any steps that supplier countries might take to adopt a more active stance in helping consumer countries in managing the back-end of the fuel cycle and notably in the disposition of their spent fuel would significantly enhance the use of nuclear power.

One of the key reasons that some countries have given for acquiring a reprocessing capability is that it helps solve their nuclear waste management problems. A cradle-to-grave leasing policy could help to remove that rationale. If the United States made clear that a foreign country would have to forego a national reprocessing facility as a necessary condition for the United States to take responsibility for taking back the spent fuel, some countries might consider that a sufficient incentive to forswear their own ambitions to move in this direction. On the other hand, states like Iran that have strong nationalistic reasons for obtaining enrichment or reprocessing capabilities may simply reject the idea of foregoing their rights to acquire independent fuel cycle facilities regardless of the external incentives they are offered. Thus, even with its nominal attractions, a cradle-to-grave service might not be sufficient to deter some countries from pursuing such goals or to preserve their rights to acquire enrichment or reprocessing capabilities, which they might regard as a matter of their basic national sovereignty. Nonetheless, if successful, a cradle-to-grave regime would set a "norm" that could be useful in negotiating with other countries.

From a commercial perspective such a policy could also give United States as a commercial supplier a competitive advantage since several countries would probably prefer to lease nuclear fuel from the United States rather than buy it from other countries, if the United States agreed to assume responsibility to take their spent fuel off their hands. Undoubtedly this has been an important factor in efforts by some in Russia to put in place a Russian policy of accepting foreign power reactor spent fuel for protracted storage.

## Challenges and Obstacles

Despite the obvious appeals of the cradle-to-grave concept, a number of difficulties prompt the need for further thought. First, GNEP rests on the assumption that the cradle-to-grave concept will not become operational for several years, i.e., until the proposed advanced separations and reactor technology are deployed. Unless more is done at this stage, the cradle-to-grave proposals stands as just a general goal that states should work toward in the future rather than the adoption of an operational policy in a near-term time frame. This raises the question as to whether the cradle-to-grave policy is likely to have any significant influence in the near future in actually discouraging the spread of sensitive nuclear facilities or in shaping the fuel cycle plans and policies of so-called consumer or “reactor” states in the near future.

This, in turn, raises the question of whether it would be feasible for suppliers to try to put into place some form of more limited cradle-to-grave scheme on an earlier basis, or to do more to elevate the idea as a desirable collective goal.

However, none of the major fuel-cycle states, with the possible exception of Russia, has in place a program to lease power reactor fuel to foreign countries or to take back spent fuel from the nuclear material they supply.

The United States Government has no such program in effect and its ability to undertake such a program would face a number of difficulties and challenges.

First, it could face tough political questions about the suitability of taking such a step when the U.S. Government is subject to suits by many domestic utilities for its failure to meet its responsibilities under the National Nuclear Waste Policy Act to take their spent fuel off their hands.

Second, such a step could be challenged as premature at best given the status of the Yucca Mountain Project.

Third, even if the Yucca Mountain Project moves forward, the repository is already committed to taking on more domestic spent fuel than it can handle. Accordingly the Department of Energy has been making the point that it may have to build several additional repositories in the United States unless the United States can bring into being the kind of advanced fuel cycle approach that GNEP is proposing. Some observers may argue that DOE was on solid ground when it stated in the original presentation of GNEP that the leasing of power reactor fuel to other countries will have to await the successful demonstration of advanced fuel cycle technologies.

Fourth, any proposal for the United States to leased power reactor fuel would have to meet the special requirements of U.S. law. The Nuclear Non-Proliferation Act of 1978 (NNPA) placed important restrictions on the importation of foreign power reactor spent fuel into the United States. Under the so-called McClure amendment to the NNPA (Section 131 (f) (1), arrangements for the disposition of spent fuel are treated as a so-called “subsequent arrangement” and are thereby subject to a formal review procedure and to a determination by the Secretary of Energy. The McClure amendment provides that

where any such arrangement involves a direct or indirect commitment of the United States for the storage or other disposition, interim or permanent, of any foreign spent nuclear fuel in the United States, the Secretary of Energy may not enter into any such subsequent arrangement, unless



A(i) Such commitment of the United States has been submitted to Congress for a period of sixty days.....but any such commitment shall not become effective if during such sixty day period Congress adopts a concurrent resolution stating that in substance it does not favor the commitment...or (ii) if the President has submitted a detailed generic plan for such disposition or storage in the United States to the Congress for a period of sixty days of continuous session... and there has not been the adoption of a concurrent resolution stating in substance that Congress does not approve the plan.”

Section 131.f (4) of the AEA applies to

“any nuclear fuel irradiated in any foreign power reactor located outside the United States and operated by any foreign legal entity, government or nongovernment, regardless of the legal ownership or other control of the fuel or the reactor and regardless of the origin or licensing of the fuel or reactor, but not including fuel irradiated in a research reactor.”

Thus the Congressional review procedures apply to all power spent fuel proposed to be imported from abroad regardless of ownership and even if title rests with a U.S. entity.

In addition, under the Department of Energy Act of 1978-Civilian Applications (P.L. No. 95-238) the Secretary of Energy is prevented from using any funds for the repurchase, transportation or other disposition, interim or permanent, of any such foreign spent nuclear fuel in the United States unless the use of funds has been expressly authorized by Congress through legislation or concurrent resolution, or unless the President has submitted a plan and thirty days have elapsed without either House having a resolution disapproving it.

Thus although these provisions of the law permit the President to import power reactor spent fuel from abroad, any Administration proposal to do so would be subject to an extensive Congressional review process.

However, it is important to note that the law does permit the President to bring power reactor spent fuel into the United States in emergency situations. Specifically, the NNPA provides for an exception for limited quantities “if the President determines that an emergency exists and the national interest so requires. Sections 131 (f) (2) states that the above provisions shall not apply to the storage or other disposition of limited quantities of foreign nuclear fuel if the President determines that (A) a commitment under section 54 or 55 of this Act of the United States for storage and/or disposition of such limited quantities in the United States is required by an emergency situation, (B) it is in the national interest to take such immediate action, and (C) he notifies” the Congress “of the determination and the action with a detailed explanation and justification thereof, as soon as possible.”

This provision of the NNPA suggests that the United States has some flexibility to import foreign power reactor spent fuel or possibly to lease fuel when a compelling national security situation, include nonproliferation reasons, justifies so doing.

At least for now, however, the prospects for the U.S. Government putting in place a broad cradle-to-grave program open to a large number of countries does not appear to be very good.

On the other hand, if the U.S. Government is able to manage domestic spent fuel arisings from U.S. nuclear power plants in a way that utilities find to be acceptable, U.S. industry conceivably might not object to a nuclear fuel leasing or cradle-to-grave program, particularly if they see this

as support of U.S. export interests. Domestic objections to a leasing program might be further muted if such a program were limited in scale, not adversely impacting disposal of domestic spent fuel, and if the U.S. Government were able to make a convincing argument to industry, Congress and others that it would contribute importantly to the achievement of nonproliferation objectives.

How Russia behaves in this area could be of considerable interest to the United States as well other countries, including France, the UK, and others. In recent months, Russia has shown an increasing lack of interest in this issue, and it appears to be backing away from its offer of accepting foreign spent fuel of non-Russian origin, at least for the foreseeable future. On the other hand, Moscow does seem interested in the possibility of taking back Russian-supplied foreign spent fuel or to lease Russian fresh fuel, which would be returned to Russia for disposition.

There would have to be a number of issues that the U.S. Government would need to address if it were to move seriously to the adoption of a cradle-to-grave policy. If the United States were ever to adopt a nuclear fuel leasing policy, it would obviously wish to do so without disrupting existing nuclear fuel supply and related contracts that U.S. companies have in force with foreign customers. Thus it would presumably wish to avoid policy initiatives that would lead customers to terminate their existing contracts and avoid establishing new contracts in the future to the disadvantage of the U.S. nuclear fuel suppliers that would be adversely impacted by a new leasing policy. In addition, if the U.S. Government decided to proceed with a fuel leasing policy, it would obviously have to take special care in making changes to avoid damage to the credibility of the United States as a reliable nuclear trade partner by introducing any major new uncertainties in the nuclear fuel market. The credibility and stability of the United States as a nuclear trade partner is vital to its efforts to advance U.S. nonproliferation objectives, including on-going efforts to arrest the spread of enrichment and reprocessing facilities.

One conceivable way to mitigate possible disruptions to existing fuel supply contracts would be to provide that a new leasing policy would apply only to new fuel supply contracts with foreign parties or that new leasing arrangements would come into effect after a certain date.

The commercial fuel supply companies in the United States do not themselves lease fuel to utilities in the United States or to their customers in other countries. They are not in the business of providing financing through leasing. In addition, the U.S. Government does not sell nuclear fuel to other countries for use in commercial nuclear power plants. Furthermore, owners and operators of nuclear power plants in other countries may purchase uranium elsewhere and have it processed in the United States (e.g., converted by Converdyn, enriched by USEC, fabricated by Framatome, GE, or Westinghouse) before having it returned to them in other countries. Moreover, in many cases the customer in the other country is likely to have purchased the uranium concentrates from a third country (not the United States, which does not have much uranium), and therefore already has title to the uranium.

Therefore, the basic question of who would actually lease nuclear fuel to foreign customers is one of the first issues that the U.S. Government would have to address in fleshing out a possible nuclear fuel leasing policy in the future. Options include:

- Seek voluntary industry participation in a fuel leasing policy.

- Mandating the leasing of nuclear fuel to foreign customers.

- The U.S. Government could purchase enriched uranium from private sources or utilize its own enriched uranium sources and then lease such material to foreign parties.

The prospect that the United States could persuade private U.S. parties to lease nuclear material to foreign nuclear power plants could be so complex and challenging that a leasing policy may prove practical only by looking to the U.S. Government to lease the fuel directly or through some special trust.

One possible approach might be to involve a third U.S. party in the establishment of a trust. The trustee would be the lessor to the foreign party, and it could either purchase or take title to the nuclear fuel from the utility during a particular stage of processing or directly from the fuel supply company.

### Major Policy Questions

In the period since the initiation of GNEP, DOE with the assistance of the PNNL Center for Global Security (and its subcontractor, Bengelsdorf, McGoldrick and Associates.) has been giving some preliminary thought to the question of whether the United States should consider taking any further steps in the near term to advance the cradle-to-grave concept as a desirable objective in light of its prospective importance to promoting U.S. nonproliferation objectives.

To date, the U.S. Government has alluded to the concept in only the most general terms, and part of the current effort is to give the idea greater specificity and to develop an appropriate strategy for the future. Therefore the views of industry will be extremely important in helping to shape how the United States will approach this subject. With this in mind DOE has requested the Center to open up an informal dialogue with representatives of various sectors of U.S. industry to help ascertain how they view various aspects of this issue.

The major questions that we propose to discuss are the following:

What nonproliferation and other benefits might the United States expect to attain if the United States and some other “fuel-cycle states” were able to offer a cradle-to-grave policy to foreign reactor operators? How important would such a policy be in helping to discourage the spread of enrichment and reprocessing facilities, in helping various states meet their waste management needs and in advancing nuclear power? (We would expect the U.S. Government attendees at the workshop to address this question.)

Is this a desirable goal that the United States should promote in collaboration with other suppliers? Should steps be taken to elevate the status of the cradle-to-grave concept as a desirable goal?

What are the major political, legal and technical impediments to adoption of the cradle-to-grave concept at this time in the United States and when and under what conditions would the United States be in a position to implement such a policy?

What steps would the U.S. Government have to take in order to make a cradle-to-grave policy politically, legally economically and technically feasible?

What are the known or likely reactions of the major “fuel-cycle” countries (e.g., France, Japan, Russia, the United Kingdom and China) to the U.S. cradle-to-grave proposal in the near and long term?

What would be the implications if Russia were to move to implement a cradle-to-grave policy in the next few years?

Is it prudent to tie the implementation of the cradle-to-grave concept to the ambitious goals relating to the demonstration and deployment of advanced separations and reactor technologies (ABRs)?

Could some circumstances develop that might make it feasible to implement the cradle-to-grave concept on a more rapid schedule than currently envisioned?

Are there any partial steps towards adoption of the cradle-to-grave concept that supplier states could credibly take in the near term pending the adoption of more generic cradle-to-grave programs applicable to a broad range of countries? For example, would it be desirable or feasible for the United States and other advanced fuel-cycle countries be prepared to take responsibility for accepting a limited amount of foreign spent fuel in emergency situations or offer cradle-to-grave services in cases of involving serious risks to nonproliferation and national security interests, even if suppliers could not take such steps outside of emergency situations?

What conditions do you believe must be applied to make any fuel-leasing or cradle-to-grave concept a viable proposition for industry to support and participate in?

Are there steps that the federal government could take that would enhance the attractiveness of cradle-to-grave fuel management in the United States? In the near term? In the long term?

What political, social, business and legislative conditions would you see as necessary to enable the United States to adopt some form of cradle-to-grave regime?

Are there sectors in private industry that might be interested in participating in any U.S. program to provide cradle-to-grave fuel cycle services to foreign customers, i.e., make arrangements for fuel to be taken back in the United States or sent to another country for further processing?

Under what circumstances can you visualize a policy of nuclear fuel leasing and/or acceptance of foreign spent fuel in the United States being advantageous to industry?

What thoughts have you given to the possibility that some other supplier states that might offer cradle-to-grave services to foreign customers and thus putting the U.S. nuclear industry at a competitive disadvantage? For example, what would be the implications for U.S. nuclear exports if Russia were to provide full-service fuel supply services internationally?

If the direct return of spent nuclear fuel to the United States is not a near-term option, how feasible might it be for the United States, as an interim measure, to persuade any third countries to accept spent fuel for interim storage or disposal? If it can't be done in the near term, and the long term is too long, should consider midterm?

What kinds of basic institutional and legal conditions would have to be established to enable the United States to offer cradle-to-grave services to foreign countries? What roles should be played by the U.S. Government and private industry in putting such a scheme into effect?

#### Some Questions of Implementation

What might be the key elements of a cradle-to-grave program in the future? What are the key questions that would have to be answered in defining the major institutional and commercial attributes of a cradle-to-grave program? Are there options that could enhance attractiveness of a deal or that could reduce its attractiveness to prospective consumer countries?

Since uranium is now largely owned by private parties and often by the foreign utilities themselves, who would actually hold title to the nuclear fuel in any new cradle-to-grave policy? If the United States decides to try to use private U.S. companies to implement a new nuclear fuel leasing policy, what mechanism or mechanisms would the United States have to employ in order to require or induce private companies to adhere to whatever new leasing policy the U.S. Government adopted? Would the use of private parties to lease nuclear fuel appear to be a viable option? Would it be more appropriate or even necessary, as an alternative, that the U.S. Government itself lease nuclear fuel for use in foreign power reactors?

Are there some significant distinctions between leasing power reactor fuel and schemes where suppliers sell the fuel outright but agree to take back all or a significant portion of the spent fuel? (Would this serve to save capital?)

Even if they are positive about the cradle-to-grave concept, are all the suppliers likely to adopt a common approach in advancing the idea? Is it likely that all supplier countries will accept some commonly agreed upon criteria for cradle-to-grave programs?

Which consuming countries are likely to be the most interested participants in a cradle-to-grave program? Are there some countries that may not be likely to accept any such proposals?

What are the major options that the United States might consider in shaping a cradle-to-grave policy? What terms and conditions might the United States incorporate in any arrangements? Might the arrangements include just an option for the U.S. Government to take back the leased nuclear fuel to the United States, or would contracts have to provide for the return of the spent fuel to the United States after its irradiation?

Should a cradle-to-grave policy cover all countries with which the United States has a peaceful nuclear cooperation agreement and which have no plans to acquire enrichment and reprocessing capabilities, or which agree to forego such facilities?