

Session III: Promoting Peaceful Uses of Nuclear Energy
“Multilateral Cooperation for the Back-end Nuclear Fuel Cycle”
The 8th UN-ROK joint Conference on Disarmament and Nonproliferation Issues
Jeju, 16-18 November 2009
by
Mr. Hee-Seog Kwon
Visiting Fellow at the Center for Nonproliferation Studies,
Monterey Institute of International Studies

Scope-setting

The discussion of the subject requires a clear understanding of what constitutes the back-end of the nuclear fuel cycle. The back-end fuel cycle, in the IAEA usage, generally refers to a host of operational, administrative, and safety-related activities that manage the irradiated (spent) nuclear fuel and radioactive wastes from the power or research reactors. It therefore comprises all activities associated with spent fuel storage, reprocessing, recycling, disposal (collectively known as “spent fuel management”), and other low- and intermediate-level radioactive waste disposal. Given the context of this session, the discussion in this paper will focus on the issues relating to spent fuel management, specifically how the international nuclear establishment grapples with ever increasing spent fuel challenges through multilateral cooperation, on the basis of the following three basic options:

- Closed cycle: spent fuel will be reprocessed, and the product of reprocessing (Pu + U, or others) recycled and the residual waste disposed.
- Once-through cycle (open cycle): spent fuel will be stored temporarily and then disposed in the permanent deep geological repository.
- Long-term interim storage in dry cask: deferring a decision between closed and open cycles (wait-and-See option).

Status of Multilateral Cooperation for the Back-end Fuel Cycle

At present, there are a number of forums where multilateral cooperation on spent fuel management is being carried out. These forums include the Global Nuclear Energy Partnership (GNEP), the IAEA, the Generation IV International Forum (GIF), and INPRO (International Project on Innovative Nuclear Reactors and Fuel Cycles) under the IAEA auspices, and OECD/Nuclear Energy Agency (NEA) at the inter-governmental level, and various private entities, most notably World Nuclear

Association (WNA) and Nuclear Energy Institute (NEI). Apart from most of the entities that are devoted to performing the research-level exercises, both the IAEA and GNEP adopted a systematic and action-orientated approach to the issue of spent fuel management. Should substantial progress be made in these forums in the foreseeable future, it would have a significant impact on the national spent fuel management strategy. However, the IAEA and GNEP have not yet produced a major breakthrough in handling the back-end issue. The overall status of multilateral cooperation in this area remains flimsy, standing at the level of information-sharing and joint technical study or research, and it will take quite a long time for the multilateral cooperation to reach the point of making a concrete proposal to the wider nuclear community or implementing a meaningful project that can resolve the spent fuel problem. I will take a look at the situation in the IAEA first, and then GNEP and other relevant forums.

IAEA

The dismal state in all fronts of the NPT-based nonproliferation and disarmament regime and the proliferation risks associated with the continuing spread of enrichment and reprocessing (ENR) technology prompted the IAEA Director General ElBaradei to make a proposal in 2003 on limiting the use of weapon-usable material in civilian nuclear programs and the processing of such material through enrichment and reprocessing, only under multilateral control.¹ He also proposed to consider the merits of multinational approaches to the management and disposal of spent fuel and radioactive waste. The Group of Experts he appointed to examine this issue submitted a report in 2005 that effectively endorsed the value and utility of the multilateral control over the most proliferation-sensitive parts of the fuel cycle.

Then, in the past few years, the fluctuating costs in fossil fuels and the deepening concern over climate change, along with the ever-increasing demand for cheap electricity, have stimulated a strong interest in the use of nuclear energy, setting off the so-called “nuclear renaissance.” Despite the global economic crunch last year, the established nuclear power producers have continued to be expanding their program, and the potential newcomer states mostly in the developing areas of the world have expressed or maintained their interest in nuclear power. The number of countries which approached the IAEA for counsel and technical assistance has recently grown to over 60. The global expansion in the utilization of nuclear power would increase the need for

¹ Mohamed ElBaradei, “Towards a safer world,” *The Economist*, 18 October 2003, pp.51-52.

fuel-cycle services, which might cause the unchecked spread of sensitive nuclear technology.

Recognizing the urgency of finding a solution to these challenges, the IAEA Secretariat has further elaborated on its ideas, and a number of countries have put forward various proposals relating to multilateral nuclear approaches. The current status is, while there are a dozen proposals regarding the assurances of nuclear fuel supply that are intended to entice countries not to develop an indigenous enrichment capability, there is no single formal proposal addressing the back-end problem.

From the Secretariat side, at the IAEA General Conference of 2006, ElBaradei called for the development of a new, multilateral framework for the nuclear fuel cycle to strengthen nonproliferation and cope with the expected expansion of nuclear power use.² He saw it as a complex endeavor, which in his view could best be achieved in a gradual manner, and suggested that:

- The first phase: establishing mechanisms for assurances of supply of fuel for nuclear power plants;
- The second phase: developing, as needed, assurances regarding the acquisition of nuclear power reactors; (* later on, this phase was deleted)
- The third phase: facilitating the conversion of existing enrichment and reprocessing facilities from national to multilateral operations, and would encourage limiting future ENR to multilateral operations.

In fact, the Director General indicated his preference for this incremental approach already back in 2005³ and maintained this position ever since. Most recently, ElBaradei submitted a consolidated proposal to establish an IAEA fuel bank, which, together with the Russia's updated proposal to set up an LEU reserve in its territory, triggered serious debate at the IAEA June Board meeting. For the time being, the main emphasis of the

² Mohamed ElBaradei, Statement to the 50th Regular Session of the IAEA General Conference 2006. In the statement, he also suggested a new, broader framework for the use of nuclear energy, which encompasses a new framework for the fuel cycle as a subset in its scope.

³ Mohamed ElBaradei, Statement to the 49th Regular Session of the IAEA General Conference 2005, p. 22.

Secretariat is on the fuel supply assurance, and the Secretariat therefore won't be in a position to present a proposal on the spent fuel management in the near future.

Also, several IAEA member states circulated a dozen proposals of either comprehensive or supplementary nature, all of which were dedicated to the front-end solution. (* The front-end issue was discussed by the previous speakers of this session.)

Analysis

Why does the nuclear community focus on the front-end issue, and why not consider seriously the back-end problem? There are several reasons behind this state of affair in the IAEA.

First, the multilateral approach to the nuclear fuel cycle is chiefly aimed at the “newcomers.” In the newcomer states which start a nuclear power program, the front-end fuel requirement comes first, compared to the back-end challenge of spent fuel management. The power plant needs to be fueled before the start-up.⁴ Spent fuel problem would arise some 20-30 years after the first nuclear power station begins operation. For the “newcomers,” the front end is a priority, which should be quickly addressed by key suppliers.

Second, both the key nuclear power states and the Director General converge on their views that the multilateral nuclear approach is a complex endeavor that should be tackled sequentially, starting from the front end. The six countries of France, Germany, the Netherlands, Russia, United Kingdom, and United States contended in their concept paper on the reliable access to nuclear fuel submitted to the member states that “to simplify the problem, we propose to deal initially with supply of enriched uranium, with the intention of addressing other elements which are more difficult, like spent fuel management, in subsequent steps,” and that “we recognize the logic of extending the benefits of the mechanism to back-end issues, which would be more complex and difficult, in a future step.”⁵

⁴ Jim Timbie on behalf of France, Germany, Russia, the Netherlands, United Kingdom, and United States, Statement on the Six Country Concept for a Multilateral Mechanism for Reliable Access to Nuclear Fuel at the 50th Regular Session of the IAEA General Conference 2006.

⁵ “Concept for a Multilateral Mechanism for Reliable Access to Nuclear Fuel,” GOV/INF/2007/11, IAEA, 23 June 2007.

Third, there is a general perception that the revival of the interest in multilateral nuclear approach to the fuel cycle was spurred by the proliferation threat that Iran has posed to the global nonproliferation regime. Particularly, the concern about the Iran's clandestine enrichment program galvanized actions in the IAEA to revisit and develop the old ideas of harnessing the fuel cycle, in particular the front-end challenge.

Fourth, if one gives thought to what elements could constitute a proposal that seeks to address the back-end challenge, it is likely that no country is in a position to make a comprehensive proposal under the current situation. The basic content of any back-end initiatives can be categorized into two folds; i) the assurances of the reprocessing and recycling services in a non-discriminatory, apolitical manner, ii) the assurances of the geological disposal services.

The first option is currently commercially available, and the reprocessing capacity exceeds the demand. Among the technology holders, France and the United Kingdom possess excess capacity based on the traditional PUREX (Plutonium-Uranium Extraction) technology to provide such services. Presently, not many nuclear power states buy the services of these countries for various reasons of nonproliferation concern, un-economics, and the lack of real benefits in reducing heat and radiotoxicity of spent fuel.

From the client's perspective, there are not much advantages from this off-shore exercise: the residual radioactive wastes resulting from the reprocessing campaigns should be returned to the country of origin which still require a permanent domestic repository and the required area for a repository is as large as for the entire spent fuel; the MOX fuel for LWR which is the potential end product of this option is highly costly to manufacture and it is cheaper to buy fresh LEU, plus the transportation and storage fees for all the materials. The only benefit of purchasing the PUREX service is to buy time to avoid public uproar over accumulating spent fuel while a country is sending, processing, and getting back the spent fuel. As it stands now, the off-shore reprocessing is an unattractive option. The UK reprocessing plant was closed down, due to technical problem; anyway it will be closed soon, lacking new reprocessing customers. One of the two lines of the French reprocessing facility is also expected to be closed soon, unless there are customers (one line can continue to be used for reprocessing domestic spent fuel).

In particular, given the high sensitivity surrounding the reprocessing issue in the United States, other technology holders may have a difficulty in obtaining the US consent to formally offer the reprocessing and recycling services within the IAEA, beyond the commercial off-shore reprocessing contracts being freely reached at the private level. At any rate, in their concept paper, the afore-mentioned six countries recognized the reliable access to existing reprocessing capabilities as an alternative to national reprocessing capabilities that could be developed over time, and maintained that “the same rationale [the assurances of reliable fuel supply] could apply in due course to reprocessing services at the back end of the fuel cycle, and options in this field could be explored at a later stage.”⁶

The second option is far harder to consider. In many key nuclear power states, national laws prohibit the long-term storage and disposal of foreign spent fuel or radioactive waste in their territory, out of health and environmental concerns. For example, the French law provides that following the reprocessing campaigns, France should eventually return all separated plutonium (in MOX form or not) and residual high-level waste to the country of origin. A few years ago, the Russian Duma enacted a law allowing the Russian authorities to take foreign spent fuel into Russia, but in early 2006, Russia’s nuclear authority cancelled this idea, apart from a continuing acceptance of foreign spent fuel produced from nuclear reactors that it had supplied. Currently, no country is considering the sort of comprehensive geological repository service.

Besides the above efforts to develop the multilateral nuclear approach, the IAEA has been playing a clearing-house role in pooling the expertise and technology of advanced nuclear countries for information-sharing and joint research on the spent fuel disposal options. The outcome of the collaboration is occasionally published as technical documents and shared with the other countries. The Agency’s 20/20 vision report explains the current worldwide situation and the Agency’s facilitating role on this subject.

“High level geological waste disposal, however, has not yet been demonstrated. The Finnish, French, Swedish and US repository programmes are the most developed, although none of these countries is likely to have a repository in operation much before

⁶ Ibid.

2020. The IAEA could facilitate the flow of information from States which are most advanced in developing deep geological facilities or conducting research in this field. Also, it could assist countries to conduct more uniform assessments of their high level waste disposal options.”⁷

And the Commission of Eminent Persons on the Future of the Agency, appointed by ElBaradei, submitted a report in May 2008, that recommended, *inter alia*, the establishment of mechanisms for fuel leasing or spent fuel take-back, along with a suggestion for multinational spent fuel storage, processing, or disposal sites. It also proposed that reactor-leasing arrangements that already contain lifetime fuel cores should also be explored.⁸ This will be a point of future direction for multilateral cooperation to solve spent fuel challenges.

At the recent IAEA General Conference, the US Energy Secretary Steven Chu stated that President Obama called for a new framework for civil nuclear cooperation and that the framework should seek international cooperation to relieve nuclear fuel consumers of the uncertainty emanating from spent fuel management. He highlighted that it was time for governments to work together to take responsibility for managing the back end of the fuel cycle.⁹ The new emphasis by the US administration on the back-end issue is an encouraging sign, but it remains to be seen if the new commitment would be transformed into concrete actions.

GNEP

Apart from the multilateral endeavors at the IAEA in the quest for the back-end solution, the Global Nuclear Energy Partnership (GNEP) represents another important multilateral forum to grapple with this issue. GNEP appears to be advanced than the IAEA in its deliberations of this issue and to offer a real chance of progress, considering the very high-level government officials are engaged. However, the Partnership is still at the level of establishing an organizational mechanism to tackle this issue and of exchanging views among the partner countries. At this stage, one can only hope that GNEP could present a practical way forward in the foreseeable future.

⁷ “20/20 Vision for the Future,” IAEA, February 2008, p. 9.

⁸ “Report of the Commission of Eminent Persons on the Future of the Agency,” Gov/2008/22, IAEA, 23 May 2008, p. 10.

⁹ Steven Chu, US Secretary of Energy, Statement at the IAEA General Conference 2009, p. 5.

GNEP was initiated by the Bush administration in February 2006, designed to meet the domestic challenges arising out of the accumulated spent fuel at the reactor sites and the potential rapid expansion of nuclear power programs in the United States. At the same time, the Partnership took on an international dimension to address the risks stemming from the global spread of sensitive ENR facilities. It planned to liaise with a consortium of nations with advanced nuclear technologies (or undesignated “fuel supplier nations”) to jointly develop the advanced reprocessing and recycling technologies such as UREX+, pyroprocessing and advanced burner reactors, which will significantly reduce the volume and radiotoxicity of nuclear waste to be disposed of in the planned geological repository of Yucca Mountain (63,000 MT of spent fuel and 7,000 MT of defense waste). On the flip side, the consortium of nations would provide the assurances of fuel supply to the nuclear power states, hoping that they would forgo their own investments in ENR technologies, and once the advanced recycling technologies are demonstrated over the long-term, they would take back spent fuel from the user nations for recycling and possibly ultimate disposal, along with developing and deploying small-scale reactors that contain the lifetime fuel core.¹⁰

GNEP represented a major U-turn in the US anti-reprocessing policy that has been maintained for the last 30 years since the Ford Administration, which was alarmed by the 1974 India’s nuclear test using the reprocessing technology the US has provided. It is exactly the vigorous embrace of reprocessing that caused the GNEP’s demise in the new administration before the Partnership’s endeavor was fully realized. Energy Secretary Steven Chu signaled the changed attitude by the Obama administration towards GNEP in his confirmation hearings at the Congress, stating that the near-term deployment of a commercial reprocessing facility was not necessary, however the administration would continue the research on recycling (including reprocessing) aimed at reducing the volume and toxicity of spent fuel. Accordingly, the administration’s request for funding for GNEP in the FY-2010 was substantially reduced, which scaled down GNEP similar to the Advanced Fuel Cycle Initiative (AFCI) R& D project. Alongside its R&D work, the international cooperation component of the Partnership survived and is still going on today. I will look into the process of deliberations that have been underway in GNEP on the back-end issue.

¹⁰ GNEP Policy Statement, US Department of Energy, February 2006.

In September and again December 2007, the GNEP partner countries gathered in Vienna to adopt an action plan and set up two working groups on nuclear infrastructure development and reliable nuclear fuel services respectively. In October 2008, the third working group on the development of grid-appropriate reactors was created. Among them, the working group on reliable fuel services focused mainly on the task of identifying international fuel supply frameworks, but it also included in the terms of reference the considerations for comprehensive fuel service arrangements, including spent fuel management.¹¹

At the second meeting held in Vienna in September 2008, the group decided to establish three sub-groups on high priority areas, including a sub-group on elements and criteria for closing the fuel cycle which would discuss the back-end issue. This represented a growing recognition of the need to address back-end fuel cycle that may prove more important for nuclear power expansion than front-end services that are largely available on the market. At the Ministerial meeting held in Paris in October 2008 that endorsed the establishment of the sub-working group, the UK energy minister argued that it was important to focus on waste management and final disposal, right from the start of national nuclear programs, and that it would be irresponsible to put it off for decades. The UK delegation initially proposed a separate working group on this issue to give sufficient visibility and not to be confused with debates on front-end fuel supply that have dominated the reliable fuel services working group discussions. In any case, the objective of the sub-working group was to recommend measures for moving towards fuel service arrangements achieving the management of spent fuel through the following activities (these specific activities were formulated at the fourth meeting of October 2009):

- compile current national practices and frameworks
- identify factors and limitations relevant to the needs of fuel service suppliers and users
- identify long-term and advanced options for the back-end of the fuel cycle
- recommend measures for developing fuel service arrangements and closing the fuel cycle, for the short term and long term

¹¹ Terms of Reference, Reliable Nuclear Fuel Services Working Group, GNEP, US Department of Energy.

Around the fourth meeting in Warsaw last month, the sub-group changed its name to “Approaches for Selection of Back-end Fuel Cycle Options,” and it adopted the work plan that was approved by the Ministerial meeting held in Beijing on 23 October. Based on the work plan, the sub-group will first collect information on current approaches taken by states. While the group intends to finalize its options and recommendations for implementation by the end of 2010, it might not bring the back-end issue to a final closure by that time, considering the inherent stalemate faced by national governments to offer a permanent disposal site for foreign spent fuel and the slow pace of the entire group’s schedule of meeting twice a year. However, in the high-level meeting held in Beijing late last month, the United States and other nuclear power countries refocused their attention on the “cradle-to-grave nuclear fuel services,” as a key part of the Partnership’s new framework for nuclear energy cooperation, with the planned name change from GNEP to International Nuclear Energy Framework (INEF).

Granted the US leadership in the global nuclear energy, the US internal dynamics could set the general tone on the course of discussions in the GNEP on the back-end issue. The Obama administration not only shelved the near-term deployment of the reprocessing facility conceived by GNEP but effectively terminated the Yucca Mountain waste repository project by eliminating the necessary funding for the development of the facility from the fiscal year 2010. The administration allocated only \$197 million to phase out the project and explore alternatives for nuclear waste disposal. To that end, it plans to set up a blue-ribbon commission of experts to evaluate spent fuel disposal options and make recommendations. With this policy shift, the new administration has narrowed the disposal options down to only one – the long-term interim storage. Energy Secretary Chu made clear the point by telling the IAEA General Conference last September that “The United States has chosen to step back from an early decision about the final disposition of that material [used fuel] in a geologic repository. We are confident, however, that we can safely store that material in dry-cask storage for a sufficient period of time while we develop and deploy better alternatives.”¹²

For a time, the consolidated interim storage idea was turned down by the Energy Department under the Bush administration because it would not reduce volume and thermal output of spent fuel and therefore have a limited effect on the use of space in a geological repository. For this option to be viable, any local or state government should

¹² Steven Chu, US Secretary of Energy, Statement at the IAEA General Conference 2009, p. 5.

accept the storage of spent fuel. In the nuclear waste project in any country, public acceptance is the most difficult barrier to overcome. The US anti-reprocessing community favors this option, because the permanent repository in Yucca Mountain seems no longer available. However, the US nuclear industry continues to assert the reconsideration by the administration of the recycling and repository option. Also, the Yucca Mountain project was not entirely dead at this stage. Following the Congressional approval of the Yucca Mountain site for development of a geological repository in 2002, the Department of Energy moved forward to prepare a license application to the Nuclear Regulatory Commission for authorization to construct the repository. The application was submitted in June 2008, and the Commission docketed the application in the following month. The Commission is now required by statute to make a decision on the construction authorization no later than 2012. Despite the administration's negative view on the Yucca Mountain project, the Commission's final decision may be influenced by different stakeholders. What options the future blue-ribbon commission would offer is unknown. Currently, the US reactor sites harbor about 60,000 MT of spent fuel and the reactor fleet is churning out 2,000 MT annually. Spent fuel and high-level radioactive waste are stored at 121 temporary locations in 39 states across the country.¹³

GIF & INPRO

The Generation IV International Forum (GIF) was established in January 2000 under the US leadership to investigate innovative nuclear energy system concepts for meeting future energy challenges. The forum serves to coordinate international R&D on promising new nuclear energy systems. Approximately 100 system concepts were analyzed and evaluated for their potential to meet the goals of the forum. The criteria for evaluation included advanced safety, enhanced proliferation-resistance, minimization of waste and optimization of natural resource utilization. The GIF has developed a technology roadmap for the six most promising reactor designs selected in 2002, with the goal of developing and possibly demonstrating each system over the long term.

Since it was set up in 2000 in the IAEA as proposed by Russia, the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) has been developing a methodology for evaluating innovative nuclear energy systems. So far, INRPO activities

¹³ Tom Doggett, "Obama budget seeks end to Yucca nuclear waste dump," *Reuters*, 7 May 2009.

have focused on the case studies in member states to test the methodology.

These two initiatives share the fundamental goal of developing a new generation of nuclear reactors which are energy efficient, proliferation-resistant, safer and environment-friendly. For the time being, the two entities seek not to duplicate each other's activities, with INPRO concentrating on developing an evaluation methodology for the future nuclear reactors and GIF directly focusing on the future reactor designs and component development. However, there is a possibility that the two forums could converge in the future. As these two forums contemplate the long-term development and deployment of fast burner reactors, they, if succeeded, will give a strong impetus to the reprocessing and recycling option in the spent fuel management strategy.

In light of the foregoing, at this moment of time, there are no mature joint actions under way in the multilateral organizations or forums to deal with the back-end problem. Rather, the issue is largely left in the hands of individual states, occasionally through the bilateral collaboration. The problem facing Korea is among the most acute, given the amount of the accumulated spent fuel at the reactor sites and the continuing discharge of spent fuel from its sizable fleet of nuclear power plants. In the absence of an effective multilateral mechanism which Korea and other countries affected by the back-end challenges could rely on, the resolution to the spent fuel question is a top priority, high on the agenda of Korea's long-term nuclear power generation program.

Case for Korea

Since the first nuclear power plant came online in 1978, Korea has expanded significantly its installed capacity of nuclear power generation. It is now the world's sixth largest nuclear power-generating country, with 20 reactors in operation (17.4 GWe) and six units under construction. The new government plan envisages that the number of nuclear power plant will be doubled and the share of nuclear power in the total electricity generation will increase to about 60% by 2030, compared to the current 40%. Importing 98 % of its energy sources, Korea has significantly depended on nuclear energy for its socio-economic development during the past decades. Without nuclear energy, Korea may have not been able to maintain its sustainable development throughout the world oil crises in the 1970s and 1980s and the financial crisis in the late 1990s. Even now, Korea is taking advantage of nuclear energy in overcoming the worldwide economic recessions. One important lesson Korea has learned in developing its peaceful nuclear program is that the transparency of and international confidence in a

country's peaceful nuclear program are crucial.

For the last thirty years, Korea's nuclear power plants have discharged roughly 10,000 metric tons of spent fuel that are stored at the four reactor sites as of the end of 2008:

<u>Nuclear sites (unit)</u>	<u>Amount of spent fuel</u>	<u>wet storage capacity</u>
Kori (4)	1,685 MT	2,253 MT
Yonggwang (6)	1,623 MT	2,686 MT
Ulchin (6)	1,294 MT	1,642 MT
Wolsong (4)	5,481 MT	5,980 MT

From the year 2016 on, starting from the Kori site, spent fuel storage pools will be saturated one by one. Furthermore, by 2030, Korea must find a way to store more than 30,000 MT of spent fuel, due to its expanded nuclear power fleet. If the fuel cannot be removed from the pools by 2016, regulations require that the reactors be shut down indefinitely. The spent fuel re-racking exercises in the pools to enlarge capacity have already been exhausted, and there will be considerable opposition from the local population in building dry casks at the reactor sites. In the meantime, the Korean atomic energy research institute has been researching and developing the pyroprocessing technology to substantially reduce the volume and toxicity of spent fuel by extracting a mix of plutonium and other transuranics. In the search for solutions, the Korean government established the Korea Radioactive Waste Management Co. (KRMC) at the beginning of this year. This organization was responsible for transport, storage, management and disposal of spent fuel and radioactive waste, and also tasked to forge a consensus among the stakeholders on how to manage the growing inventory of spent fuel and other high-level waste problems. Given the Korea's tortuous experiences with finding a storage site for low- and intermediate-level radioactive waste spanning the past 20 years, it won't certainly be easy to find a storage or disposal site for spent fuel.

An effective and efficient multilateral cooperation for the back-end fuel cycle is badly needed to ensure the long-term viability of nuclear power worldwide. It is high time for key nuclear power states to muster political will and resources to face up to the spent fuel challenges. /end/