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Workshop Report

Nuclear Security And Regional Fuel Cycle Decisions: Northeast Asia

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WORKSHOP REPORT
NUCLEAR SECURITY AND
REGIONAL FUEL CYCLE DECISIONS:
NORTHEAST ASIA

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On December 2, 2015, the Center for Strategic and International Studies hosted a workshop in Singapore on Nuclear Security and Regional Fuel Cycle Decisions. The purpose of the workshop was to explore how nuclear security objectives can influence regional fuel cycle decisions of China, Japan, South Korea and Taiwan and to identify potential avenues for collaboration. The participants included experts from governments, academia, industry and think-tanks. This report describes the discussions and recommendations. Workshop presentations are included in the Appendix, along with a list of participants and the agenda.

Background

The Nuclear Nonproliferation Treaty (NPT) has provided imperfect guidelines for nuclear policies, whether these apply to nuclear weapons or the peaceful uses of nuclear energy. The treaty proscribes the acquisition of nuclear weapons by states that have not acquired nuclear weapons (by 1967), supports negotiations toward nuclear disarmament by the states that have nuclear weapons and encourages parties to expand the peaceful uses of nuclear energy. Most observers agree that the treaty does this imperfectly – there are far more restraints to achieve nonproliferation than disarmament, and no restraints (except for a requirement for IAEA safeguards) in the treaty on peaceful uses. Some justify this imbalance because the purpose of the treaty was itself nonproliferation rather than disarmament or the peaceful uses of nuclear energy. Regardless, over time, complaints have grown about increasing burdens for nonproliferation with slow progress on disarmament. A byproduct of this dispute has been the relative lack of any restraints on the peaceful uses of nuclear energy beyond the obligation to accept IAEA safeguards. This extends to the fuel cycle: states reject restraints on enrichment or reprocessing, even though virtually all states recognize their sensitivity for proliferation.

Ultimately, the harmony of the regime will require progress in each of the disciplines – disarmament,

nonproliferation and peaceful uses. The starting point of the workshop was to recognize that the nuclear security framework has the potential to help harmonize such progress. Until 2001, nuclear security was a dusty corner of nuclear policy but in the last 10 years, it has gained increasing attention and importance. In particular, since 2007, nuclear security has been recognized as a motivating factor for disarmament. With each successive nuclear security summit, the benefits of treating nuclear security seriously have become clearer. And while the connection of nuclear security to nuclear fissile materials stockpiles is obvious, the link to the nuclear fuel cycle --which in fact produced these materials – is not so obvious. One goal of the workshop was to make such considerations explicit.

Ms. Squassoni in her opening remarks highlighted the fact that spent fuel management is a national decision and nuclear security and nonproliferation are not the primary drivers for activities in this area. She noted that greater attention to nuclear security objectives could affect decisions about when to move spent nuclear fuel (SNF) from wet to dry storage; how/whether to consolidate storage and/or reprocess; the desirability of coordinating storage/repository requirements regionally, and waste disposal options. Some fuel cycle principles could include setting guidelines for minimizing weapons-usable material in fuel, for minimizing

Figure 1 Dry Storage. Source: Portland general electric Co.

transport, for keeping separated Pu close to zero; avoiding stove-piped decision making; acting now versus taking a "wait and see" approach; and promoting incentives/collaboration over "rights" internationally.

Nuclear Energy and Security Challenges in North East Asia

The discussion began with a presentation by *Dr. Tatsujiro Suzuki* on global fissile materials stockpiles and then progressed to specific challenges in Northeast Asia. In mid-2015 there were approximately 1350 tons of highly enriched uranium (HEU) and 500 tons of separated plutonium (Pu) – enough for tens of thousands of weapons. Most of the HEU stockpile is for military use and the total amount is decreasing. About 70% of the Pu stockpile is for civilian use and it is increasing because of reprocessing. Japan committed in 2014 to remove all special nuclear material from the Fast Critical Assembly at Tokai.

In Northeast Asia, most enrichment demand is met by the international market (except for Japan with its modest domestic capacity). On the back end, reprocessing is seen as increasingly attractive because of SNF storage problems. Possible options for regional cooperation include:

- LEU fuel bank or a URENCO-like consortium
- Mutual inspection/trust building scheme – e.g., ABACC – or transparency for HEU/Pu like Japan's no surplus policy
- International PU disposition program (international, with UK, France?)

One option for Japan would be to let the UK take ownership of Japan's Pu stored there. One participant wondered whether letting the UK take ownership of Japan's plutonium stored in Britain would be a "win" for nuclear security, since this accounting sleight of hand would leave Japan with a lot less separated Pu, and therefore make it easier to start up the Rokkasho reprocessing plant even without certain plans for MOX use. Dr. Suzuki suggested that, as part of an international program to optimize the global Pu stockpile, this makes sense. The UK is committed to reducing Pu stockpiles and will build a MOX fuel fabrication plant. In addition, it makes commercial sense for UK to receive additional payments from Japan for financial reasons while Japan can save money for plutonium transportation. The "win-win" is that everyone saves money & transportation and it's easier for Japan to reduce stockpiles.

Figure 2 Rokkasho Reprocessing Plant. Source: Wikimedia Commons.

Dr. Man-Sung Yim outlined the growth of nuclear energy generally and particularly in Asia, where spent fuel accumulation is a concern. He suggested that China will become a bigger player, but that there are certain governance challenges that may need to be addressed. For the present, Russia will be dominating nuclear fuel cycle services. Dr. Yim also shared public opinion survey data on changing attitudes in South Korea about the attractiveness of nuclear weapons. Looking ahead to the future, it will be important to figure out a way to address North Korea's enrichment and reprocessing capabilities.

Dr. Zhiwei Zhou portrayed a hugely ambitious Chinese nuclear energy program, placing it in the context of China's enormous energy needs. In addition to the vast growth in nuclear energy capacity (400 GWe by 2050), China has ambitious plans for reprocessing, fast reactors, and fusion. Given the scope of China's programs, some of the questions centered on whether China could avoid some of the steps that other advanced nuclear states have taken, like use of MOX in light water reactors (LWRs) or PUREX-type reprocessing. In the interest of nuclear security, avoiding a lot of separated plutonium might be useful. Dr. Zhou anticipated that China will use MOX in its LWRs as a transitional stage. This will depend on the actual LWR NPP capacity and the fast reactor NPP capacity by 2050. As for PUREX, he suggested it was likely to be cheaper than pyroprocessing, although the

National Academy of Sciences has been exploring pyroprocessing for reprocessing of future spent fuel from ADS' subcritical system. Overall, China has not experienced any nuclear security problems.

National Fuel Cycle Decisionmaking

The participants discussed the concept of "stovepiped" decisionmaking – in which different decision-makers may see an issue only from their area of expertise. In the United States, there are three potential stovepipes involved in fuel cycle decisions: nuclear energy, national security and waste management. On the nuclear energy side, it is largely a science & technology-driven, and profit-driven industry focused to provide safe and reliable, economic power. In the second sector are policy people who focus on nonproliferation and national security. These are often not scientists, who differ on the objectives of policy. In the third sector (for back-end fuel cycle decisions) the waste management group has two challenging issues: to find a suitable site (societal, political, institutional issues) and to try to demonstrate how to manage and permanently dispose the waste safely. This can require geologists, climatologists, hydrologists, etc. A participant challenged the group to consider frameworks that entailed win-win cooperation that would encompass R&D, national security, waste management.

Dr. Alan Hanson contrasted how decisions about fuel cycle were made in the United States with experience in France. He suggested that the more centrally governed a country is, the more successful it will be in nuclear energy (presumably because fuel cycle activities are expensive). In the United States, decisions about reprocessing were made largely with little connection to industrial concerns, partly because nuclear energy was a "nice to have" energy option rather than absolutely essential. France was able to strongly commit to nuclear power and decided that government ownership would be maintained and that control over the nuclear enterprises would be exercised from Paris.

Amb. Nobuyasu Abe described the changes in decision-making in Japan that have come in the shadow of the Fukushima accident. In some respects, Japan has adopted an approach similar to that in the United States – separating out industry (i.e., METI) from regulation. This more decentralized style reflects power divided not only

within the Cabinet, but also with the judiciary and the legislature (Diet).

For Japan, there are three major nuclear security objectives: physical protection, reduction of nuclear material and international cooperation. On physical protection, the Japanese public is only slowly awakening to the prospect of nuclear terrorism on its soil. In the meanwhile, the NRA recently issued requirements for facility resilience against terrorist attacks (especially by aircraft) and an expert committee issued recommendations for background check of personnel on a voluntary basis. On minimizing material, Japan agreed to remove HEU and Pu from the Fast Critical Assembly in Tokai and return it to US. However, separating Pu from spent fuel will increase the amount of Pu, depending on what happens with reactor restarts. Amb. Abe listed several uncertain issues, including how many reactors may be restarted, whether reactor life-spans can be extended beyond 40 years, and whether the government will successfully promote new reactor construction.

Dr. Yongsoo Hwang described the Korean process of decision-making about the nuclear fuel cycle as far more complicated than Japan's. There are many players, including Nuclear Safety and Security Commission (NSSC), KINS, KINAC and organizational experts. After the PECOS (Public Engagement Commission on Spent Nuclear Fuel Management) recommendations this year, there may be a new organization created specifically to handle SNF. In Hwang's opinion, it is very difficult to harmonize views. In addition, there are a lot of problems to work on spent fuel management already. Hwang suggested that factors such technology, cost, proliferation, public acceptance, and efficiency all now factor into decisionmaking but in the past, the government only considered efficiency and technology. Cost has now become very important. PUREX and pyroprocessing are very expensive technologies to be commercialized. A key development this past year was the passage of a law reclassifying waste. According to the old national act, all spent nuclear fuel was classified as waste, but the Safety Act 35.4 Promotion Law 3 changes the classification to allow for direct disposal or reprocessing.

Participants noted how negative public opinion can affect minor issues regarding storage of waste, even at the low-level categorization. There are parallels between Japanese experience

after Fukushima and U.S. experiences after Three Mile Island regarding public acceptance of storage of low-level waste. This may make waste management considerations take higher precedence over security or technical considerations.

Negative public opinion can affect major fuel cycle decisions also. For example, although Taiwan's official policy is to dispose of spent nuclear fuel, Taipower has not been able to obtain a license from the local government for a dry cask storage facility because of negative public opinion. This could make it necessary to ship SNF abroad for reprocessing because at-reactor pool storage is filling up to capacity. In terms of public acceptance in China, participants noted that this is increasingly becoming a concern and that a lot of education is needed for local people to make the process more transparent. Recently, construction on a fuel fabrication plant in Guangdong Province was stopped by the opposition of local people.

One participant noted that the decentralized process in the United States was not always that way. In fact, in the early years of the nuclear energy program in the United States, there was very strong centralization through the Atomic Energy Commission and within the Congress by virtue of the Joint Committee on Atomic Energy. This existed for at least twenty years but was strongly influenced by the role of the military program. That participant also noted decentralization of decision-making does not necessarily mean a gap between government and industry in Japan. Huge investments by industry in anticipation of formal requirements (something that would never happen in the United States) suggest that industry expects licenses to be granted. Two examples are the $1B seawall at Hamaoka, begun before any such requirement was in place, and JNFL's plans to build an emergency response center twice as large as the old one in anticipation of new licensing requirements. Even if the political structure is decentralized, there is still a strong government/industry relationship.

Regional Collaboration

John Carlson led off the discussion with a framework for considering collaborative, regional approaches. Beyond nonproliferation and nuclear security gains, collaboration could provide assurance and confidence in the intentions of partners. He offered examples of current collaboration at the institutional and policy levels: the

Forum for Nuclear Cooperation in Asia (led by Japan), ASEANTOM, the proposed Asia Pacific Nuclear Energy Community (APNEC), and the Northeast Asia Peace & Cooperation Initiative (Korean initiative). At the institutional level, it could be possible to set standards and provide a forum for reporting on national implementation of standards. Other efforts could address ensuring the security of supply (supply guarantees and fuel banks) and Pu management guidelines or codes of conduct.

Of course, it is also possible to conduct projects at the national level that could include collaboration on R&D, reactor design, reactor issues, fuel development, relevant for spent fuel management; collaboration on 3S (safeguards, security and safety), and handling of spent fuel.

On a regional basis, it might be possible to conduct joint R&D, collaborative power programs, a multinational project in enrichment, fuel fabrication for common reactor models, approach of recycle on regional basis (multinational control, nuclear islands), management of spent fuel and high-level waste (HLW).

Dr. Atsuyuki Suzuki asserted in his presentation that improving transparency was a significant public good but that it was very hard to do. Nonetheless, this was an important reason to try to engage in multilateral approaches.

Assurance benefits of multilateral approaches include guarantees of services, economic benefits, political acceptance, and safety & security. For Japan, a guarantee of services is not as important as other benefits because Japan already has fuel cycle capabilities, but Dr. Suzuki regarded diversification as still important. From an economic perspective, regional interim storage would be the most preferable but a difficult socio-political challenge. In Japan, political acceptance is the most crucial problem but could be softened by Japan's collaboration in international efforts. Finally, multilateral approaches do have significant safety and security benefits from the viewpoint of improving transparency.

Dr. Suzuki raised three potential areas for collaboration. The first would be for Japan to provide reprocessing services. The second would be using Japan's facilities for collaborative R&D (such as Joyo, Chemical Processing Facility, underground research laboratory). The third would be to network back-end facilities and

provide opportunity for mutual inspections. None of these options seemed to provide overwhelming assurance benefits but could be feasible with some changes. For example, the first option would only be possible if Japan had significant buffer storage (either in Japan's npps or at the reprocessing plant). The second option seemed to have few drawbacks but if Japanese officials saw significant benefits in transparency, could be easily implemented. The third option presents more significant challenges because "networking" back-end facilities has never been tried, nor necessarily have regional inspections. However, it might be possible to start on a volunteer basis, providing a tangible benefit for facility owners, to induce real participation. When asked about whether the inspections would be safeguards, safety and/or security, Dr. Suzuki suggested that safety culture would be an excellent starting point for transparency. Another participant suggested that there were real differences in safety culture among the Chinese, Japanese and Koreans. Dr. Suzuki stated that INRA (international nuclear regulators association) meetings, which are closed to members, have focused on information exchange, trying to overcome such differences between member countries.

Dr. Andrew Newman described the benefits and costs of multilateral storage and disposal options. In addition to security benefits, multilateral storage could allow spent fuel to be consolidated more quickly, create political and technical "breathing room," demonstrate safe operation and help build trust among partners. The successful operation of a facility that stores and disposes other types of radioactive waste (e.g. low and intermediate level waste) can also help build trust in the ability of waste management organizations to safely operate with more radioactive material, including spent fuel. Storage can be a business opportunity for host countries, but we should remember that it is not an alternative to disposal. In fact, public acceptance of storage sites often come with the requirement that they will not become permanent. Multilateral disposal sites can help promote economies of scale and provide earlier access to disposal. Reduction of the number of sites globally can lower the environmental impact and provide wider choice for geological conditions, as well as provide incentives to forego reprocessing.

However, these approaches are not without their challenges and risks, which can include national legislation

banning or restricting import (ex: Kazakhstan) and/or export, resistance from countries with advanced repository programs, who worry multinational solution may undermine their own programs, resistance from neighboring countries, from potential host governments, from potential host communities and from anti-nuclear groups. Finally, waste management is a lower priority compared to nuclear power generation, and there is significant negative public reaction to accepting waste from somewhere else.

In reviewing past examples of collaborative approaches, Dr. Newman suggested that identifying a host community should not be a first step in a national or regional spent fuel management strategy. Rather, nuclear waste management organizations should begin cooperation on topics that could later be useful to siting – for example, spent fuel transportation, engagement strategies, and lessons learned.

Dr. Zhongmao Gu described China's nuclear energy targets and resultant plans for fuel cycle capabilities. Although he noted that China does not yet have industrial-scale reprocessing, these will be required as China's new build program connects over 5 reactors to the grid each year. Looking further ahead, China has an ambitious program for fast reactor development, divided into three phases:

- **Phase 1** (2020) – using pilot reprocessing plant, small MOX fuel production (500kg/yr), CEFR (China Experimental fast Reactor)
- **Phase 2** (2025-30) – use 200t/yr reprocessing plant, 20t/yr MOX plant, CFR600 as platforms to close the fast reactor fuel cycle
- **Phase 3** (>2035) – using a 800t/yr reprocessing plant, 20t/yr MOX plant, CFR1000 as platforms

China has a negligible plutonium stockpile in the civilian sector and overall, a good record of nuclear security. But Dr. Gu stressed that nuclear terrorism is a common threat in the world and that potential collaboration on nuclear security is a very important issue. Dr. Gu mentioned three particular roles for China in collaboration on fuel cycle issues:

- *Possible regional center of uranium enrichment.* China's centrifuged uranium enrichment technology has been commercialized since 2013 and enrichment capability is increasing to meet domestic needs. China will be able to offer enrichment services to newcomer countries in near future. This is a ripe idea.

- *Regional center for reprocessing based on proliferation resistant technology.* In East Asia, Japan, Korea and China all have national plans to develop proliferation-resistant reprocessing. However, since these technologies are under development, this idea is not yet ripe for implementation.
- *Possible take back of spent fuel*.

Dr. Gu noted that China's new Center of Excellence on nuclear security could possibly act as a platform for regional collaboration, particularly since the Japanese and Korean Centers have been advocating regional collaboration.

On decision-making about fuel cycles in China, Gu noted that the Chinese Academy of Sciences and the Chinese Academy of Engineering conduct strategic studies that are submitted to the government. The central government has several administrative bodies that are involved, for example, the National Energy Administration and also the State Administration for Science, Technology and Industry for National Defense and for nuclear regulation, the Nuclear Safety Administration under Ministry of Environmental Protection.

Looking Forward: Recommendations

In the roundtable discussion, participants considered the achievements of and gaps in nuclear security. One participant suggested we needed a global approach (not just regional) to plutonium stockpiles and other participants suggested that focusing on regional approaches could exclude some key fuel cycle service providers. In terms of gaps, most participants agreed that both cybersecurity and insider threats need to be considered more carefully in all states. Sabotage and cyber security are the new security threats and spent fuel wet storage is more vulnerable than ever before. Dry cask storage will be a priority for safety, economics and also security.

In the near term, nuclear exports present an opportunity to influence new nuclear states. In this regard, China, Japan, and South Korea are to export nuclear security & safety culture in addition to the reactor exports. All three should become models for safety and security culture for the other parts of the world. One participant noted that although the range of cooperation between South Korea and the UAE (which has purchased Korean nuclear power

reactors) is broad, it does not specifically include cooperation in safety and security culture development. Also, given differences in safety approaches, it will be important to exchange information on different safety systems among the countries. Although participants noted the potential for the new Centers of Excellence to provide an institutional basis for cooperation, these centers do not normally cover safety culture, but could cover security culture. This might be a first area for substantive exploration.

Participants discussed whether SNF storage, as a high priority, should be addressed nationally or regionally. A regional approach could enhance mutual trust, confidence-building and transparency. As a longer term solution, participants advocated R&D on fuel recycling and on safe disposal of plutonium. Addressing a broader point, one participant suggested we should examine the barriers between Asian countries for collaboration. For example, are they all at the strategic level or at a much lower level, for example, among different regulatory systems?

A final point of discussion concerned leadership. There are good reasons for each country to demonstrate leadership, as well as clear leadership opportunities coming up. For example, the ROK will host the Nuclear Security Conference within the IAEA. Japan will continue to lead the way on its "no surplus plutonium" policy. Several participants stated that U.S. leadership was key, however, since it would be difficult for any of the Northeast Asian countries to accept a leadership role for the region or the globe.

In general, the national/nuclear security community has not appreciated the potential benefits that could come from regional collaboration on the nuclear fuel cycle, particularly on the back end. A good solution to waste could include regional cooperation, increased transparency, allowing countries to have less concern about what their neighbors are doing in regard to spent fuel, plutonium, and reprocessing. On the waste management end of the spectrum, a national security element/dimension could help mitigate difficult public acceptance challenges and help convince people that disposal is in a public good.

APPENDIX

NUCLEAR SECURITY AND REGIONAL FUEL CYCLE CHOICES

Wednesday, December 2, 2015, 9:00 a.m.-5:15 p.m.

AGENDA

9:00-9:15 a.m. **Introduction** – Ms. Sharon Squassoni, Senior Fellow and Director, Proliferation Prevention Program, CSIS
Results of last workshop and objectives for this one

9:15-10:30 a.m. **Session I: Nuclear Security Challenges in Northeast Asia: Beyond The 2016 Nuclear Security Summit** (Moderator: Dr. Trevor Findlay)
Dr. Tatsujiro Suzuki, Director and Professor, Research Center for Nuclear Weapons Abolition, Nagasaki University
Dr. Man-Sung Yim, Professor and Head, Department of Nuclear and Quantum Engineering, Korea Advanced Instituted of Science and Technology (KAIST)
Dr. ZHOU Zhiwei, Professor, Institute of Nuclear and New Energy Technology, Tsinghua University
Questions: *How are we defining nuclear security challenges? What are the achievements and where are the gaps? How might fuel cycle activities in Korea, Japan and China affect HEU, Pu material stockpiles?*

10:30-10:45 a.m. **Break**

10:45-12:00 p.m. **Session II: National Structures and Approaches to link Nuclear Security Considerations to Fuel Cycle Decisions (**Moderator: Mr. Tom Isaacs)
Dr. Alan Hanson, Executive Director of the International Nuclear Leadership Education Program, Massachusetts Institute of Technology (MIT)
Amb. Nobuyasu Abe, Commissioner, Japan Atomic Energy Commission (JAEC)
Dr. Yongsoo Hwang, Director General, Center for Nuclear Strategy and Policy, Korea Institute of Nuclear Nonproliferation and Control (KINAC)
Question: *How do national governments link their fuel cycle decisions to nuclear security? What is the range of practical institutional approaches (e.g., fuel banks, Pu management guidelines, multilateral collaboration)?*

12:00-1:00 p.m. Lunch

1:00-3:00 p.m. **Session III: Potential Areas for Regional Fuel Cycle Collaboration** (Moderator: Mr. John Carlson)

Dr. Atsu Suzuki, Professor Emeritus at the University of Tokyo.
Dr. Andrew Newman, Senior Program Officer, Material Security and Minimization, Nuclear Threat Initiative (NTI)
Dr. GU Zhongmao, Professor (retired), China Institute of Atomic Energy (CIAE)
Question: *What is the range of practical institutional approaches (e.g., fuel banks, Pu management guidelines, multilateral collaboration)?*

3:00-3:15 p.m. Break

3:15-5:00 p.m. **Roundtable Discussion** -- all participants, moderated by Sharon Squassoni
Where should time, attention and focus be placed in the next 5 years? 10 years? 20 years?
Bridges between nuclear security, fuel cycle, nuclear safety

5:00-5:15 p.m. **Summary and Closing Remarks**

Participants List

Ambassador Nobuyasu Abe, Commissioner, Japan Atomic Energy Commission

Mr. John Carlson, Counselor to the Nuclear Threat Initiative

Dr. Wen-Chuan CHEN, Section Chief, Fuel Cycle and Materials Administration, Atomic Energy Council

Dr. Alina Constantin, Scientific Researcher, Institute for Nuclear Research

Dr. Trevor Findlay, Associate, Project on Managing the Atom, Harvard

Dr. GU Zhongmao, Professor (retired), China Institute of Atomic Energy

Dr. Alan S. Hanson, Executive Director of the International Nuclear Leadership Education Program, MIT

Dr. Yongsoo Hwang, Director General, Center for Nuclear Strategy and Policy, KINAC

Mr. Thomas Isaacs, Director, Office of Planning and Special Studies, Lawrence Livermore National Laboratory

Dr. Min Lee, Vice President/Secretary General and Distinguished Professor, Department of Engineering and System Science, National Tsing Hua University

Dr. Andrew Newman, Senior Program Officer, Material Security and Minimization, Nuclear Threat Initiative

Ms. Sharon Squassoni, Senior Fellow and Director, Proliferation Prevention Program, CSIS

Dr. Atsuyuki Suzuki, Professor Emeritus at the University of Tokyo

Dr. Tatsujiro Suzuki, Director and Professor, Research Center for Nuclear Weapons Abolition, Nagasaki University

Dr. Man-Sung Yim, Professor and Head, Department of Nuclear and Quantum Engineering, KAIST

Dr. ZHOU Zhiwei, Professor, Institute of Nuclear and New Energy Technology, Tsinghua University