A Study of Building and Sustainable Operation of an International Nuclear Fuel Cycle System

Interim Report

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This study was performed from the academic aspects by the above authors (group). The content described in this report does not represent the organizations to which the above authors belong.

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1. Overview of the report

Background and purpose

- "A Study of Building and Sustainable Operation of an International Nuclear Fuel Cycle System – a Study of the International Nuclear Fuel Cycle Framework and Handling of Spent Fuel " was carried out based on the premise that, taking into consideration the accident at Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company, introduction of nuclear power to the Asian region should be facilitated in the future especially after sufficient nuclear security measures are taken with regard to the nuclear power generation. The key words of the study are "Nuclear-Nonproliferation", "Sustainability", and "Feasibility".
- The schematic non-proliferation measures targeting national governments with a focus on safeguards, the Convention on the Physical Protection of Nuclear Material, etc., have been effective to some degree. However, as many more states have used nuclear power including Sensitive Nuclear Technologies (SNTs), it is hard to say that these measures are perfect from the viewpoint of effectiveness toward nuclear non-proliferation. In addition, the measures for enhancement of nuclear non-proliferation on the supply side that mainly consists of the nuclear power technology advanced countries may interfere with the right for peaceful uses of nuclear power, which is guaranteed by Article 4 of the Nuclear Non-Proliferation Treaty (NPT). Furthermore, as to the nuclear security for SNTs and nuclear material handling and the safety management of nuclear facility operations, the state-by-state efforts made so far are not necessarily enough from the viewpoint of effectiveness, efficiency, and economic reasonability.
- Under the circumstances, one of the influential ideas is execution of a nuclear fuel cycle among multiple countries, which is called a demand-side approach. According to this approach, the nuclear fuel cycle services, especially centered on the SNTs, are multinationally executed and controlled, and therefore unnecessary proliferation of the SNTs is prevented and safe and appropriate control of nuclear technologies and nuclear materials is attainable. This can effectively and efficiently assure risk control and risk reduction with regard to safety, safeguards, and security (3S). At the same time, as a result of sharing of a nuclear fuel cycle, etc., this approach is executable without interference with fostering the peaceful uses of nuclear power in emerging and other states.
- The purpose of this study is to propose an "International Nuclear Fuel Cycle System" which can strengthen international non-proliferation scheme and even provide stable energy/nuclear fuel cycle services in a region. It should contribute to enhancement of transparency and trust-building in the region. The study investigated the schematic issues and the countermeasures concerning the specific measures to achieve the stable maintenance of the multilateral international nuclear fuel cycle including stable uranium supply system, spent fuel (SF) handling system, usage of plutonium, establishment of regional safeguards scheme for the international nuclear fuel cycle, requirements for an organization that carries out international nuclear fuel cycle, and roles of industry in the international nuclear fuel cycle scheme. Furthermore, the study aims to propose a feasible

international nuclear fuel cycle scheme centered on Asia and present it to the international society.

Basic concept of the proposed Multilateral Nuclear Approach (MNA) framework

- The proposed “International Nuclear Fuel Cycle System” (Framework) is designed based on nuclear-nonproliferation, sustainability, and feasibility.
- The fuel cycle service system by the MNA Framework (including the regional safeguards measures) shall prevent the proliferation of SNTs and nuclear materials (it shall be the equal or higher level of the existing global nonproliferation measures (including bilateral nuclear agreement)). However, based on the equal rights of peaceful uses and nonproliferation, the MNA proposal adapts the similar objective criteria approach of the 2011 Nuclear Supply Group (NSG) Guidelines (related to SNTs). This approach basically allows the member states that meet the criteria to introduce enrichment/reprocessing. The MNA shall perform strict control of the fulfilled regional safeguards and the SNTs. Furthermore, in consideration of the possibilities of member states’ withdrawal from the MNA Framework, the requirements shall include right to demand for return of nuclear materials, termination of the use/operation of the facilities (related to SNTs) which are built based on the participation in the Framework, prohibition of the transfer to a third state, etc.
- In addition to nonproliferation, the proposed MNA Framework shall include a function that allows maintenance/strengthening of safeguards and nuclear security, in order for the fuel cycle service scheme within the MNA Framework to safely and adequately manage nuclear technology and nuclear materials, in other words, to effectively and efficiently ensure risk management and risk reduction concerning 3S.
- The proposed MNA Framework shall present rational solutions for both nuclear fuel supply (frontend) and spent fuel (SF) handing services (backend).
- For the frontend (nuclear fuel supply), the MNA Framework will not only assure the supply but also provide supply services that meet the demands within the Framework.
- For the handling of SF, the direct disposal (eternal disposal) is out of scope of the MNA Framework based on the viewpoints of 1) nuclear nonproliferation (to avoid worldwide proliferation of so-called “Pu-mine” as a result of direct disposal in the long term viewpoint), 2) saving of repository space, and 3) reduction of environmental burden. Instead, the SF will be treated in 2 parallel ways; 1) with international storage, and 2) by existing reprocessing facilities. (It is one of the effective measures of nuclear nonproliferation for the nuclear weapon states to take away other states’ SF and reprocess or directly dispose of them. However, it is not realistic for the nuclear weapon states to take back all SF around the world. Thus, this is not considered as an option in this study.)
- The states that generate SF must be responsible for disposal of high level waste generated from reprocessing service.
- In the short term, it is realistic to perform SF storage by MNA along with reprocessing by existing facilities. If the facilities already exist, discussion on “postponement” of reprocessing does not hold major significance, since SF reprocessing needs be performed sooner or later from the viewpoint of

securing processing space and reducing environmental burden as mentioned above.

- Recovered Plutonium (Pu) is used in the form of MOX for Light Water Reactor (LWR)-MOX partially to the extent possible. However, it is also stored as future resources*. (*Basically until the time when MOX fuel can be expected to be equivalent to U fuel). The so-called “accumulation of Pu” as a result of reprocessing is considered not favorable for nuclear nonproliferation. However, measures such as MOX stockpile without separation of Pu, improvement of nuclear proliferation resistance due to production of americium, international storage under MNA control (including transfer of the ownership to NMA), and robust nuclear security strategies enable us to consider the production of MOX as “stockpile for regional energy security” for the future rather than “storage” by states.
- Utilization of MOX can also be applied for future LWR MOX as well as Fast Reactor (FR)/Fast Breeder Reactor (FBR) when its economic feasibility is enhanced.
- Each state will be responsible for disposal of high level waste (HLW) in the future. In order to secure the disposal space and to reduce environmental burden (e.g. low level within 300 to 500 years), solutions (i.e. development of technology and establishment of its service system) shall be discussed among the member states of the Framework within a certain period of the multinational storage, as a part of MNA member states’ obligation.

Method used for the framework study

The expansive MNA examination method as shown in IAEA’s INFCIRC640 was adapted. The following 3 types were examined. For each type, 12 requirements (label A to L) were examined.

Types of MNA

Type A: Although Type A does not meet all the above-mentioned basic concepts, it promotes regional multilateral management of nuclear nonproliferation, safeguards, and security of the existing and new facilities in each member state. This means that there is no involvement of fuel cycle service. In the Type A framework, the ownership of the existing or new facilities would not be transferred to MNA (specifically, only the regional safety measures, regional safeguards, and regional nuclear security will be implemented multinationally).

Type B: Without transferring the ownership of the existing and new facilities to MNA, the fuel cycle service will be implemented. This is the framework that should be aimed now.

Type C: With transferring the ownership of the existing and new facilities to MNA, the fuel cycle service will be implemented. (This is the form that should be aimed in the future.)

Prerequisites for formulation of MNA (Items to be included in the basic agreement)

12 prerequisites to be prepared for each option are set as follows:

Label A: Nonproliferation (Safeguards, nuclear security, etc.)

Label B: Fuel cycle services (uranium fuel supply, SF storage, SF processing (SF reprocessing), MOX storage)

Label C: Selection of a host country (sitting country)

Label D: Access to technology

Label E: Degree of multilateral involvement

Label F: Economics

Label G: Transportation

Label H: Safety

Label I: Nuclear liability

Label J: Political and public acceptance

Label K: Geopolitics

Label L: Legal aspects

Followings are the key points of the Labels A to L of Type B and Type C. For the detailed differences between Types B and C, refer to the main body of this paper.

- Obligation with regards to nuclear non-proliferation must be performed while it is guaranteed that the right of peaceful uses of nuclear energy pursuant to Article 4, NPT (equality) is not interfered.
- The specific requirement to participate in the multilateral framework is to satisfy conditions almost equivalent to the “objective criteria” described in INFCIRC 254 part 1, 6-7 (NSG Guidelines revised in 2011).
- Regional material accounting and safeguards must be established within the MNA Framework to implement the nuclear non-proliferation regime.
- The MNA agreement to be proposed must contain nuclear non-proliferation capacity equivalent to the existing bilateral agreements (e.g. one with the United States).
- In the multilateral framework, the states that already have nuclear fuel cycles and those that will newly build nuclear fuel cycle will be candidates for host states (type B) and site states (type C) of the fields regarding the facilities they have already had or will have, including uranium fuel supply, SF storage, SF processing (reprocessing), and MOX storage. At the same time, they will be candidates for service recipient states for the other fields. In type B, only MOX storage will be under MNA control/owned and in type C, all the fields will be under MNA control/MNA-owned.
- The recipient states will receive/enjoy fuel cycle services with regards to uranium fuel supply, SF storage, SF processing (reprocessing), and MOX storage.
- However, in addition to satisfying the above-mentioned membership requirements, the host states/site states must be “politically and geopolitically stable”. For the selection of the site states, we must establish systems and rules to judge political and geopolitical stabilities within the

framework (e.g. determination of a non-dispute condition).

- Within the framework, we must establish systems and rules to surely control the SNTs (limited to technology-holding operators only).
- As membership requirements with regards to SF under the MNA framework, the member states (host, site, and recipient states) must determine long-term SF processing measures within a specific given period (until it is expected that MOX fuel can compete with U fuel in terms of cost: e.g. 50 years). If they cannot make a decision/solution, the received SF (international storage) will be returned to the generating states.
- The long-term SF processing measures must include reprocessing technologies and a service system that will make it easier to finally dispose of radioactive wastes from the viewpoint of environmental burden reduction (i.e. technologies to make high-level wastes to intermediate-level after reprocessing, that enables the waste to become low level within 300 to 500 years by removing long-half-life radionuclide, etc. The low level means, for example, the targeted SF to reach the level of the natural uranium equivalent to the pre-burned fuel).
- Measures must be taken to attain the international levels with regards to the nuclear security of the facilities within the Framework (not only fuel cycle facilities but also nuclear power generation facilities). Specifically, setting of criteria and establishment of an inspection system are included.
- As to safety of the facilities within the Framework (not only fuel cycle facilities but also nuclear power generation facilities), similar to the above requirement, criteria must be set and an inspection system must be established to attain the international standard levels.
- As a requirement, the Framework to be proposed must be more economically advantageous than the “fuel service on per country basis.”
- As a requirement, the Framework member states that are geographically associated must cooperate in and agree to "transport” with regards to the nuclear fuel cycle service.
- Liability for compensation of damages at a possible level must be agreed within the Framework.
- The member states must cooperate in efforts to obtain public consensus in host and site states.
- Any legal regulation that is inconsistent with, or antagonistic to, existing international rules, bilateral agreements, etc. must be cleared.

Specific framework concept (below are suggestions supposed by the authors taking into account the existing and future possible facilities, although more careful political/geopolitical considerations should be taken)

States to be included in the multilateral framework in East Asia

- Japan, Korea, Kazakhstan, Russia, China, Mongolia, emerging countries in Asia (in addition, IAEA plays an international coordination role in establishing partners and framework for the regional safeguard measures)

- It is necessary to consider expansion of the Framework to "Asia Pacific" including the USA, Canada, and Australia, on the ground of nuclear non-proliferation, although its possibility is not examined in this interim report.

Framework concept proposal for the near future (Example)

- Type B is pursued as a regime (MNA framework but no ownership transfer).
- Establishment of international storage of SF: Among few countries that have latent potentially, there might be a possibility of, for example, Kazakhstan to use nuclear tests lots (the regulatory issues must be solved).
- Reprocessing: International use of the existing facilities in Japan, international use of existing facilities in Russia, and international use of newly built facilities in China are possibilities (the regulatory issues must be solved and the public consensus must be obtained). The HLW from reprocessing shall be returned to the generating state (If there is a bilateral agreement for taking the waste over between the generating and other states, however, the agreement will be respected.)
- Handling of Pu (MOX) after reprocessing: It will be chosen from the following options: 1) international storage as MOX, 2) returning to the generating state as LWR MOX, if the state wishes (high level safeguard measures/ nuclear security will be applied), and 3) selling to nuclear-weapon states (including those outside of the framework). However, 1) will be the fundamental principle to make the Pu to contribute the regional energy security of the future.

Development of the framework for a long-term perspective (Proposal)- may also be applied for short or intermediate cases*

- Type C is pursued as a regime (MNA framework with ownership transfer to MNA). .
- Reprocessing of internationally stored SF: Within a certain storage period of the multilateral framework, the reprocessing facilities with advanced reprocessing technology (to be multinationally controlled) will be determined through the examination by the member states based on the viewpoints of processing space streamlining and environmental burden reduction. Russia, China, Japan, Korea, etc. are the candidate site states, and the reprocessing system including removal of actinide, long-half-life radionuclide, etc. shall be established. The processing methods of the removed materials shall also be discussed (the high-level wastes as a result of reprocessing will be returned to the generating states after they are treated for environmental burden reduction.). (If there is a bilateral agreement for taking the waste over between the generating and other states, however, the agreement will be respected.)
- Handling of Pu (MOX) after reprocessing: It will be chosen from the following options: 1) returning to the generating state within the framework as (LWR/FR) MOX, if the state wishes (very high level safeguard measures/ nuclear security will be applied), 2) international storage as MOX, and 3) selling to nuclear-weapon states (including those

outside of the framework). However, 1) and 2) will be the fundamental principles.

* If "no transfer of ownership" of SNT facilities (type B) impedes or rules out the establishment of MNA in terms of non-proliferation, type C may be better and only the solution for NMA.

Characteristics of the proposal

- The proposed MNA promotes nuclear non-proliferation and has sustainability and feasibility.
- The proposal focuses on backend and presents solutions through regional multilateral approaches for nuclear fuel cycle issues (SF interim storage, MOX international storage, reprocessing, and HLW).
- The proposal is based on equality of member states.
- The contents of the proposal were examined on the basis of expansive INFCIRC640. Each requisite (label) is summarized and evaluated.
- Specific agreement examples are presented.
- Specific potential member states in East Asia are listed, and their possibilities for potential rules are presented.
- Legal systems which would be the key to the framework establishment are examined (a part of it will be examined in FY2012).
- Economic efficiency, transport issues, safety/nuclear security effect, role of industry, geographical consideration will be reviewed and assessed (a part of it will be examined in FY2012).
- Furthermore, the key words such as nuclear non-proliferation, sustainability and feasibility will be assessed (in FY2012).

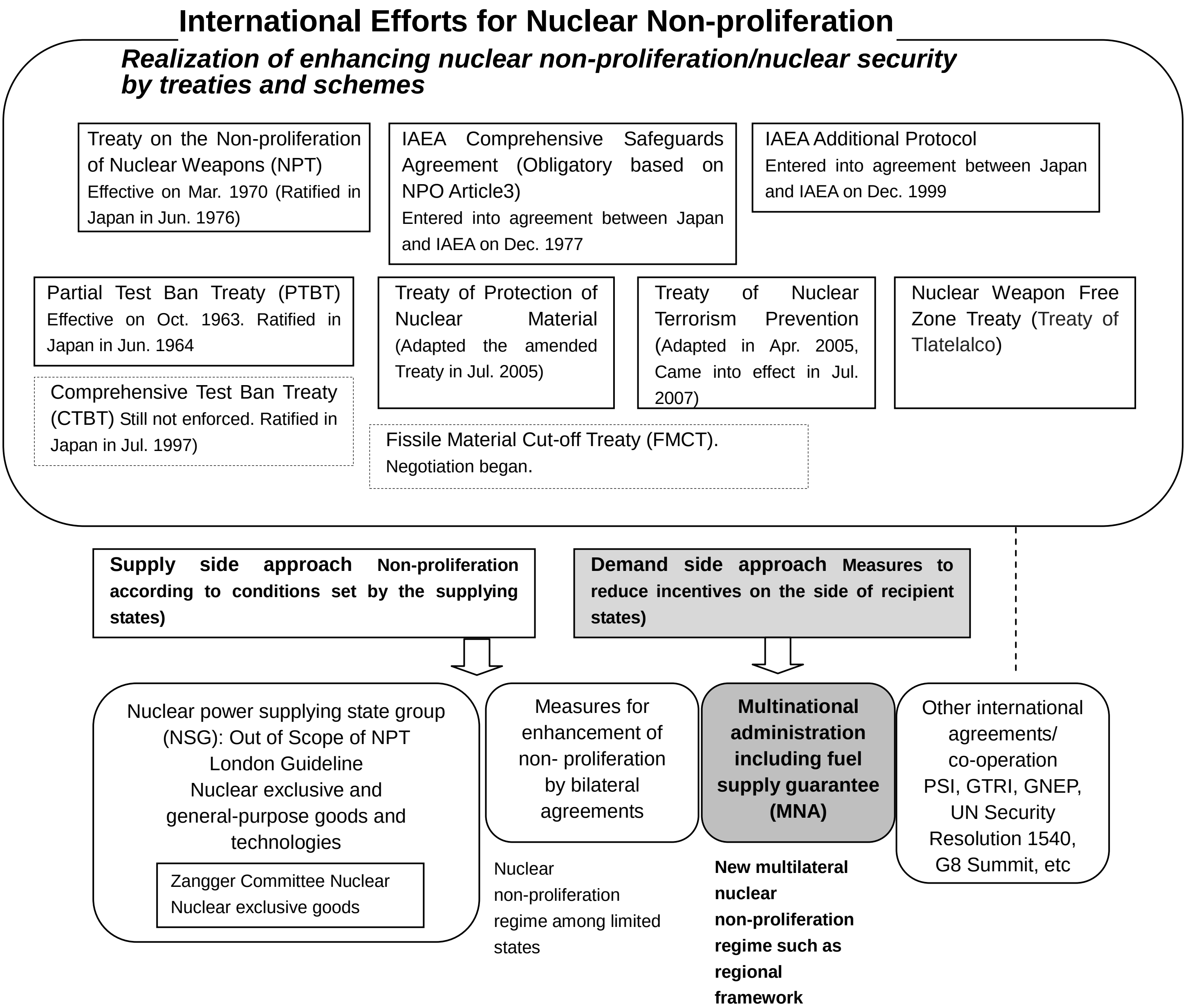
2. Purpose of the study

The accident at Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company at the time of the Great East Japan Earthquake was a critical phenomenon that brought changes to the global trend of the expansion of the peaceful uses of nuclear power until that time. In Japan, it may influence the continuation of the peaceful use of nuclear power. On the other hand, it is undeniable that nuclear power remains one of the most important countermeasures against the global economic/energy consumption growth and greenhouse gases issues. Although the temporally termination of nuclear power use may be unavoidable, in the long run, we predict with high probability that the needs for nuclear power in the world will grow again to accommodate the increasing energy consumption in line with the rapid economic growth especially in Asia, etc., unless its replacement technology is identified. “A Study of Building and Sustainable Operation of an International Nuclear Fuel Cycle System – a Study of the International Nuclear Fuel Cycle Framework and Handling of Spent Fuel” was carried out based on the premise that, introduction of nuclear power to the Asian region should be facilitated in the future, especially after sufficient nuclear security measures are taken with regard to the nuclear power generation.

If the needs for use of nuclear power increases from the viewpoint of global warming caused by fossil fuel and securing energy as a result of enhanced living standards, the demands for not only the generation of power but also uranium refining, conversion, enrichment, re-conversion, and fuel production will increase. In addition, the concerns for the proliferation of so-called “Sensitive Nuclear Technologies (SNTs)”, namely, enriched uranium fuel production technology (frontend) and spent fuel (SF) reprocessing technology (backend), and proliferation of fissile materials will also increase. At the same time, with an increase in the amount of SF, the SF will be stored in many states. In other words, there will be a growing concern from the nuclear non-proliferation perspective that plutonium may globally proliferate as a form of SF. Furthermore, issues with regards to nuclear security and SF safeguards (all combined and called 3S) will also increase.

Conventionally, international society had been responded to the concerns over nuclear non-proliferation including nuclear security by strengthening schematic measures centered around the safeguards under the NPT, Convention on the Physical Protection of Nuclear Material, etc. However, with an increase in the number of states using nuclear power including SNTs, the nuclear non-proliferation measures through the systems targeting the overall international society have limitations. Thus, additional tight measures have been taken by setting conditions on the supply side such as nuclear technology, equipment, and nuclear fuel (supply side approach: export control regulation, control on technology transfer based on bilateral agreement, etc.).

On the other hand, the measures for enhancement of nuclear non-proliferation on the supply side that mainly consist of the nuclear power technology advanced countries may interfere with the right of peaceful uses of nuclear power that is guaranteed by Article 4 of the NPT. Thus, there is a need to develop nuclear non-proliferation measures with high non-proliferation capacity based on a new concept which is completely different from the conventional ones. In addition, as to the nuclear security for handling SNTs and nuclear materials as well as safety management of nuclear facility operations, the conventional state-by-state efforts have limitations from the viewpoint of effectiveness, efficiency, and economic reasonability.



Under the circumstances, one of the influential ideas is a demand side approach: execution of a nuclear fuel cycle among multiple countries. The structure of measures that international society has been taking so far is presented in the above figure.

According to this approach, the nuclear fuel cycle services, especially centered on the SNTs, are multinationally executed and controlled, and therefore unnecessary proliferation of the SNTs is prevented, and safe and appropriate control of nuclear technologies and nuclear materials is obtainable. This can effectively and efficiently assure risk control and risk reduction with regard to 3S. At the same time, due to sharing of a nuclear fuel cycle, etc., this approach is executable without interference with fostering of the right of peaceful uses of nuclear power in emerging and other countries. Furthermore, this approach will promote regional confidence-building among the states in the field of nuclear power development.

Although many discussion and studies have already been made concerning the multilateral management concept, most of them focus on the frontend of nuclear fuel cycle and guarantee the supply of nuclear fuel (enriched uranium fuel) to the nuclear power generating states. These approaches may be effective for preventing proliferation of uranium enrichment technology, which addresses one of the above concerns. However, they are not addressing the issues such as proliferation of plutonium as a result of accumulation of "spent fuel" and handling of reprocessing technology with regards to backend. Furthermore, there is a need to examine the international framework for fuel supply and handling of SF for a normal time, because these approaches (guaranteeing the supply of nuclear fuel) focus on the termination of supply only at the time of emergency.

Graduate Schools of the University of Tokyo have been carrying out the "Study on the International Nuclear Fuel Cycle Concept from the Viewpoint of Nuclear Non-proliferation" [1]. Their study, however, does not examine solutions for specific issues to materialize the said-concept, including feasibility and stability of the framework to implement the international nuclear fuel cycle and setting conditions for the contribution from the industry.

This study investigated the specific measures to achieve the sustainable multilateral international nuclear fuel cycle including stable enriched uranium supply system, SF handing system, usage of plutonium, establishment of regional safeguards system for the international nuclear fuel cycle, requirements for the organization that carries out international nuclear fuel cycle, and role of industry in the international nuclear fuel cycle system. It also examined the issues of the systems and the countermeasures to achieve the international nuclear fuel cycle. Furthermore, the study aimed to propose a feasible international nuclear fuel cycle scheme centered on Asia and present it to the international society.

[1] http://www.n.t.u-tokyo.ac.jp/gcoe/jpn/research/nonproliferation/docs/asia_fuel_cycle_kuno.pdf

3. Significance of multilateral/international framework

As nuclear non-proliferation measures while expanding peaceful use including uranium enrichment and reprocessing, the international society had been taking actions such as application of systematic measures such as “safeguards” and limiting holding of SNTs by supply states groups agreement or bilateral agreement. On the other hand, because the situation of nuclear proliferation has been getting more serious, the international society is requiring tighter measures including the “nuclear proliferation resistance” and environment surrounding peaceful uses of nuclear energy is increasingly getting severe. It is also not desirable to pay higher prices for taking the measures of the nuclear proliferation resistance, etc.

On the other hand, the characteristics of the needs for enrichment, reprocessing, and international storage are that the needs can be covered as long as there is a limited number of facilities in the world. Thus, the idea of “multilateral management of nuclear fuel cycle”, which facilitates the implementation of fuel cycle not just by one state but by multiple states based on the stand point of fulfilling both peaceful uses and nuclear non-proliferation, has been discussed. It should contribute to enhancement of transparency and trust-building in the region.

If we can propose a solution that is internationally acceptable, the multilateral (international) administration of nuclear fuel cycle will economically and efficiently attain both fostering of peaceful uses of nuclear power and nuclear non-proliferation.

Recently, first, as to the frontend (= processes from raw material through mining, uranium enrichment, and fuel production to nuclear power generation), arguments about international frameworks such as “assuring nuclear fuel supply” have been advanced. Being led by IAEA, specific proposals around these arguments are being materialized. However, in reality, the issues for responding to the backend including spent fuel handling (storage and reprocessing) have been getting more serious. Therefore, the multilateral management concept, which includes the backend, is expected to be one solution. We believe that by establishing an appropriate multilateral management concept, the SNTs will be well managed both at frontend and backend and equal and efficient fuel cycle (effective use of nuclear fuel) can be achieved.

Furthermore, for the nuclear fuel cycle – plutonium utilization polity, which must be retreated on one-state basis due to nuclear non-proliferation concerns and economic aspect, the multilateral framework will advance the discussion for the future based on the viewpoint of regional energy security strategy and HLW environmental burden reduction.

The multilateral management concept is also expected to provide solution to the uniqueness of Japan (i.e. the only nonnuclear weapon state which has nuclear fuel cycle).

4. Issues with the past and existing proposals concerning multilateral/international framework

4.1 Historical review of international framework[2]

"Uranium enrichment" and "spent fuel (SF) reprocessing technology", together with the heavy water production technology, are called "Sensitive Nuclear Technologies (SNT)". From the perspective of preventing proliferation of SNT, the concept of "international control" had been proposed for long time. The old one is the international control of nuclear materials, which was developed under the Truman Administration in 1946 (i.e. pooling all nuclear materials, etc. in an international organization and lend them to wishing states). This plan was later put on the table of the UN Atomic Energy Commission (UNAEC) in the form of "Baruch Plan" by UN Representative B. Baruch. The Plan, however, did not take off successfully because it was contradicting with the US's free enterprise system of that time as it was promoting international ownership of the US technology. It also reached deadlock in the negotiation between US and Soviet Union. However, the Plan triggered the "Age of International Collaboration for Peaceful Use of Nuclear Energy" on the "Atoms for Peace" speech by US President Eisenhower in 1953 at the UN. In this initiative, the uranium bank (reserve) with an intension of international management of fissile materials was proposed. After these debates, the International Atomic Energy Agency (IAEA) was established in 1957. Provision of nuclear materials, etc. became one of the missions of the IAEA. However, the uranium bank plan was eventually abandoned because a) uranium supply was not as limited as was initially envisioned, and b) competition of commercial nuclear energy technology/supply of nuclear materials in the major supplying states based on the above speech was intensified.

In the post-war Europe, European Atomic Energy Community (EURATOM) was established to promote nuclear energy development. The most important requirement of the Convention was "to guarantee nuclear materials supply" by the member states. At the same time, the Convention had safeguards systems to ensure that the nuclear materials within EURATOM were to be used only for peaceful uses.

International debate with regards to exporting nuclear technology and material/equipment is another international framework concerning the supply. In 1971, Zangger Committee was established. The member states shall apply the IAEA's safeguards to the exported "nuclear materials" when exporting them to the non-NPT member states without nuclear weapons as well as when transshipping them from these nonnuclear weapons states. The Committee also created a list of equipment as subjects of the regulation. Meanwhile, after the first nuclear test by India, the Nuclear Suppliers Group (NSG) was established in 1974 for a similar purpose. The NSG controls exports based on the so-called "NSG Guidelines", the guidelines designed for the states which export nuclear energy related equipment, material and technologies (it is a "gentleman's agreement" without any legal binding power).

In 1975, the IAEA began the exploration of the first Regional Nuclear Fuel Cycle Center (RFCC) and

2 http://www.jaea.go.jp/04/np/activity/2008-07-10/2008-07-10-9.pdf

assessed the advantages of applying backend to the RFCC. The RFCC report examined and presented basic research from international and regional approach regarding the backend of fuel cycle in various geographical sites. From 1977 to 1980, the International Nuclear Fuel Cycle Evaluation (INFCE) was conducted, and the effectiveness of nuclear fuel cycle was thoroughly evaluated by 8 working groups (WGs). Through this activity, many WGs picked up “fuel cycle center” and described it as a systematic arrangement to strengthen nuclear non-proliferation. Furthermore, for the SF issues, they considered the fuel cycle as a solution that includes legal framework and multinational arrangement. Based on the results of the INFCE, the IAEA supported the experts group to examine the concept of international plutonium storage (IPS), established the Committee for Assurance of Supply (CAS) in 1980 and continued the deliberation until 1987. The experts’ examination concluded that the multilateral approach was technically and economically feasible but there were still issues in terms of difficulty in prerequisites for participation and transfer of rights towards nuclear non-proliferation.

At GLOBAL 93, an international conference, the “International Monitored Retrievable Storage System (IMRSS)” was proposed by Dr. Häfele from Germany. IMRSS proposes that spent nuclear fuel and plutonium shall be stored in retrievable condition under the monitoring by an international entity. It chose the IAEA as a desirable entity to lead the initiative. Although it was considered as a temporally measure to buy some time until the conclusion of whether SF would be directly disposed or plutonium would be retrieved, there was no developed thereafter. Dr. Atsuyuki Suzuki of the University of Tokyo made a proposal for SF storage in the East Asia region, and Choi of CISAC/Stanford University made a proposal for the regional treaty including regional SF storage. Their proposals show significance of the systems in which the host states offer interim storage of SF for a limited time (40 to 50 years), even though the handling of SF from other states is not easy.

In 1994, the US and Russia agreed that the US would purchase 500 tons of highly-enriched uranium (HEU) from Russia, convert it to low-enriched uranium (LEU) and make peaceful uses of it. Furthermore, both states agreed that each state would declare 50 tons of excess plutonium to be used for defense purposes, dismantle and retrieve 34 tons of it from nuclear weapons, and convert them to power generating fuel as MOX. For the purpose of nuclear non-proliferation, the US also began the “Foreign Research Reactor Spent Nuclear Fuel Acceptance Program (FRRSNFA)” in 1996 to accept the US-origin spent HEU and LEU fuels from foreign research reactors by May 2009. Furthermore, under the Russian Research Reactor Fuel Return (RRRFR) Program, some 2 tons of HEU and some 2.5 tons of LEU SF, which were previously supplied by Soviet Union/Russia to foreign reactors, were shipped to the Mayak reprocessing complex near Chelyabinsk. The US and the Russian Federation cooperated in several repatriation projects for Russian-origin HEU fuels.

Based on the recognition that SF and high level waste (HLW) are the common critical issues which could be factors to hinder nuclear energy promotion in the East Asia region, the Pacific Nuclear Council (PNC) began deliberation to promote understanding and cooperation for the management of SF and HLW among the PNC members and investigate possibilities of the International Interim Storage Scheme (IISS) in 1997. The IISS is managed at national, regional, or international levels and is to augment (not to replace) the national system. The IISS operates during the contract period from the time when SF and HLW are deposited to the storage facility in the host state till the time when "they are returned to the originating state". The host state would be responsible for safety and safeguards of the storage facility and receive financial compensation from the contact member state, which is the owner of the SF and HLW.

In reality, the interim storage of SF, a part of reprocessing contract, had been offered by reprocessing operators such as the BNFL and the AREVA. With this system, the state which makes a reprocessing contract can store SF as long as it is stored in the reprocessing facility; however the separated plutonium and HLW at the time of reprocessing would be returned to the state. On the other hand, the concepts of the IMRSS, the RSSFEA, regional treaty and the IISS demand the host state to store or dispose of other state's SF. However, this is not easy in reality.

4.2 Recent proposals[3,4]

The concerns about nuclear proliferation by states and the acquisition of nuclear weapons by terrorists had grown after nuclear test by India/Pakistan in 1998 and terrorist attack on September 11, 2001. The nuclear weapons black market network issues by Democratic People's Republic of Korea (DPRK, hereafter referred to as North Korea), Libya, Iran and A.Q. Khan are driving the international society to make efforts through various trials and proposals in preventing proliferation of the SNT related to fuel cycle such as isotope separation and reprocessing.

The proposals made by Director General of the IAEA, M. ElBaradei, in October 2003 presented that (1) reprocessing and enrichment operations must be restricted under the multinational control, (2) nuclear energy system shall have nuclear non-proliferation resistance, and (3) multinational approaches shall be considered for the management and disposal of SF and radioactive wastes. However, it was anticipated that his idea of multilateral system of SNT and radioactive substances would take long time to overcome issues.

Former US President G.W. Bush strongly demanded in his speech at Defense University in February 2004 that exporting SNT should be limited to the states which were already using them in full scale and respecting the Additional Protocol. However, this proposal may lead to international cartel and may split the member states into the states with SNT and without SNT. The "Nuclear Fuel Leasing" proposal by V. Rice, et al. and "Nuclear Fuel Service Assurance Initiative" proposal by E. Moniz, et al. expect the improvement of nuclear non-proliferation though institutionalization. However, the proposals still contain a concern over supply assurance to the user states as well as a concern over the dichotomization of the member states, similar to the other proposals.

Later, a group of experts for multinational nuclear (fuel cycle) approaches (MNA) was formed (ElBaradei Commission). The group was assigned to (1) identify and provide an analysis of issues and

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3 http://www.jaea.go.jp/04/np/activity/2008-07-10/2008-07-10-9.pdf & U.S. and Russian Committees on Internationalization of the Nuclear Fuel Cycle, National Research Council and Russian Academy of Sciences: Internationalization of the Nuclear Fuel Cycle : Goals, Strategies, and Challenges, September 30, 2008,

4 Kuno, Choi: Internationalization and regional administration of nuclear fuel cycle – Why internationalize nuclear fuel cycle. Genshiryoku Eye 59-62, Vol.55, No.5 (2009)

options relevant to multilateral approaches to the frontend and backend of the nuclear fuel cycle, (2) provide an overview of policy, legal, security, economic, institutional and technological incentives and disincentives for cooperation in multinational arrangements, and (3) provide a brief review of the historical and current experiences and analysis relating to multinational fuel cycle arrangements. In the report, MNA was assessed based on two primary factors, namely, assurance of supply and services, and assurance of nuclear non-proliferation. Furthermore, 3 potential MNA options were presented.

1) To strengthen existing market mechanism case by case with an assistance from governments through long-term and transparent arrangement;
2) To establish an international supply assurance such as fuel bank in collaboration with the IAEA as an organization to assure fuel supply; and
3) To promote voluntary transformation of existing facilities of member states to MNA (including regional MNA by collaborative ownership and collaborative administration)

The study results by the expert group at the IAEA are summarized in INFCIRC/640, which gave an impact on the successive examination of multinational approach framework.

After this report, a number of proposals related to supply assurance and multilateral approaches had been put forward. Followings are some of these proposals/approaches:

1) In order to achieve "Reliable Fuel Supply (RFS) Initiative", announced by former Secretary of the US Department of Energy (DOE), Bodman in September 2005, the US is in the process of down-blending about 17.4 tons of HEU to about 290 tons of LEU (4.9%) within 3 years and storing them. The RFS Initiative was later renamed to the American Assured Fuel Supply (AFS) and it will be operationalised in 2012.

2) During the discussion of fuel supply assurance at the Global Nuclear Energy Partnership (GNEP), the US, in collaboration with the partner states, declared that it would aim at establishing a fuel service mechanism including fuel supply at frontend and SF disposal at backend to achieve international nuclear non-proliferation. In the Nonproliferation Impact Assessment (NPIA) (draft) presented by DOE in January 2009, the importance of maintaining advanced reprocessing capacity including minor actinide recycling was insisted. It also emphasized the significance of US's participation in the overall fuel services including backend service in order to suppress incentives for the emerging states to individually develop enrichment and reprocessing technologies. Later, as was influenced by political regime change, the GNEP terminated its domestic activities (i.e. cancellation of prompt construction of commercial reprocessing facility and fast reactor) and decided that they would maintain international collaboration framework as International Framework for Nuclear Energy Cooperation (IFNEC) only for the international activities from 2010. The fuel supply working group at IFNEC expressed their willingness to support collaborative actions among member

states and organizations towards establishment of international fuel supply framework. They would also provide trustworthy and worth the cost fuel services/supply to the global market and provide options relating to the development of nuclear energy usage in accordance with reduction of nuclear proliferation risks. In the speech of the new director, he expressed their willingness to achieve so-called “from cradle to graveyard”.

3) World Nuclear Association (WNA) proposed a three-level assurance mechanism: 1) basic supply assurance provided by the existing market, 2) collective guarantees by enrichment operators supported by relevant governmental and the IAEA commitments, and 3) government stocks of enriched uranium product. According to them, it is necessary to promote international reprocessing recycling center idea when nuclear energy usage is expanded in the future.

4) Reliable Access to Nuclear Fuel (RANF) (nuclear fuel supply assurance concept by 6 states): Similar to the above, this proposal contains a three-level mechanism: 1) supply through market, 2) system in which enrichment operators would substitute for each other based on the collaboration with the IAEA, and 3) virtual or physical low-enriched uranium banks by a state or the IAEA.

5) Japanese proposal: The states willing to participate shall voluntarily register at/notify the IAEA their capacities (current stockpiles and supply capacity), and the member states shall notify the IAEA their service provision capacity in accordance with the availability of service utilization capability by three levels (Level 1: provision of service on the domestic commercial basis – no exporting at commercial scale, Level 2: international provision on the commercial basis, Level 3: storage that can be exported for a short time). The IAEA would make an agreement of standby-arrangement with member states and manage the system. If fuel supply actually gets confused in a state, IAEA will play a role as a mediator. This proposal is to improve market transparency, prevent supply termination, and augment the RANF proposal.

6) UK Enrichment Bond proposal: Enrichment tasks shall be carried out by domestic enrichment operators. The supplying state, consuming state and the IAEA will make a treaty in advance. The IAEA shall approve commitment of the consuming state for nuclear non-proliferation. If assurance is activated by bonding, the supplying state would not be prevented from supplying enrichment services to consuming state. This proposal is to enhance credibility of supply assurance mechanism and augment the RANF proposal. The Bond proposal was later renamed to the Nuclear Fuel Assurance (NAF) proposal and was approved by the IAEA Board of Governors in March, 2011.

7) The Nuclear Threat Initiative (NTI) proposal: This is a storage system for LEU stockpile possessed and controlled by the IAEA, and it is the anchor proposal for the actual realization. For the activity of the NTI, US pledged $50 million, Norway $5 million, the United Arab Emirates $10 million, EU

$32 million, and Kuwait offered $10 million. The total pledge had reached $107 million. Furthermore, in April 2009, Kazakhstan's President Nazarbayev announced that the country was ready to receive the IAEA nuclear fuel bank and officially announced its willingness to be a host state in January 2010 (INFCIRC/782). In May 2009, the IAEA presented a proposal for deliberation at the Board of Governors to be held in June 2009. The proposal included consuming state's requirement in relation to the IAEA nuclear fuel bank, supply process, contents of model agreement (e.g. supply price of LEU, safeguards, nuclear material protection, nuclear liability), etc. Later, at a regular Board of Governors on December 3, 2010, the establishment of "nuclear fuel bank" which will internationally manage and supply LEU to be used as fuel for nuclear energy generation was agreed. If the IAEA receives a request from a state which cannot purchase LEU due to exceptional circumstances impacting availability and/or transfer and is unable to secure LEU from the commercial market, State-to-State arrangements, or by any other such means, the IAEA will supply LEU to the state at the market price under the guidance of the Director General of IAEA. Through this agreement, the first system in which LEU would be controlled by an international organization began. The IAEA owns the bank based on the contributions from the member states. The Board of Directors will later deliberate the location of the bank. Kazakhstan is already declaring its candidacy for a host state. The resolution was proposed collaboratively by over 10 states including the US, Japan and Russia and was adapted with 28 states voting for favor. The developing countries which were planning to have nuclear energy later had been insisting that the bank would lead to the monopoly of nuclear technology by developed countries and "right for peaceful use of nuclear energy" stipulated by the NPT would be threatened. To address this issue, the resolution clearly stated that it would not "ask for abandoning" nuclear technology development by each state and obtained understanding from the developing countries.

8) International Uranium Enrichment Center (IUEC): The IUEC was established in Angarsk, Russia, with investment by Russia and Kazakhstan. The IUEC is not only to assure supply but to provide uranium enrichment services. Thus, this proposal is more realistic than the others. The proposal states that the uranium enrichment technology will be black-boxed, namely, the investing states will not be informed, and the technology will be under the control of the IAEA. Other than Russia and Kazakhstan, Armenia and Ukraine are now members of the IUEC, while Uzbekistan is expressing their intention of participation. It will have the LEU reserve of 2 1000MW-level cores. In May 2009, for the deliberation at the IAEA Board of Governors to be held in June, Russia submitted the proposal including the summary of agreement for LEU storage between the IAEA and Russia and summary of agreement for the LEU supply between the IAEA and the consuming states. In November 2009, being led by Russia, the nuclear advanced states submitted a resolution to the IAEA Board of Governors of November. The resolution was to seek approval of two agreement plans: 1) agreement plan between the IAEA and Russia to establish the LEU reserve under Russian IUEC, and 2) a model agreement plan between the IAEA and the LEU recipient states concerning the LEU

supply from the reserve. The resolution was approved by a majority. In March 2010, the IAEA's Director General, Amano, and Director General of Rosatom Nuclear Energy State Corporation, Kiriyenco, signed on the agreement for the establishment of the LEU reserve under Russian IUEC, and the LEU storage was established in December, 2010.

9) Multinational Enrichment Sanctuary Project (MESP) (proposed by Germany): This proposal is for the IAEA to manage enrichment plant and exportation on an extra-territorial basis in a host state. The SNT will be black-boxed.

10) The Science Academies of the US and Russia presented analysis and proposals for nuclear fuel assurance as a measure to prevent proliferation of nuclear weapons under the title of "Internationalization of Nuclear Fuel Cycle – Goals, Strategies, and Challenges". In its report[2], the options and technological issues for the future international nuclear fuel cycle are presented. The report also contains the analysis of the incentives for the states that opt for accepting fuel supply assurance and developing enrichment or reprocessing facilities and do not opt for it. Furthermore, they examined new technologies for reprocessing/recycling and new reactors and made various proposals to the governments of US and Russia and other nuclear supplier states to stop proliferation of SNT and contribute to reduction in the risk of nuclear weapons proliferation. The report analyzed and summarized critical issues and presented several standards for assessing the options.

Figure 4-1 shows the flow of nuclear non-proliferation measures centered on multilateral approach/supply assurance in the past. As shown, the debates are becoming more and more active in recent years, and the needs for internationalization of fuel cycle, which was not very realistic until now, are gradually becoming reality. As described above, as of December 2011, the IAEA nuclear fuel bank, LEU reserve in Angarsk, Russia, and the UK's NFA proposal were approved by the IAEA Board of Governors, and the US's AFS will begin its operation in 2012.

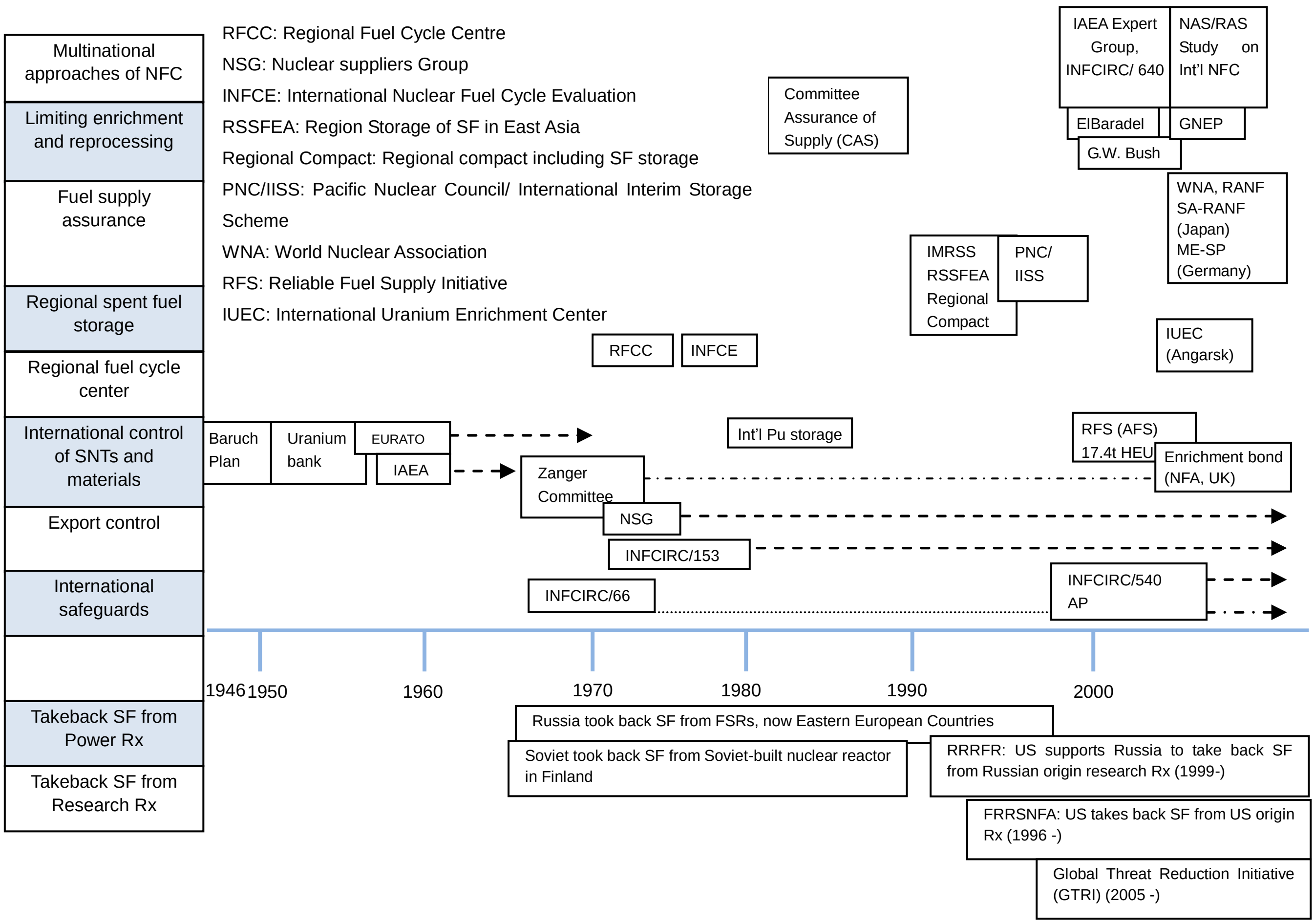


Figure 4.1 Transition of proposals/initiatives for international/regional management of nuclear fuel (cycle) relevant to nuclear non-proliferation.

4.3 Issues with the past and current proposals

From 2009 to 2011, most of the multilateral approaches had never been implemented in any forms until the nuclear fuel bank and the LEU storage were approved by the IAEA Board of Governors. It was probably because the nuclear proliferation was not recognized as a sufficiently serious issue and there was not so strong economic motivation.

However, as was explained above, the situation has been changing in the last few years. Despite the Fukushima Nuclear Power Plant accident as well as the actual global concern over nuclear non-proliferation, the expansion on the peaceful uses of nuclear energy in the world is unavoidable in the long run. In that sense, the role of supply assurance of nuclear fuel bank, etc. was reviewed, and the establishment of the IAEA nuclear fuel bank was approved by the IAEA Board of Governors.

Another reason why many proposals on multilateral approaches have not been implemented so far was because the proposals did not specify states to be involved. For example, the INFCIRC/640 report did not specify the name of the states but only evaluated and examined the nuclear non-proliferation and supply assurance from a comprehensive perspectives.

This study intends to examines and propose a very plausible multinational approach. Thus, although the study examine and evaluate the framework based on the INFCIRC/640, it is important to evaluate and examine the adequate supply assurance based on a model specific to states or region, which was not taken into consideration in the INFCIRC/640, in terms of the nuclear energy situation, specific uranium material supply, uranium enrichment, spent fuel reprocessing services or (interim) storage of each state and region.

Furthermore, since the states or regions are specified, the geopolitics and transport issues of the state or region shall also be added as evaluation elements.

5. Requirements for establishing multilateral/international nuclear approach (MNA)

There had been many proposals with regards to nuclear fuel cycle multilateral nuclear fuel cycle framework. Particularly, the INFCIRC/640 (Pellaud Report) adequately evaluates the advantages and disadvantages of various elements from frontend to backend for each option (type) of the framework. The key points of the report are as follows:

Three options are assumed as a framework of a MNA.

Type I Assurances of services not involving ownership of facilities

i) Suppliers provide additional assurance of supply

ii) International consortium of governments

iii) IAEA-related arrangement

Type II Conversion of existing national facilities to multinational ones

Type III Construction of new facilities

Next, the INFCIRC/640 evaluates the advantages and disadvantages of each item of nuclear fuel cycle technology (i.e. uranium enrichment, spent fuel reprocessing, spent fuel disposal, spent fuel storage) based on the following evaluation elements.

Label A Nuclear non-proliferation value of MNA

Label B Assurance of supply value of MNA

Label C Selection of siting and a host state

Label D Access to technology

Label E Multilateral involvement

Label F Special safeguards provisions

Label G Non-nuclear inducements

As a result of analysis, the INFCIRC/640 states that the objective of maintaining fuel supply and service assurance while strengthening nuclear non-proliferation can be achieved by introducing Type I to III in a phased manner.

Our study evaluated and reviewed the adequate options for MNA and their requirements based on the above options and evaluation results as well as other various elements. As a result, we believe that the appropriate options of MNA would be as follows:

Type A No involvement of fuel cycle services (i.e. uranium fuel supply, spent fuel storage service, spend fuel processing (reprocessing) service)
Without transfer of ownership of existing or new facilities to MNA

Type B Fuel cycle services, without transfer of ownership of existing or new facilities to MNA

Type C Fuel cycle services with transfer of ownership of existing or new facilities to MNA

As prerequisite items for each option, the following 12 items are set:

- Label A Nuclear non-proliferation

If a state meets certain criteria (e.g. regional safeguards under MNA, nuclear security, export control), it is considered that the state can adequately maintain nuclear non-proliferation. Thus, the possession of SNTs (i.e. uranium enrichment and spent fuel reprocessing), which is one of the measures for nuclear non-proliferation, would not necessarily be controlled (criteria-based approach).

- Label B Fuel cycle service

Appropriate state becomes a host state (or site state) and provides fuel cycle service.

The state will provide uranium fuel supply service to those states without enrichment facilities (i.e. partner state).

As establishment/membership requirements with regards to SF storage under the MNA framework, the member states (host, site, and recipient states) must determine long-term SF processing measures within a specific period (until it is expected that MOX fuel can compete with U fuel in terms of cost: e.g. 50 years). If they cannot make a decision, the received SF (international storage) will be returned to the generating states.

Excess separated plutonium as a result of reprocessing is considered not favorable for the nuclear non-proliferation. However, from now on, they will be considered as stockpiles for the future regional energy security.

In the future, the states will be responsible for disposal of HLW. In order to secure the disposal space and to reduce environmental burden (e.g. natural level within 300 to 500 years), solutions shall be discussed and implemented among the member states of the Framework within a certain period of the multinational storage.

- Label C Selection of a host state (site state)

The state that meets all requirements shall be a host state (or site state).

- Label D Access to technology

The access to SNTs shall be strictly controlled under the MNA Framework.

The following prerequisites are summarized in Table 5.1 for each option, together with all other prerequisite.

- Label E Multilateral involvement
- Label F Economics
- Label G Transport
- Label H Safety
- Label I Liability
- Label J Political and public acceptance
- Label K Geopolitics
- Label L Legal aspect

It is desirable that each option will be introduced in a phased manner as follows:

Option A

No provision of fuel cycle services.

Because considerable nuclear non-proliferation capacity can be secured by regional safeguards, nuclear security, and the NSG Guidelines, this option basically does not limit SNTs possession by MNA member states. This is presented as a reference.

Option B

Provision of fuel cycle services.

Because considerable nuclear non-proliferation capacity can be secured by regional safeguards, nuclear security, and the NSG Guidelines, the SNTs possession by MNA member states will not be limited.

It is a long-term and highly transparent supply system either through additional fuel cycle service by suppliers or through the support by the government, or participation by IAEA.

This is the first choice of our study.

Option C

Provision of fuel cycle services.

Because considerable nuclear non-proliferation capacity can be secured by regional safeguards, nuclear security, and the NSG Guidelines, the SNTs possession by MNA member states will not be limited.

Existing and new facilities will be voluntarily transferred to MNA.

MNA is based on the collaborative ownership of frontend and backend nuclear facilities.

This framework will be targeted in the future as a highly reliable MNA.

Table 5.1 Formation of MNA based on INFCIRC/640 (Pellaud Report) [1], etc (Fuel cycle service (uranium fuel supply service, SF/MOX storage service, SF reprocessing service)) (Requirement for framework establishment)

Options for MNA	Label A: Requirements for nuclear non-proliferation				
	Restriction to the states having sensitive nuclear technologies (SNT)/right of peaceful use of nuclear energy		NPT, Safeguards Agreement (CSA,AP)		
	Nuclear facility owner	Notes	Safeguards implementer (s) (Comprehensive safeguards Agreement, CSA)		Complementary access implementer(s) (Additional Protocol (AP))
			Material accounting	Inspector(s)	
Conventional state-basis management	Member state	Conventional state-basis safeguards, etc.	Member state operator	IAEA	IAEA
Type A (Not in INFCIRC/640) No provision of fuel cycle services (i.e. uranium fuel supply, SF/MOX storage and SF reprocessing service). Framework in which ownerships of existing or new facilities are not transferred to MNA.	Member state	Framework in which having SNTs are not limited if a certain condition is met (regional safeguards, nuclear security, export control guideline, etc) Reference) Followings indicate the MNA in which uranium fuel supply service provision is not a condition. ・In the debate of the nuclear proliferation resistance against INS, the potential advantage of MNA nuclear fuel cycle was discussed[2]. ・If the enrichment or reprocessing facilities or technologies is transferred, the supply state shall be encouraged to accept appropriate MNA[3].	Member state operator and MNA member states	IAEA ＋ MNA member states	IAEA ＋ MNA member states
			Regional safeguards: RSAC (CSA+AP) State operator material accounting, material accounting data are checked by MNA member states, and joint inspection by IAEA/MNA member states		
Type B (Equivalent to Type I of INFCIRC/640) Fuel cycle service framework in which ownerships of existing or new facilities are not transferred to MNA.	Member state	Framework in which the fuel cycle services are not limited to states having SNTs if a certain condition is met (regional safeguards, nuclear security, export control guideline, etc) (criteria-based approach) Host state , E_H (State offering fuel cycle service) Partner state, E_P (State receiving fuel cycle service) Reference) Many conventional proposals[1,4,5] intend to limit the possession of SNTs such as enrichment and reprocessing technologies by fuel supply service.	Data check by domestic entity and MNA member states	IAEA ＋ MNA member states	IAEA ＋ MNA member states
			Regional safeguards: RSAC (CSA+AP) State operator material accounting, material accounting data are checked by MNA member states, and joint inspection by IAEA/MNA member states.		
Type C (Equivalent to Type II and III of INFCIRC/640) Fuel cycle service framework in which ownership of existing or new facilities is transferred to MNA facilities.	MNA	Fuel cycle service facility will be established in states that meet a certain condition (regional safeguards, nuclear security, export control regulations, etc) and the ownership is transferred to MNA. (criteria-based approach)	MNA consortium	IAEA ＋ MNA member states	IAEA ＋ MNA member states
			Regional safeguards: RSAC (CSA+AP) MNA member state’s material accounting and joint inspection IAEA/MNA member states.		
Nuclear reactor	Member state	The state will participate in MNA for the requirements of nuclear security and safety, after Fukushima accident, in addition to enjoying nuclear fuel cycle services and enhancement of nuclear non-proliferation (SNT facility’s participation in the regional safeguards).	Nuclear reactor operator	IAEA ＋ MNA member states	IAEA + MNA member states

Table 5.1 (continuation-1) Formation of MNA based on INFCIRC/640 (Pellaud Report)[1], etc (Fuel cycle service (uranium fuel supply service, SF/MOX storage service, SF reprocessing service)) (Requirement for framework establishment)

<table>
<tr><th rowspan="2">Options for MNA</th><th colspan="4">Label A: Requirements for nuclear non-proliferation</th></tr>
<tr><th>Nuclear security</th><th>Export control
(Not included in a nuclear non-proliferation evaluation element of INFCIRC./640)</th><th>Limited access to SNTs
(Included in nuclear non-proliferation evaluation element of INFCIRC./640)</th><th>Requirement for withdrawal</th></tr>
<tr><td>Conventional state-basis management</td><td>To be carried out by MNA state consortium (e.g. military, police)</td><td>To be a member of NSG[3] and conduct export control.</td><td></td><td>–</td></tr>
<tr><td><u>Type A</u></td><td>To be carried out by MNA state consortium (e.g. military, police)
International standards to be applied.
Security audit by MNA</td><td rowspan="3">To be a member of NSG[3] and conduct export control based on the following criteria.
(i) To be a Party to the NPT and is in full compliance with its obligations under the Treaty. The safeguards here indicate the regional safeguards;
(ii) To have not been identified in a report by the IAEA Secretariat which is under consideration by the IAEA Board of Governors, as being in breach of its obligations to comply with its safeguards agreement, nor continues to be the subject of Board of Governors decisions calling upon it to take additional steps to comply with its safeguards obligations or to build confidence in the peaceful nature of its nuclear program, nor has been reported by the IAEA Secretariat as a State where the IAEA is currently unable to implement its safeguards agreement.
(iii) To respect for the NSG guideline;
(iv) To has concluded an inter-governmental agreement with the supplier including assurances regarding non-explosive use, effective safeguards in perpetuity, and retransfer;
(v) To have made a commitment to the supplier to apply mutually agreed standards of physical protection based on current international guidelines; and
(vi) To have committed to IAEA safety standards and adheres to accepted international safety conventions.

(c) Transfer should be allowed only when the recipient has brought into force a Comprehensive Safeguards Agreement, and an Additional Protocol based on the model Additional Protocol, or pending this, is implementing appropriate safeguards agreements in cooperation with the IAEA, including a regional accounting and control arrangement for nuclear materials, as approved by the IAEA Board of Governors.

The subjective criteria of NSG guideline will not be considered.</td><td rowspan="3">Access to NSTs will be limited to the states which already have the NSTs.

SNTs will be managed by black box, etc.</td><td rowspan="3">(1) After withdrawal, the state must return to the safeguards before its participation in the framework (IAEA safeguards).
(2) The use and operation of the facilities that are newly built due to participation in the framework must be terminated. Confirmation and verification of termination must be entrusted to IAEA.
(3) Of the nuclear material produced by the new facilities built due to participation in the framework, enriched uranium must be returned via the MNA to the state that asked for enrichment service. Even if possessed by the state concerned (withdrawing state), plutonium (MOX) must be transferred to and stored at the MNA (international MOX storage facility) as international stockpile of the region. This will support future energy source of the region (corresponding service cost should be paid to the withdrawing state).
(4) It must be prohibited to transfer or sell, to any state out of the framework, any nuclear material produced by the new facilities built due to participation in the framework.</td></tr>
<tr><td><u>Type B</u></td><td>To be carried out by MNA state consortium (e.g. military, police)
International standards to be applied.
Security audit by MNA</td></tr>
<tr><td><u>Type C</u></td><td>To be carried out by MNA consortium
(e.g. multinational force)
International standards to be applied.
Security audit by MNA</td></tr>
<tr><td>Nuclear reactor</td><td>To be conducted by nuclear reactor operator.
International standards to be applied.</td><td>To be a member of NSG and will carry out export control.</td><td></td><td></td></tr>
</table>

	Security audit by MNA			

Table 5.1 (continuation-2) Formation of MNA based on INFCIRC/640 (Pellaud Report) [1], etc (Fuel cycle service (uranium fuel supply service, SF/MOX storage service, SF reprocessing service)) (Requirement for framework establishment)

Options for MNA	Label B: Fuel Cycle Service			
	Enhancement of nuclear non-proliferation, intending to limit SNTs holding.	Incentives for nuclear fuel cycle service		
		Uranium fuel supply service	Spent fuel/MOX storage service	Spent fuel reprocessing service
Conventional state-basis management				
<u>Type A</u>	Enhancement of nuclear non-proliferation, intending to limit SNTs holding, is not particularly considered.	Uranium fuel nuclear fuel cycle service to the other states is not provided.	Spent fuel storage service to the other states it not provided.	Spent fuel reprocessing service to the other states it not provided.
<u>Type B</u>	Enhancement of nuclear non-proliferation, intending to limit SNTs holding, is not particularly considered.	Host state or site state provides uranium fuel supply service to meet the needs of a state which does not have an enrichment facility (partner state). Avoid excessive intervention to the market.	Host state provides spent fuel storage service to a partner state (assurance of spent fuel storage service). As establishment/membership requirements with regards to SF storage under the MNA framework, the member states must determine long-term SF processing measures within a specific period (until it is expected that MOX fuel can compete with U fuel in terms of cost: e.g. 50 years). If they cannot make a decision, the received SF (international storage) will be returned to the generating states.	Recovered Plutonium (Pu) from reprocessing is partially used in the form of MOX as LWR-MOX fuel, but it is mainly stored as future resources*）（*Basically until the time when MOX fuel can be expected to be equivalent to U fuel）. The so-called "excess separated plutonium" as a result of reprocessing is considered not favorable for nuclear non-proliferation. However, through MOX international storage under MNA control (enhancement of nuclear non-proliferation such as regional safeguards and strong nuclear security measures), MOX production shall be considered as the "stockpile for regional energy security" for the future. The MOX can be used for LWRMOX as well as fast reactor when the economic feasibility becomes high enough. In the future, the states will be responsible for disposal of HLW. In order to secure the disposal space and to reduce environmental burden (e.g. natural level within 300 to 500 years), solutions shall be discussed and implemented among the member states of the Framework within a certain period of the time. Avoid excessive intervention to the market.
<u>Type C</u>	Enhancement of nuclear non-proliferation, intending to limit SNTs holding, is not particularly considered.			
Nuclear reactor	-	Participate as a partner state.		

Table 5.1 (continuation-3) Formation of MNA based on INFCIRC/640 (Pellaud Report) [1], etc (Fuel cycle service (uranium fuel supply service, SF/MOX storage service, SF reprocessing service)) (Requirement for framework establishment)

Options for MNA	Label C: Selection of a host state (site state)	Label D: Access to technology	Label E: Multilateral involvement	Label F: Economics	Label G: Transportation
Conventional state-basis management	—	—	—	Depends on the member state.	
Type A	Even if a state has an enrichment facility, a SF storage facility, or processing (reprocessing) facility, it does not become a host state.	Access should be permitted only by technology holders	・No participation for supply ・Ownership of facility: Technology holder (each state) ・Management: Technology holder (each state) ・Operation: Technology holder (each state) ・Research, development, design and construction of facility: Technology holder (each state)		
Type B	It should be politically and geographically stable.	Access should be permitted only by technology holders	・Participation only for supply ・Construction and ownership of facility: Technology holder (host state) ・Management: Technology holder (host state) ・Operation: Technology holder (host state) ・Research, development, design (mainly SF processing technology) : MNA	As for uranium enrichment, the economics will be improved by 10% at 10 times larger than the usual scale. Due to market mechanism, operation cost (price) reduction can be expected.	It should aim at high security transportation. International transport standards should be satisfied. It should cooperate in transportation.
Type C	Special management: Legal framework to restrict national jurisdiction regarding location of the MNA fuel cycle facility ("Special region" situation). It should be politically stable.	Access should be permitted only by technology holders	・Ownership of facility: MNA ・Management: Technology holder (state) under commission from MNA ・Operation: Technology holder (state) under commission from MNA ・Research, development, design and construction of facility (mainly SF processing technology): MNA	Economics will be improved when compared with execution on an each country basis. It should have an incentive that execution on each country basis cannot be economically competitive. Economic benefit can be expected through functioning economics of scale due to centralization.	It should aim at high security transportation. International transport standards should be satisfied. It should cooperate in transportation.
Nuclear reactor	Most of the nuclear power emerging states and small scale nuclear power states do not have SNTs. Thus, they become partner states.	—	Partner states will participate as part of the MNA (regional) safeguards.	—	—

Table 5.1 (continuation-4) Formation of MNA based on INFCIRC/640 (Pellaud Report) [1)], etc (Fuel cycle service (uranium fuel supply service, SF/MOX storage service, SF reprocessing service)) (Requirement for framework establishment)

Options for MNA	Label H: Safety	Label I: Liability	Label J: Political and public acceptance	Label K: Geopolitics	Label L: Legal aspects
Conventional state-basis management	To be carried out by MNA state consortium.	Liability by each state.			
Type A	To be carried out by MNA state consortium. Safety will be enhanced by application of international nuclear safety standards, safety audit by MNA, etc.	Liability by each state.			It should follow the NPT Article IV: 1. Nothing shall be interpreted as affecting the inalienable right of all the parties to the Treaty to use of nuclear energy for peaceful purposes without discrimination. 2. All the Parties to the Treaty undertake to facilitate the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy.” It requires coordination with bilateral treaty and regional nuclear free zone treaty.
Type B	To be carried out by MNA state consortium. Safety will be enhanced by application of international nuclear safety standards, safety audit by MNA, etc.	Liability by each state.	Highly acceptable justification should be made.	It will be a general requirement such as MNA member states are to be politically stabile.	
Type C	To be carried out by MNA (consortium). Safety will be enhanced by application of international nuclear safety standards, safety audit by MNA, etc.	Certain level liability by member states.			
Nuclear reactor	To be carried out by MNA state (consortium). Safety will be enhanced by application of international nuclear safety standards, safety audit by MNA, etc.	Liability by each state.			

References)

1) IAEA, Multilateral Approaches to the Nuclear fuel cycle, INFCIRC/640 (Pellaud Report), Feb., 2005

2) IAEA, Guidance for the Application of an Assessment Methodology for Innovative Nuclear Energy Systems, IAEA-TECDOC-1575 Rev.1, INPRO manual, Proliferation Resistance, Nov., 2008

3) NSG Guidelines, INFCIRC 254/Part1 6, 7 (revised), June, 2011

4) Report on Nuclear Fuel Cycle by European Union, GOV/INF/2007/11, Annex 16, June, 2007

5) Acheson Lilienthal Report, March, 1946

6. Proposal for multilateral/international framework (regional framework) – Basic agreement example

Basic agreement (proposal), namely the Multilateral Framework Agreement (MNA University of Tokyo Model) in the Asian Region, was developed based on the following basic principles.

1) The fundamental philosophy of the Framework is nuclear nonproliferation, sustainability, and feasibility. At the same time, it shall take into consideration the member states' equality (Fundamental principle).
2) The overall fuel cycle service including both frontend (nuclear fuel supply centered uranium enrichment) and backend (SF handling service: MOX interim storage and reprocessing) are target. (Target range).
3) The target area of the Framework is Asia (it may include Pacific states) (Target area).
4) The member states that satisfy criteria (NSG Guidelines, 2011) are basically allowed to introduce enrichment/reprocessing facilities. Accessibility/introduction of the SNTs shall be equal if the states meet a certain condition (Equality).
5) The fuel cycle service scheme based on the MNA University of Tokyo model (including 3S and regional safeguards) satisfies the needs of nuclear non-proliferation in the current international treaties, agreements, guidelines and a bilateral agreement, etc. The scheme shall also be the level that can adequately prevent the proliferation of the SNTs and nuclear materials (Coherence with existing laws and regulations).
6) The SF shall be internationally stored and processed. The direct disposal (permanent disposal) is out of scope of this MNA Framework proposal (Not targeting SF Once-through).
7) The reprocessing service shall be carried out by existing reprocessing facilities or future new facilities. Each state (member state) is responsible for the disposal of High Level Waste (HLW). 1) In the short term, the SF storage by multinational approach and reprocessing by existing facilities, etc. shall be carried out simultaneously. 2) Recovered Plutonium (Pu) is internationally stored as future resources in the form of MOX, but it will be partially used as Light Water Reactor (LWR)-MOX to the extent possible. 3) Utilization of Pu can be applied for future LWR MOX as well as Fast Reactor (FR) when the economic feasibility is enhanced. 4) The states will be responsible for disposal of HLW. In order to secure the disposal space and to reduce environmental burden (e.g. natural level within 300 to 500 years) in the future, solutions (i.e. development of technology and establishment of its service system) shall be discussed among the member states of the Framework within a certain period (e.g. 50 years) of the multinational storage (Recycle options).

Outline of the MNA Basic Agreement (University of Tokyo Model)

	Name of Agreement	MNA Basic Agreement (University of Tokyo Model): Multilateral Agreement on the supply of Enriched Uranium and Nuclear Fuel Cycle Services in Asian Region
	MNA Operating body MNA-3S Supervising body (supervision of safeguards, nuclear security, safety)	Asian Multilateral Nuclear Approach Organization, AMNAO AMNAO 3S Control Center, AMNAO-3SCC
Preamble	Background	
	Member states	Name of member states of this Agreement shall be listed by the types of participation: host states, site states, partner states, and other members
	Prerequisites to be member states	The states which have conducted or have plans for nuclear power plants and/or nuclear fuel cycle facilities in Asia as well as have satisfied the prerequisites stated in Articles 2 to 6 (i.e. commitment to nonproliferation, regional safeguards, nuclear security, export control and safety) and requirements for withdrawal as in Article 21.
	Cooperation	Multilateral cooperation shall be carried out in relation to any of Type A, Type B and Type C stated in Article 1.
	Objectives	The objective of this Agreement is to construct Multilateral Nuclear Approach (MNA) in order to promote efficient utilization of nuclear energy in Asia, to keep political stability and transparency and to increase economics in Asia, to maintain and enhance nuclear-nonproliferation, nuclear security and safety considering equality.
	Definitions (Label A, B, and C)	(1) Member states: All states that meet prerequisites stated in Article 2 to 6 and 21, and sign and ratify this agreement. They can also be called as signed parties. (2) Host states: The states that have SF storage, MOX storage, and existing or new uranium enrichment/ reprocessing facilities and provide enriched uranium, services for handling spent fuel (i.e. SF storage, reprocessing, MOX storage) to partner states through AMNAO. (3) Site states: The states that have transferred ownership of their existing and new facilities such as uranium enrichment, spent fuel storage, reprocessing, and MOX storage to AMNAO.

		(4) Partner states: The states that have nuclear power plants and receive enriched uranium supply and SF handling services (i.e. SF storage/reprocessing/MOX storage) from AMNAO's facilities in host or site states. (5) Regional safeguards: It shall have accountancy by Operator and MNA, and verification based on comprehensive Safeguards and additional protocol. (6) Cooperative Industrial Consortia: Cooperative Industrial Consortia which carry out businesses under the Type A, B, and C circumstances (for Type C, Cooperative Industrial Consortia would be Multinational).
	Rights and obligations (Label A and B)	Rights: For Type A stated in Article 1, member states will have rights to have uranium enrichment facility and SF reprocessing facility when they satisfy prerequisites stated in Articles 2 to 6 and 21. Refer to Article 1 for their ownership rights, etc. For Type B and C stated in Article 1, partner states can receive provision of enriched uranium and SF processing services (i.e. storage, reprocessing, and MOX storage). Obligations: The obligations are to comply with Regional Safeguards, Nuclear Security, NSG Guideline and Safety, which are stated in Articles 2 to 6.
Article 1	Contents of Cooperation and Scope of Activities (Label B and C)	(1) Type A: Collaboration under the framework which does not involve fuel cycle services (uranium fuel supply and SF treatment as SF storage and reprocessing). Type A applies implementation of regional safeguards (Article 3) and strengthening nuclear security (Article 4) and safety (Article 6). (2) Type B: Collaboration under the framework where ownership of existing and new facilities will not be transferred to AMNAO. However, the management of MOX storage facility will be conducted by MNA (no transfer of ownership). Type B applies provision of uranium fuel supply and SF handling services (e.g. SF storage/ reprocessing/ MOX storage) by existing or new facilities in host states, implementation of regional safeguards (Article 3) and strengthening nuclear security (Article 4) and safety (Article 6). (3) Type C: Framework which involves transfer of the existing and new facilities, including ownership, to AMNAO. Type B applies provision of uranium fuel

		supply and SF handling services (e.g. SF storage/ reprocessing/ MOX storage) by existing or new facilities in host states, implementation of regional safeguards (Article 3) and strengthening nuclear security (Article 4) and safety (Article 6). (4) Promotion of establishment/operation of AMNAO-3SCC (including safeguards, nuclear security, and safety) and Cooperative Industrial Consortia that is needed to implement the above collaboration (1), (2), and (3).
Article 2	Commitment to Nonproliferation (Label A)	(1) The member states must not assist any non-nuclear-weapon states in manufacturing nuclear weapons or other nuclear explosive devices. (2) The member states must ensure that cooperative industrial consortia shall not produce weapons grade uranium.
Article 3	Safeguards (Label A)	Appropriate safeguards procedures shall be applied (=implementation of regional safeguards system by AMNAO-3SCC) (a) Material accounting by Operator and/ or AMNAO-3SCC (b) Verification by IAEA and AMNAO-3SCC (based on comprehensive safeguards and additional protocol) (c) In the case of export, international procedures (Article 5)
Article 4	Nuclear Security (Label A)	(1) International standards shall be applied. (2) Security inspection shall be made by AMNAO-3SCC.
Article 5	Export Control (Label A)	Member states must be NSG members (compliance with NSG regulations) NSG Guideline (INFCIRC 254/Part 1, 6 and 7 revised, Jun., 2011)
Article 6	Safety (Label H)	(1) International standards shall be applied. (2) Mutual safety inspection shall be made by AMNAO-3SCC.
Article 7	Assurance of Nuclear Fuel Cycle Services (Label B)	(1) For Type B, host states shall assure supply of enriched uranium and SF handling services (i.e. SF and MOX storage, and reprocessing) to partner states. MNA should control for MOX storage service. Supply from outside MNA would be considered on supply-demand balance and price. However, the MOX storage facility will be the service under the control of MNA. Note, however, that supply of enriched uranium may be exempted if obtainment from outside of the framework is more advantageous considering the price and the demand/supply balance within the Framework.

		(2) For Type C, AMNAO shall provide enriched uranium and SF treatment services (SF and MOX storage, and reprocessing) to partner states based on the contract. Note, however, that supply of enriched uranium may be exempted if obtainment from outside of the framework is more advantageous considering the price and the demand/supply balance within the Framework. The site states must take necessary procedures with regards to, and cooperate in, enriched uranium supply and SF fuel handling services (SF and MOX storage, and reprocessing) provided by AMNAO facilities to partner states based on the contract. (3) The period of SF storage within the MNA Framework shall be a certain period which shall be agreed by the member states. During the period, AMNAO, in cooperation with member states, should develop reprocessing technology including environmental burden reduction technology, construct the facility for the technology, and establish the service provision system. The method and degree of cooperation should be discussed at AMNAO. (If a specific method is not established within a certain period, the SF shall be basically returned to the generating state.) (4) In principle, the generating states should have the right to use the MOX stored as future energy resource but this must be discussed and determined within the AMNAO Framework. The following options should be reviewed: (a) To return as LWR MOX to the generating states (possessing states) within the framework if they desire it (high-level safeguards and nuclear security to be applied); (b) To return as fast reactor MOX to the generating states (possessing states) within the framework if they desire it (high-level safeguards and nuclear security to be applied); and (c) To sell to nuclear weapon states (including outside the framework).
Article 8	Access to SNTs, Security of SNTs and Information (Label D)	To protect the proliferation of SNTs, access to SNTs should be limited only to technology holders (states). This is applicable when introducing the enrichment/ reprocessing facilities from outside of the state. Concerning security procedures and classification of sensitivity, member states shall apply to the provisions of Annex I to the Agreement.
Article 9	Selection of Host States and Site States	(1) For type A, in principle, all the member states may be allowed to have facilities for uranium enrichment and

	(Label C)	SF handling (SF storage and reprocessing). (2) For type B, in principle, the member states may be allowed, as host states, to have facilities for uranium enrichment and SF handling (SF storage, reprocessing, and MOX storage). The service for MOX storage facilities, however, must be provided under the control of MNA. Furthermore, to be selected as a host state, however, the state must be politically and geopolitically stable (including being in a non-conflict situation). (3) For type C, in principle, the member states may be allowed, as site states, establish facilities for uranium enrichment and SF handling (SF storage, reprocessing, and MOX storage). To be selected as a site state, however, the state must be politically and geopolitically stable (including being in a non-conflict situation) and establish a special administrative scheme, that is, a legal framework (agreement between AMNAO and site state) that limits national governmental jurisdiction with regard to the site of AMNAO facility.
Article 10	Degree of involvement with MNA (Label E)	(1) In type A, the ownership, management, and operation of facilities and research, development, designing, construction, etc. must belong to the technology holders (states). (2) In type B, the ownership, management, and operation of facilities must belong to the technology holders (states) and the management and operation of MOX storage facilities and the research, development, designing and construction with regard to future SF handling technology must belong to AMNAO. (3) In type C, the ownership of facilities must belong to AMNAO; the management, to AMNAO (technology holders); the operation, to the technology holders commissioned by AMNAO; and research, development, designing, and construction (mainly with regard to SF handling technologies), to AMNAO.
Article 11	Liability (Label I)	(1) In types A and B, damages must be compensated by the states concerned. It is desirable that the member states owning facilities should participate in an appropriate international agreement with regard to liability. To MOX storage facilities in type B, however, provision (2) below should be applied. (2) In type C, a certain degree of damages must be compensated among the member states (for details, refer to attached documentation II). It is desirable that

		the member states should participate in an appropriate international agreement with regard to liability.
Article 12	Transport (Label G)	(1) Must satisfy international standards with regard to transport. (2) The member states must cooperate in transport of nuclear fuel, SF, etc. based on the MNA Framework.
Article 13	Organizations and the tasks	AMNAO Board of Directors, AMNAO Secretariat (1) Establishment (2) Configuration, items to decide, and decision-making methods (3) Methods of selecting the chairman and the Secretary-General (4) Decision of regulations of Board of Directors and Secretariat procedures (5) Duties, etc. of Board of Directors and Secretariat (6) Issuance of directives based on decisions
Article 14	Prohibited corporation items	Prohibition on cooperation items other than those stipulated in agreement (1) (a) Except for the cooperation described in Article 1 of this Agreement, the member states must not execute any participation, fostering, and support in any way. (b) Duties of industrial consortiums (2) (a) Prohibition on participation in, fostering, and support of, any new development program with regard to uranium enrichment and SF reprocessing technologies out of the MNA framework. (b) Prohibition on use of deliverables by Agreement states concerned. (3) Without consent of AMNAO, the member states must not transfer nuclear material and export enrichment, reprocessing, and other facilities to any state out of the framework.
Article 15	Patents/ Industrial Ownership	Handling of patents and industrial properties (Details are stipulated in attached documentation III)
Article 16	Resolution of Dispute	(1) Problems shall be solved by the Board of Directors (2) If not solved, the problem shall be solved between the concerned states. (3) Arbitration by the arbitration committee. (4) Composition of Arbitration committee and assignment of members. (5) Methods of decision making at the arbitration committee. (6) No right to appeal.
Article 17	Signatory to Agreements with other states, other organizations	The member states may, on a joint basis, conclude contracts for cooperation with Asian or other states or international organizations provided that these contracts

		are not concerned in transfer of the SNTs and nuclear material.
Article 18	Applicable scope	Asian region, territorial lands and waters of member states
Article 19	Ratification and Entry into Force	This Agreement must follow ratification. The document of ratification must be deposited to the Government of xxx. This Agreement must come into effect on the date when the xx-th document of ratification is deposited to xxx. The Government of xxx must give notice of deposit of each letter of ratification and the date of enforcement of this Agreement to the other signatory states.
Article 20	Amendment	Any member state or the Board of Directors may any time propose an amendment to this Agreement.
Article 21	Withdrawal	When a member state of the regional multilateral framework withdraws from the framework, the state must satisfy the following items: (1) After withdrawal, the state must return to the safeguards before its participation in the framework (the IAEA safeguards). (2) The use and operation of the facilities that are newly built based on participation in the framework must be terminated. Confirmation and verification of termination must be entrusted to the IAEA. (3) Of the nuclear material produced by the new facilities built due to participation in the framework, enriched uranium must be returned via the MNA to the state that asked for enrichment service. Even if possessed by the state concerned (withdrawing state), plutonium (MOX) must be transferred to and stored at the MNA (international MOX storage facility) as international stockpile of the region. This will support future energy source of the region (corresponding service cost should be paid to the withdrawing state). (4) It must be prohibited to transfer or sell, to any state out of the framework, any nuclear material produced by the new facilities built due to participation in the framework.
Article 22	Expiration of Membership	In the following cases, membership may be invalidated by a resolution at the Board of Directors: (1) Having acted against the member state requirements. (2) Having acted against the member state obligations. (3) Having carried out any activity other than cooperation that the member states can give.
Article 23	Termination	The Agreement may any time be cancelled by unanimous consent of the member states. In this case, as a result, in order to arrange their rights and duties, the member states must conclude a protocol that includes provisions with

		regard to settlement of assets and debts resulting from their cooperation based on this Agreement.
Article 24	Necessary Measures, etc.	Necessary measures, etc. in case of Articles 21, 22, 23, 2, 3 and 8: In case of withdrawal of any member state from this Agreement pursuant to Article 21 and invalidation of membership of this Agreement pursuant to Article 22 or cancellation of this Agreement pursuant to Article 23, then with regards to Articles 2 and 3 that are related to promises and safeguards and Article 8 that is related to measures to protect confidential information, documents and devices, appropriate provisions must be created to continue these provisions, to assure the right of claim for return, to prohibit transfer to any third state, etc. Until the said provisions are created, Articles 2, 3, and 8, and any amendment made or any procedure applied thereto at the time of attainment thereof, must be effectively sustained.
Ending part		The signers legally empowered to witness signatures and certify the document's validity concluded this Agreement: The X of Agreement were made in ××, ○○, △△, □ languages, on XX, XX, XXXX, at YYYY. Each Agreement is equally original. Date of signature Representing State A: Representing State B: Representing State C: Representing State D:
Attached documents		I: Security Procedures and Confidentiality Classification II: Liability III: Patents and Industrial Properties Ownership

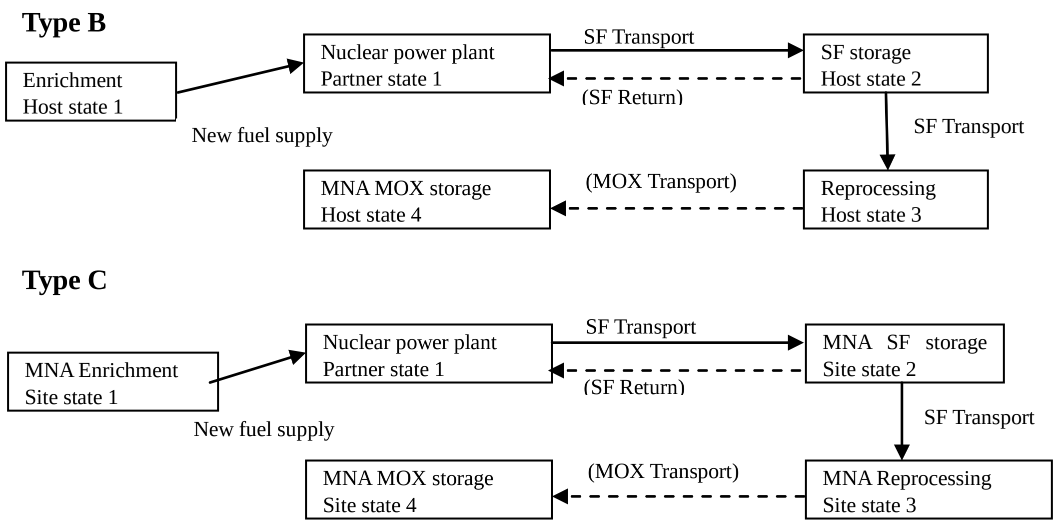
7. Specific MNA framework example (selection of host states)

7.1 Prerequisite

7.1.1 Collaboration form

Figure 7.1 shows the combination of supply/service among member states based on Type B and C as a collaboration form under the MNA Framework. For FY 2011, new MOX storage is added to the collaboration items, in addition to the SF interim storage. Furthermore, we added to the Basic Agreement (Article 7(3)) that SF shall be returned to a generating state if an effective processing method for the SF stored in the international storage is not developed within a certain period of time.

Figure 7.1 Combination of supply/service among the MNA member states



7.1.2 Collaboration target states

It is anticipated that the future development of nuclear power in Asia is apparently large as compared with the other regions (IAEA predictive statistics). Meanwhile, it is becoming increasingly critical to find solutions to SF issues in Asia and Far Eastern region including Japan. Below are suggestions with some specific countries supposed by the authors taking into account the existing and future possible facilities, although more careful political/geopolitical considerations should be taken. Based on the current situation of nuclear power in each state and the results of our study visit to relevant states as shown in Table 1 and 2, we examined nuclear power energy promoting states in North East Asia, which is the adjacent area to Japan, and emerging states in South East Asia as the main targets of the framework.

Specifically, the target states include Japan, Republic of Korea (hereafter referred to as South Korea), China (including Taiwan), Russia, Kazakhstan, Mongolia and emerging nuclear energy states in South East Asia (North Korea is excluded for the time being. India and Pakistan are geographically out of target). On the ground of nuclear non-proliferation, it can be a realistic option to include the US in the "Asia/ Pan Pacific" framework (if it adapts this name, Canada and Australia will also be included). However, this interim report only refers to these states as "US, etc."

7.1.3 Target facilities

The target facilities include frontend and backend, especially, enrichment, reprocessing, and SF storage facilities. For MOX storage, this report assumes that it will be carried out by the states responsible for reprocessing.

7.1.4 Selection of host states

This study chose Japan, South Korea, Kazakhstan, Russia, China and Mongolia as host states. For these states, the study investigated the possibility of providing fuel supply services (i.e. enrichment, interim storage, reprocessing) as current and future host states. The results are shown in Table 7.1. For the activities based on Type B and C, the candidates for host states and site states and their collaborative activities are shown in Table 7.1. This table represents the list of future potential candidates of the facilities that our study group supposed, although installation and operation of those facilities may not be easily realized due to (1) conflict with the existing laws/regulations/agreements, and (2) short of capacities of existing facilities. Regarding "Reprocessing" and "MOX Storage" in Non-Weapon-Countries, application of Type C (transfer of ownership to MNA) is more realistic approach rather than Type B from the viewpoint of nuclear non-proliferation. Mongolia is excluded from the candidates for the time being, taking into consideration the state's situation on nuclear power.

Table 7.1 Candidates for host and site states and their collaborative activities

Name of state	Enriched uranium fuel supply Host state, Site state 1	SF storage Host state, Site state 2*	Reprocessing Host state, Site state 3*	MOX storage Host state, Site state 4	Notes
Kazakhstan	○	○*	○	○	
Russia	○	○	○	○	
Mongolia	—	△*	—	—	△: taking into consideration the state's situation on nuclear power.
China	○	○	○	○	
Japan	○	—	○	○	
Korea	○	—	○	○	

* Limited to SFs whose uranium was produced in its own country

7.2 Specific combination of multilateral collaboration (Example)

Appropriate combination for multilateral collaboration from frontend to backend can be established based on the bilateral collaboration for the process of enrichment, storage and reprocessing. In this case, the partner states are those which currently have or will have nuclear power plants. Therefore, as part of multilateral collaboration, nuclear power generation is added. Table 7.2 shows the candidates for the host and partner states. As the same as the above, this table also represents the combinations of future potential candidates of the facilities that our study group supposed, although installation and operation of those facilities may not be easily realized due to (1) conflict with the existing laws/regulations/agreements, and (2) short of capacities of existing facilities. Regarding "Reprocessing" and "MOX Storage" in Non-Weapon-Countries, application of Type C (transfer of ownership to MNA) is more realistic approach rather than Type B from the viewpoint of nuclear non-proliferation.

Table 7.2 Candidates for the host and partner states for multilateral collaboration

	Enrichment	(Power generation)	SF storage	Reprocessing	MOX storage
Host state	Kazakhstan Russia Japan China South Korea	Japan Russia South Korea	Kazakhstan Russia (Mongolia)	Japan Russia South Korea China Kazakhstan	Japan Russia South Korea China Kazakhstan
Partner state	Asian emerging states Japan	Asian emerging states (including Kazakhstan, Mongolia)	Asian emerging states (Japan) (South Korea) (Taiwan)	Asian emerging states	Asian emerging states

Appendix 1 Nuclear power situation of each state at frontend

As of February 2011

	Uranium mining/uranium refining (Source: IAEA INFCIS)	Conversion, re-conversion (Source: Same as left)	Enrichment (Source: Same as left)	Processing (Source: Same as left)	Nuclear power generation (operation, construction, plan) (Source: World Nuclear Power Plants, 2010)
Russia	● Dalur: 800 t U/year (Hereafter, the same unit) ● Priargunski / Krasnokamensk: 3,500	● Angarsk(Conversion to UF6): 20,000 t HM/year (Hereafter, the same unit) ● Chepetski Machine Plant- Conversion (Conversion to UF4): 2,000 ● Ekaterinburg (Conversion to UF6 , Sverdlovsk-44): 4,000	● Angarsk: 1,000 MTSWU/year (Hereafter, the same unit) ● Ekaterinburg (Sverdlovsk-44): (No description of facility size provided.) ● Krasnoyarsk: (No description of facility size provided.) ● Siberian Chemical Combine (Seversk): 4000	● Machine - Building Plant (FBR): 50t HM/y ● Machine - Building Plant (LWR): 950 t HM/y ● Machine - Building Plant (RBMK): 950 t HM/y ● Machine - Building Plant (pellets): 1,100 t HM/y ● Novosibirsk Chemical Concentrates Plant (Assembly) : 1,200 t HM/y ● Novosibirsk Chemical Concentrates Plant (Pellets): 660 t HM/y	• Operation: 27 reactors (23.194 million kW) • Construction: 10 reactors (8.38 million kW) • Plan: 7 reactors (8.02 million kW)
China	● Benxi: 120 t U/year (Hereafter, the same unit) ● Chongyi: 120 ● Fuzhou: 300 ● Lantian: 100 ● Qinglong: 100 ● Shaoguan: 160 ● Tengchong: 20 ● Yining: 300	● Lanzhou(Conversion to UF6): 3,000t HM/year	● Shaanxi Uranium Enrichment Plant: 500 MTSWU/year(Hereafter, the same unit) ● Lanzhou: 500	● Candu Fuel Plant (PHWR) :200t HM/y ● Yibin Nuclear Fuel Element Plant （PWR) : 400t HM/y	• Operation: 11 reactors (9.118 million kW) • Construction: 26 reactors (29.444 million kW) • Plan: 10 reactors (9.022 million kW)
United States of America (USA)	● Canon City-II: 210 t U/year (Hereafter, the same unit) ● Crow Butte: 380 ● Smith Ranch: 770 ● Sweetwater (Green Mountain): 350 ● Vasquez: 310 ● White Mesa: 2,000	● Metropolis / Converdyn (Conversion to UF6): 17,600tU/y	● Under operation: ✓ Paducah Gaseous Diffusion: 11,300MTSWU/year ● Under construction/plan: ✓ American Centrifuge: 3,500 MTSWU/year ✓ National Enrichment Facility (NEF): 3,000 MTSWU/year ✓ Areva Eagle Rock Enrichment Facility: 3.3 to 6.6 million SWU/year	• BWXT (Fuel Fabrication for research Reactors) : 100 t HM/year) • Columbia (Westinghouse, U Assembly): 1, 150 t HM/year • Richland (ANF) (U Assembly): 700 t HM/year • Lynchburg - FC Fuels (U Assembly): 400 t HM/year • Wilmington (GNF) (U Assembly) : 1,200 (t HM/year)	• Operation: 104 reactors (105.344 million kW) • Construction: 1 reactor (PWR 1.20 million kW) • Plan: 8 reactors (9.40 million kW)
France	No data	• Comurhex Malvesi (Conversion to UF4): 14,000 t HM/year • Comurhex Pierrelatte (Conversion to UF6): 14,000 t HM/year • W Defluorinat (e-Conversion to U3O8 (Dep. U) : 14,000 t HM/year	● Under operation: Eurodif George Besse-I: 10,800 MTSWU/year ● Under construction: George Besse-II: 7,500 MTSWU/year	FBFC - Romans: 1,400 t HM/year	• Operation: 59 reactors (66.02 million kW) • Construction: 1 reactor (PWR 1.63 million kW)
United Kingdom (UK)	（No data）	• Springfields Enr. U Residue Recovery Plant (Conversion to UO2): 65 t HM/year (Hereafter, the same unit) • Hex Plant (Conversion to UF6): 6,000 • Springfields Main Line Chemical Plant Hex Plant (Conversion to UF4): 10,000 • Springfields OFC IDR UO2 Line (Conversion to UO2): 550 • Springfields U Metal Plant (Conversion to U Metal): 2,000	● Urenco Capenhurst: 4,000 MTSWU/year	● Springfields OFC LWR Line: 330t HM/y ● Springfields (AGR): 290tHM/y	• Operation: 19 reactors (11.952 million kW)

Japan	（No data）	（No data）	● Rokkasho Uranium Enrichment Plant: 1,050 MTSWU/year	● Global Nuclear Fuel-Japan Co. Ltd. (GNF-J,BWR): 750 tU /year (Hereafter, the same unit じ) ● Mitsubishi Nuclear Fuel Ltd. (MNF, PWR) : 440 ● Mitsubushi Nuclear Fuel Ltd. (MNF) : 450 ● Nuclear Fuel Industry Ltd. (NFI Kumatori, PWR): 284 ● Nuclear Fuel Industry Ltd. (NFI Tokai, BWR) :250	● Operation: 54 reactors (48.847 million kW) ● Construction: 3 reactors (3.036 million kW) ● Plan: 12 reactors (16.552 million kW)
India	• UCIL-Jaduguda: 175 (t U/year)	● NFC (UOP) - Block-A （Conversion to UO2）: 450 t HM/year	（No data）	● NFC (BWR、24t HM/y) ● NFC (PELLET、335t HM/y) ● NFC (PHWR、300t HM/y) ● NFC (PHWR、300t HM/y) ● Trombay FBTR (FBR、No description of facility size provided.) ● Trombay, Fuel Fabrication (PHWR、135 HM/y)	● Operation: 17 reactors (4.12 million kW) ● Construction: 6 reactors (3.16 million kW) ● Plan: 8 reactors (6.80 million kW)
Australia	● Beverley：848 t U/year (Hereafter, the same unit) ● Olympic Dam：3,930 ● Ranger：4,660	（No data）	(No data. The operation of Silex ended in 2007. Currently it is being decommissioned.）	（No data）	No reactor for commercial purpose
Canada	● Key Lake/McArthur River：7,200t U/year (Hereafter, the same unit) ● McClean Lake：3,075 ● Rabbit Lake：4,615	● Cameco -Blind River (Conversion to UO3）：18,000tU/y（Hereafter, the same unit) ● Cameco - Port Hope (Conversion to U Metal)：2,000 ● Cameco - Port Hope (UF6) (Conversion to UF6)：12,500 ● Cameco - Port Hope (UO2)（Conversion to UO2：2,800	●（No data）	● Chalk River Laboratories, NFFF（No description of facility size provided. ● N. Fuel PLLT. OP.（U Pellet-Pin、1,300t HM/y) ● Peterborough （PHWR、1,200 (t HM/y) ● Zircatec Precision Ind.（PHWR、1,200 (t HM/y)	● Operation: 18 reactors (13.284 million kW)
Kazakhstan	● Betpak-Dala JV LLP：3,000 U/year (Hereafter, the same unit) ● Appak LLP：500 ● Centralnoye (Taukent)：1,000 ● JV Inkai：700 ● JV Katco (Moynkum)：700 ● KenDala.kz JSC：1,000 ● Mining Group 6 LLP：1,000 ● Stepnogorsky Mining and Chemical Complex (SMCC)：3,000 ● Stepnoye Mining Group LLP：1,300	●（No data） ● According to the WNA, Cameco signed on an Agreement with Kazatomprom to examine conversion plant construction in 2007. In 2008, they collaboratively established a new company for a construction of a conversion facility (i.e. 12,000 tU/y) in Ulba. The feasibility study was to be completed in mid-2009. The operation of the facility will begin in 2015, and it will be fully operationalised in 2018. Comeco provides technology and occupies 49% of the project.	（No data）	● Ulba Metalurgical Plant (UMP, 2,800 (tHM/y) ● In 2007, Kazakhstan made an Agreement for collaboration with the Kansai Electric Power Co., Ltd., Nuclear Fuel Industries, Inc., and Sumitomo Corporation. The Agreement is called the “Minutes of Agreement for the Partnership for manufacturing nuclear fuel for Japan”. In the Minutes, it was agreed that 1) “Ulba Mining Plant”, an affiliate of Kazatomprom, would manufacture and provide nuclear fuel compound to the nuclear power plant of the Kansai Electric Power Co., Ltd, and 2) Sumitomo Corporation would be responsible for developing market in Japan for the service provided by the UMP (e.g. handling different uranium blended materials from uranium dioxide powder to fuel pellet, to be used for producing fuel at Nuclear Fuel Industries, Inc.). (Source: IAIF) ● In 2008, Kazakhstan signed on the Comprehensive Agreement with AREVA in France in the field of nuclear fuel cycle. It was agreed that AREVA would provide technical assistance to Kazatomprom to produce 1,200 tons of nuclear fuel assembly every year at UMP. This includes the support by France for fuel assembly line for reactor (400 tons). Kazatomptom would supply fuel pellet for the fuel assembly and also establish a joint venture corporation called Integrated Asia Star (IFASTAR) which sells the fuel assembly (AREVA 51%, Kazatomptom 49%). All 800 tons of fuel assembly (the total production volume of 1,200 tons minus 400 tons for the French plants) can be used for any purposes by Kazatomptom. Currently they are planning to sell it to the nuclear emerging countries in Asia. (Source:	● Plan: 1 reactor (No description on its outputs) ● There are 4 research reactors (IGR, WWR-K (VVER-K), EWG-1M, RA) + fast reactor 1(BN-350, it was decided for decommission in 1999). ● In October 2006, “Atomstroyexport (ASE)”, a company dealing with engineering, procurement and construction in Russia, “Techsnabeport (TENEX)”, a company dealing with conversion and enrichment, and “Kazatomprom” of Kazakhstan signed on a document to establish 3 joint venture corporations (i.e. uranium mining joint venture “Akbastau”, “Uranium Enrichment Center”, and “Atomnayastancha”). The “Atomnayastancha (meaning a nuclear power plant)” is a joint venture corporation to construct a nuclear power plant (equal contribution). They are deliberating the feasibility of constructing 2 middle-to-small size plants VBER-300, which is based on the module marine reactor, near Aktau in western Mangyshlak. (Source: JAIF)

				WNA)	
South Korea	(No data)	(No data)	(No data. Based on the Korean Peninsula Non-Nuclear Weapon Declaration, it was declared that the country would not possess enrichment and reprocessing facilities)	● CANDU Fuel Fabrication Plant (PHWR、400 t HM/y) ● DUPIC Fuel Dev. Fac. (DFDF、Laboratory 0.2t HM/y) ● PWR Fuel Fabrication Plant Fuel（PWR、400t HM/y)	• Operation: 20 reactors (17.716 million kW) • Construction: 6 reactors (6.80 million kW) • Plan: 2 reactors (2.80 million kW)
Mongolia	(No data) ●According to the red-book by OECD/NEA, Mongolia has about 49,000 tU (reasonably assured resources) + inferred resources. After 2008, Russia and China had been trying to influence over the uranium resources of Mongolia. ● In 1995, uranium production on the Dornod uranium deposit in Mongolia began with assistance from Russia. In August 2009, a joint venture corporation with Russia will be established, and uranium development began. An affiliate of China National Nuclear Corporation (CNNC) signed on an agreement with Mongolia in 2007 for uranium exploration and bought Western Prospector Company – uranium right to mine. ● Areva took a right to mine. They did mining test (in site leaching uranium recovery) successfully.			(No data)	No reactor for commercial purposes
Viet Nam	(No data)	(No data)	(No data)	(No data)	● There is only Dalat research reactor. There is no reactor for commercial purposes. ● Plan: Out of 4 reactors (4 million kW), the first 2 reactors will be contracted with Russia. Japan is planning to have orders for the other 2 reactors. The former reactors will be either VVER-1000 or 1200, for which Russia would provide financial assistance. Throughout the reactor life, Russia will provide the fuel. Russia will also take back the spent fuel. (Source: JAIF)
Thailand	(No data)	(No data)	(No data)	(No data)	● There is only a research reactor. There is no reactor for commercial purposes. ● In the Thailand Power Development Plan 2007-21 (PDP, Revised in 2007 and 2009), it is described that nuclear power plants at the level of 1 million kW will be established in 2020 and 2021 (same as above).
Indonesia	(No data)	(No data)	(No data)	● Experimental Fuel Element Facility Fuel Fabrication (Research Reactors、No description of facility size provided) ● RR Fuel Element Production Installation (IFEBRR、Pilot plant No description of facility size provided)	● There are only 3 research reactors and no reactor for commercial purposes. ● The country is planning to construct 4 reactors (total of 4 million kW) on the Muria Peninsula in the center of Java Island. The construction of the first began in 2010 and the second in 2011.The construction of the third and fourth will begin after the completion of the first and second reactors. It is aimed that the operation of the first will begin by 2016, the second by 2017 and the third and forth by 2025. In 2007, the Feasibility Study Minutes Concerning 2 Reactors was signed between Thailand and South Korea (same as above).
Malaysia	(No data)	(No data)	(No data)	(No data)	● There is only a research reactor and no reactors for commercial purposes. ● Aiming at beginning operation of the first reactor in 2021, Malaysia is deliberating the introduction of GEN-III or GEN-III + reactor with the latest technology as well as the selection of a corporation that enables technology transfer for Malaysia to establish

					independent technology.
Philippines	(No data)	(No data)	(No data)	(No data)	● There are Philippines research reactor and Bataon reactor. The construction of the latter is completed but is abundant without fuel being loaded. ● The National Energy Plan of 2008 mentioned the need for a nuclear reactor of 0.6 million kW (operation in 2025)
Taiwan[5]	(Imported from the USA, France, South Africa, Canada, Australia, and Namibia)	(They are procured from 3 suppliers from the West based on long-term contracts.)	(Long-term contracts with 2 companies from Europe and the USA. For safeguards purpose, the uranium from Canada and Australia must be enriched by the USA.)	(Long-term contracts with 3 companies at both BWR and PWR reactors).	● Operation: 6 reactors (5.144 million kW) ● Construction: 2 reactors (2.70 million kW)
Brazil	● INB - Caetite Mining & Ore Plant：340 t U/year)	(No data)	● Aerospace Technical Center：(No description of facility size provided.) ● RF Enrichment (Pilot plant)： ● 4 MTSWU/year (Hereafter, the same unit) ● BRN Enrichment (Experimental size)：5 ● INB - Resende Enrichment Plant (Test run)：120	● BRQ Pellet Production Fuel Fabrication (U Pellet-Pin、Laboratory 2.55t HM/y) ● BRTG Fuel Fabrication Fuel Fabrication (U Pellet-Pin、Laboratory 21 (Elements/year) ● Brazil INB - FCN Resende - Unit 1 Fuel Fabrication (U Assembly、240t HM/y) ● IPEN - Fuel Element Fabrication Plant for Research Reactors Fuel Fabrication (Pilot plant、10 (Elements/y)	● Operation: 2 reactors (2.007 million kW) ● Plan: 1 reactor (1.35 million kW)
Argentina	(No data)	● Cordoba Conversion Facility (Conversion to UO2)：175 t HM/year (Hereafter, the same unit) ● Pilcaniyeu Conversion Facility (Conversion to UF6) ：62	Pilcaniyeu Enrichment Facility (Pilot plant)： 20 MTSWU/year	Ezeiza - Nuclear Fuel Manufacture Plant Fuel Fabrication (U Assembly、PHWR、270t HM/y)	● Operation: 2 reactors (1.005 million kW) ● Plan: 1 reactor (0.745 million kW)
Israel	(No data)	(No data)	(No data)	(No data)	● Plan: 1 reactor (0.664 million kW)
Iran[6]	There is a uranium mining and refining facility in Saghand and a yellow cake manufacturing facility in Ardakan.	There is a conversion facility in Esfahan.	There is an enrichment facility in Natanz.	There is a fuel production facility in Esfahan.	● Construction: 1 reactor (1 million kW) ● Plan: 1 reactor (0.36 million kW)
Pakistan	• BC-1(Pilot plant)：30 t U/year (Hereafter, the same unit) • Issa Khel / Kubul Kel(Pilot plant)：	• Islamabad (Conversion to UO2): (No description of facility size)	Kahuta: 5 (MTSWU/year)	Chashma Fuel Fabrication (U Assembly、PHWR: 20 t HM/year	● Operation: 2 reactors (0.462 million kW) ● Construction: 1 reactor (0.325 million kW)
EU, excluding UK and France, and others	● Czech：400 t U/year ● Rumania：410 t U/year ● Ukraine：1,000 t U/year ● Uzbekistan：3,000 t U/year		● Gruanu (Germany, URENCO, 1,800 tU/year) ● Almelo (Netherland, URENCO, 4,500tU/year)	● Belgium: FBFC International - LWR Fuel Fabrication Plant (U Assembly, UOX-PWR,BWR): 500 t HM/y ● Germany: Advanced Nuclear Fuels GmbH Lingen Plant (U Assembly, LWR): 650 t HM/y ● Spain :Fabrica de combustible (U Assembly, LWR): 400 t HM/y ● Sweden: Westinghouse Electric Sweden AB (U Assembly, LWR): 600 t HM/y	● Germany: 17 reactors (21.507 million kW) ● Sweden: 10 reactors (9.384 million kW) ● Spain: 8 reactors (7.727 million kW) ● Belgium: 7 reactors (6.201 million kW) ● Czech: Operation: 6 reactors (3.93 million kW), Plan: 2 reactors (2 million kW) ● Switzerland: 5 reactors (3.405 million kW) ● Finland: Operation: 4 reactors (2.80 million kW), Construction: 1 reactor (1.72 million kW) ● Netherland: 1 reactor (0.51 million kW)

[5] Except for nuclear reactors, information is obtained from the University of Tokyo – UKM International Conference materials
[6] Except for the nuclear reactors, information is obtained from NTI

Appendix 2 Nuclear power situation of each state at backend

As of February 2011

	Spent fuel storage	Reprocessing	Spent fuel/radioactive waste processing/disposal	Nuclear fuel cycle policy	Legal system, etc.
Russia	● Under operation ✓Kursk NPP Site: 2000t HM ✓Leningrad NPP Site: 4,000t HM ✓Novovoronezh NPP Site: 400t HM ✓RT-1, Mayak, Reprocessing Plant Site: 560t HM ✓RT-2, Krasnoyarsk, Reprocessing Plant Site : 8,6000t HM ✓Smolensk NPP Site : 2,000t HM ● Plan ✓Mining and Chemical Complex Site, Stage I: 8,130t HM	● RT-1, Combined Mayak Spent Fuel Reprocessing (400t HM/year) ● RIAR (Research Institute of Atomic Reactors、Pilot plant)：1 t HM/year	● The study on high level waste disposal sites is carried out in 5 locations in the Kola Peninsula, Novaya Zemlya Islands, Chelyabinsk, Krasnoyarsk, and Far East (as of 2004. Source: ATOMICA). ● Because Russia prohibited the interim storage of radioactive waste and substances generated overseas as well as bringing in radioactive waste from overseas for final disposal through its 1992 Environmental Protection Act Article 50, the storage of such items in Russia had been limited for reprocessing of spent fuel generated within Russia. However, in order to obtain foreign currency, the following 3 laws were discussed at the Parliament: 1) revision of the above Act to include an exemption case, 2) revision of the Nuclear Power Act to only allow the contracts compliant with the Civil Code to export/import as well as accept interim storage and reprocessing of spent fuel from overseas, including leasing, and 3) establishment of the Special Ecological Environmental Plan Act that determines the use of foreign currency that can be obtained from the international trade of spent fuel for environmental protection actions and establishment of fuel cycle related infrastructure in Russia. The laws were signed by the President and were enacted in July 2001.	● Russia is aiming at the closed cycle using fast reactor. However, currently, the spent fuel from RBMK and VVER-1000 reactors is stored but not reprocessed. Russia is planning to construct a spent fuel storage facility which allows them to store up to 40,000tU until the reprocessing facility begins to be fully operationalised around 2022. ● Russian government approved the concept of "new generation nuclear reactor technology between 2010 and 2015 and the prospective up to 2020", aiming to move to the closed-fuel-cycle-based fourth generation reactor. Their first priority is the fast reactor. In addition to natrium cooled-reactor, they are also planning to develop/construct lead and lead-bismuth cooled-reactor.	＜Radioactive waste related＞ Environmental Protection Act
China	● LanZhou Centralized Wet Storage Facility (CWSF): 500t HM	● Lanzhou (RPP) 0.1 t HM/year	● Selection of a disposal site will be completed in 2020. China is aiming to begin the geological disposal research facility from 2020 and the disposal from 2050. ● The high-level radioactive waste will be intensively disposed via geological disposal (People's Republic of China Radiation Pollution Prevention Act of October 2003). In February 2006, the "Research Development Plan Guideline for Geological Disposal of High-level Radioactive Waste" was announced. In the Guideline, it is clearly stated that a disposal site will be constructed by mid-Century. To achieve this objective, China is planning to organize various regulatory systems, select a site, construct and test geological disposal research facility, and carry out safety evaluation of the geological disposal method.	● China is aiming to materialize the closed nuclear fuel cycle using fast reactors. ● By 2020, 70 light-water reactors (LWRs) will be operationalised and 30 LWRs will be constructed. After 2020, Gen-3 PWR (CAP1400) will be the mainstream. As for the heavy-water reactors (HWRs), CERF (20MWe) will reach critical in September 2010. CDFR (800MWe) will be constructed by 2020 and FBR commercial reactor by 2035.	＜Radioactive waste＞ ● People's Republic of China Radiation Pollution Prevention Act (2003) ● "Research Development Plan Guideline for Geological Disposal of High-level Radioactive Waste" (Feb. 2006)
USA	● Currently under operation for commercial purpose: 36 facilities, total of 9,869.4 t HM ● Currently waiting for license: 1 facility (Private Fuel Storage LLC)、40,000 t HM ● Postponed: 1 facility (Owl Creek NPP Site)、40,000 t HM	Only Los Alamos Plutonium Facility Spent Fuel Reprocessing is registered at the Integrated Nuclear Fuel Cycle Information Systems (INFCIS) as currently under operation. However, the facility size is 0t MH/year.	● Currently the spent fuel is not reprocessed but stored within the power generating plant site ● Based on the recommendation concerning the site from Secretary to the DOE to the President, the President recommended Yucca Mountain (YM) as a site to the Congress in February 2002. Although Nevada State submitted a disapproving notification to the Congress, it was overturned and the resolution to approve YM as a site was approved in July 2002. Later, the DOE submitted to application to the Nuclear Regulatory Commission (NRC) for their approval of site in June 2008, and the review process began. However, in March 2010, the DOE submitted an application to the NRC to withdraw the previous submission for approval based on the decision of the new Administration, born in 2009, to cancel the YM plan. The NRC is currently reviewing the submission for the cancellation. ● In order to identify a replacement of the YM plan, the Blue Ribbon Commission was established and back end replacement plan is being examined.	Since the 1970s, there had been no construction of a new nuclear power plant. However, after 30 years of interval, the construction of a new nuclear power plant will begin.	＜nuclear energy in general＞ ● Atomic Energy Act ● Nuclear Non-proliferation Act ＜Radioactive waste＞ ● Radioactive Waste Policy Act in 1982

France	● La Hague - C：4,800t HM ● La Hague - D：4,600t HM ● La Hague - E：6,200t HM ● La Hague - HAO：400t HM ● La Hague - NPH：2,000 t HM	● La Hague - UP2-800：1,000t HM/y ● La Hague - UP3： 1,000t HM/y	● The policy is to reprocess spent fuel. ● It is stipulated in the "Plan Act Concerning Sustainable Management of Radioactive Waste and Radioactive Substance (Radioactive Waste, etc. Management Plan Act)" established in June 2006 that the high-level and long-life middle-level radioactive wastes shall be disposed deep in underground. The Act also regulates that the application for the approval of the disposal site shall be submitted by 2015 and the operation of the site shall begin in 2025. The Act was determined based on the study results and the evaluation of 3 fields (i.e. nuclide separation/conversion, geological disposal, long-term aboveground storage) in order to examine management methods of high level and long-term middle level radioactive waste under the Radioactive Waste Management Study Act of 1991.	● In March 1974, France announced its policy as "all new power source development will be done by nuclear power plants in the future". They export the power generated through nuclear power plants to its neighboring countries. They have fuel cycle facilities that cover from front end to back end within the country. ● The spent fuel is reprocessed. The glassy solid, a vitrified form of high level radioactive waste liquid generated from reprocessing as well as the other long-life middle level radioactive waste are handled by plastic geological disposal.	＜Radioactive waste＞ ● "Radioactive Waste Management Study Law, Radioactive Waste Management Study Act" in 1991 ● "Plan Act Concerning Sustainable Management of Radioactive Waste and Radioactive Substance" (Radioactive Waste, etc. Management Plan Act) established in June 2006
UK	● NDA Sellafield B27 Pond：2,300t HM ● NDA Sellafield Fuel Handling Plant：2,700t HM ● NDA Sellafield Pond 4：1,500t HM ● NDA Thorp RT and ST-1,2：3,800t HM ● NDA Wylfa NPP Site：700t HM	● NDA B205 Magnox : 1,500t HM/y ● NDA Thorp : 900t HM/y	● The high level radioactive wastes are stored in the Sellafield reprocessing factory in the form of glassy solid. ● As for the spent fuel management policy, "as long as needed regulatory requirements are met, the owner of the spent fuel may determine whether the spent fuel is reprocessed or not." All spent fuel generated from the Gas Cooled Reactor (GCR) is reprocessed due to safety reasons. However, for about half of the spent fuel generated from the Advanced Gas-cooled Reactor (AGR) and for the spent fuel generated from the Pressurized Water Reactor (PWR), the contracts for reprocessing have not been made so far. ● As for the management of the high-level radioactive waste, in response to the advice from the CoRWM, an advisory council, the government established a radioactive waste management policy that includes both geological disposal and interim storage in October 2006. Based on the results of the public deliberation concerning the procedure for site selection plan development for the geological disposal, the government published a white paper called "Managing Radioactive Waste Safely- A Framework for Implementing Geological Disposal" in June 2008. The paper contains 6 steps of the site selection process. The government began soliciting local governments that wish to participate in the discussion with the government concerning the disposal site in the future, as a first step of the site selection process as described in the White Paper. So far, 1 state and 2 cities expressed their willingness, and the initial screening of the second step is being carried out.	● After the Chernobyl disaster in 1986, the government had been negative about nuclear power. However, they changed the policy and decided to build a new nuclear power reactor. Although the Labor Party lost at the Lower House election in 2010, it is expected that the nuclear power plant construction policy will still continue. However, it is agreed that no public subsidization will be provided to the construction of the new power plant. There is also an issue to set the price for the carbon dioxide emissions trading. Thus, the future prospect is unclear.	＜Radioactive waste＞ ● There are no laws and regulations that directly regulate disposal plan of high level radioactive waste. ● There are also no laws and regulations that directly regulate the implementation scheme of high-level radioactive waste disposal. However, in response to the advice from the Committee on Radioactive Waste Management (CoRWM), the government stated in their announcement in October 2006 that they would give responsibility to the Nuclear Decommissioning Authority (NDA) for the planning and implementation of geological disposal.
Japan	● Fukushima Daiichi: 408t HM (Cask-Bund.) ● Fukushima Daiichi: 6,840t HM (Cask-Bund.) ● Rokkasho: 3,000t HM ● Tokai Daini: 915 (Cask-Bund.) ● (Interim storage facility: Mutsu-city, Aomori. The operation will begin in July 2012. The capacity is planned to be approximately 5,000tU. Information from Mutsu-city Home Page)	Under construction：JNFL: 800tHM/y	● The policy is to reprocess spent fuel. ● The policy is to carry out geological disposal for high-level radioactive waste. ● The radioactive waste will be processed as high-level vitrified radwaste. More than 40,000 radwastes will be disposed of over 300 meters under the ground. As of now, the site and rock type are not specified yet. The NUMO is soliciting candidate sites for the study. They will select a study site from the sites that express their willingness to be the test site. The disposal will begin from the late 2030s.	The spent fuel is reprocessed, and the recovered plutonium and uranium are used. The nuclear fuel cycle including fast reactors is promoted.	＜Nuclear energy in general＞ ● Atomic Energy Basic Law ● The Law for the Regulations of Nuclear Source Material, Nuclear Fuel Material and Reactors ＜Radioactive waste related＞ The handling of radioactive waste is regulated by the Atomic Energy Basic Law

India	● Rajasthan NPP Site: 570t HM ● Tarapur (AFR) : 275t HM ● Tarapur NPP: 20t HM ✓Trombay Reprocessing Plant: Reprocessing capacity: 50? t/year. India carried out a nuclear test in 1974 using the plutonium generated from this reprocessing facility. Plutonium seems to be used for military purposes. This facility is not a subject of the IAEA safeguards. ✓Tarapur Reprocessing Plant (PREFERE): Reprocessing capacity: 100 to 150 t/year. PUREX method. ✓Kalpakkam Reprocessing Plant (KARP): Reprocessing capacity: 100 to 125 t/year. PUREX method. ✓Fast reactors fuel reprocessing plant (FRFRP): The plant is currently under construction. The reprocessing capacity, etc. is unknown.	● Coral is registered but the capacity is 0 (t HM/year) ● The following reprocessing facilities were constructed or are under operation or under construction with the country's own technology (Source: JAIF).。	The deep geological disposal is being studied. There is a Waste Isolation Plant (WIP) in Kurapool to handle high-level radioactive waste. The Plant was successful in solidifying the waste generated from PREFERE in 1999.	● The policy is directed towards the HWR-plutonium fast reactors. ● All processes including production of uranium and thorium resources, fuel forming, reprocessing, and waste disposal are carried out within the country.	
Australia	（No data）	（No data）	● The radioactive wastes are currently stored in over 100 facilities including universities, hospitals, offices, research institutes, etc. In addition to these wastes, the radioactive wastes which will be reprocessed in UK and France between 2015 and 2016 will be returned to Australia. There is a need to build a storage facility to store all of these wastes. ● In 2010, the Commonwealth Government abrogated the "Commonwealth Radioactive Waste Management (Related Amendment) Bill 2006" and submitted the "National Radioactive Waste Management Bill 2010" to the Lower House. The purpose of this Bill is to take away from the Government the right to select construction sites for radioactive wastes management facilities for the use of medicine, industry and research. Currently, 3 sites in Northern territory are chosen as the candidates for the radioactive waste management facilities.	Australia is the only developed country that does not use nuclear power as energy source. This is because the country is abound in coals and can use them inexpensively.	＜Radioactive waste related＞ ● Commonwealth Radioactive Waste Management Bill 2005 ● National Radioactive Waste Management Bill 2010 ● The construction of nuclear power facilities, etc. is prohibited in the following states: ✓ Victoria: Construction and operation of nuclear reactors are prohibited. ✓ New South Wales: Construction and operation of nuclear reactors are prohibited. ✓ West Australia: Construction of nuclear waste storage facilities within the state is prohibited. Use of sites for nuclear waste storage and processing within the state is prohibited. ✓ South Australia: Construction and operation of nuclear waste facilities within the state is prohibited. ✓ Queensland: Nuclear facilities except for uranium mining are prohibited.
Canada	● Douglas Point NPP Site：0t HM ● Gentilly 1 NPP Site：0t HM ● Gentilly 2 NPP Site：0 t HM ● NPD Spent Fuel Storage：75t HM ● Point Lepreau NPP Site：0t HM ● Whiteshell Laboratories：0t HM	（No data）	● The policy for spent fuel is the direct geological disposal, instead of reprocessing, ● Nuclear Fuel Waste Act was established in 2002, and the Nuclear Waste Management Organization (NWMO) as an executing body of disposing high-level radioactive waste was established. The NWMO examined the long-term management approach of spent fuel, and, in 2005, submitted a proposal called the "Adaptive Phased Management (ADP)" to the Government of Canada. The ADP proposes the storage for the time being and, ultimately, geological disposal. The proposal was adapted in June 2007. In May 2010, the NWMO announced the final		＜Radioactive waste＞ Act Respecting the Long-term Management of Nuclear Fuel Waste (Nuclear Fuel Waste Act, enacted in November 2002).

			version of the site selection plan and began site selection which is composed of the total of 9 processes.		
Kazakhstan	（No data）	（No data）	● Decommissioning of BN-350 is on-going. 1,000 tons of spent fuel including activated sodium is being stored on the site. Furthermore, at the Semipalatinsk Test Site where nuclear tests were carried out for 470 times, the residues from the test are still stored, and the damage to environment is of concern. ● The government is considering establishing law concerning storage and disposal system of radioactive waste (Source: WNA).	The long-term strategies of nuclear power are 1) to be the largest natural uranium production country in the world, 2) to aim at the integrated added value creation structure from front end to back end, 3) to strengthen collaboration with overseas key partners (creation of a consortium, acquisition of stocks of the partners, etc.). Specifically, the government is aiming to secure the share of 30% of uranium prospecting, 12% of conversion, 6% of enrichment, and 30% of fuel production.	＜Nuclear power in general＞ ● Republic of Kazakhstan Act No. 93 concerning nuclear power use as of Apr. 14, 1997 (Nuclear Power Use Act) ● Republic of Kazakhstan Act No. 214 concerning licensing as of Jan. 11, 2007 ● Republic of Kazakhstan Act No. 300 concerning export management as of Jul. 21, 2007 ＜Radioactive waste＞ ● The government is considering the establishment of a law concerning radioactive waste storage and disposal system
South Korea	● Wolsong Dry Storage：6,250 t HM	（No data）	● The spent fuel is managed at interim storage facilities until the government decides whether to opt for reprocessing or direct disposal reprocess in the future. ● Currently, the spent fuel generated from nuclear power plants is stored at each plant site.	● Future plan of nuclear reactors: 32 reactors to be operational by 2022 and 40 reactors by 2030. ● As for the spent fuel, the storage capacity within a nuclear power plant can be filled at earliest 2016, while the site selection for interim storage facilities is faced with difficulties. Due to this situation, reprocessing approach is also emerging. South Korea is promoting the development of dry-reprocessing technology. It is also reported that the government is planning to demand for domestic reprocessing at the time of revising USA-South Korea Nuclear Power Collaboration Agreement in 2014. (Source: World Nuclear Power Plant 2010)	● Nuclear Power Act ● Radioactive Waste Management Act
Mongolia	（No data）	（No data）	＜Future nuclear power introduction plan＞ ● The government is intending to refine uranium ore, make uranium concentrate (yellow cake) and export it in the future, instead of exporting uranium as raw material. ● The purpose of the “Mongolia Nuclear Initiative (MNI)” is to enhance role of Mongolia in the development process of nuclear power. This is to contribute to the global scale nuclear power development by adapting high-level knowledge and technology through international collaboration and regional collaboration, using the uranium resources of Mongolia as a lever. The essence of the MNI may include contribution of Mongolia as a fuel producer, taking back spent fuel, “from cradle to grave” approach, and hosting a multilateral facility. (Source: The University of Tokyo – UKM International Conference material)		Nuclear Energy Law (2009): It regulates uranium exploration, development and mining and grants the government the status of uranium benefits and ownership as well as uranium resource management.
Viet Nam	（No data）	（No data）	＜Future nuclear power introduction plan＞ ● The government is aiming to begin construction of the first reactor in 2014 and its operation in 2020. ● In 2 sites within Ninh Thuan Province, 2 nuclear reactors per site will be constructed. The output of each site is approximately 2 million kW, and the total is 4 million kW. The former 2 reactors are under the contract with Rosatom, Russia. For the latter 2 reactors, on Oct. 31, 2010, then-Prime Minister of Japan, Naoto Kan, and Prime Minister of Viet Nam, Dung, had a talk and agreed that Japan would receive the order for the contraction of the 2 reactors from Viet Nam.		Nuclear Energy Act
Thailand	（No data）	（No data）	＜Future nuclear power introduction plan＞ The government aims to begin operating the reactors of the total of 2,000 MW by 2021 (1,000 MW x 1 reactor in 2020, 1,000 MW x 1 reactor in 2021)However, as of now (March 2010), no political decision had been made concerning introduction of nuclear power generation, and political instability is on-going. Thus, the prospect of nuclear power plant plan is still unclear.		● The Atomic Energy for Peace Act will be reviewed including Articles concerning Additional Protocol, approval process and security. ● A comprehensive nuclear power

					regulation is being drafted.
Indonesia	(No data)	● (No data)	＜Future nuclear power introduction plan＞ ● The government is aiming to begin operating the first PWR equivalent of 600 to 1,000 MW in 2016 -2017 and begin operating all 4 reactors by 2025. ● The Government Regulation No. 27/2002 prohibits spent fuel reprocessing. It stipulates that the spent fuel shall be tentatively stored during the life of a reactor, and after the tentative storage period, the spent fuel shall be disposed of or handed over to BATAN to be returned to the generating country.		● Nuclear Power Act, Radioactive Waste Management Act, Nuclear Materials Export Safety Act, etc. ● Article 24 of Nuclear Power Act No.10/1997 stipulates that the high-level radioactive waste shall be tentatively stored at least during the life of a reactor.
Malaysia	(No data)	(No data)	＜Future nuclear power introduction plan＞ The first nuclear power plant in Malaysia is planned to be operationalised in 2021.		As for the radioactive waste management, the new regulations are at the final drafting stage.
Philippines	(No data)	(No data)	＜Future nuclear power introduction plan＞ ● Sign of the re-operation of nuclear power ● The government positions nuclear power as a long-term energy option for power generation. KEPCO carried out a feasibility study to explore the possibility of restoration of nuclear power in the Philippines. The study results were submitted in 2009.		Republic Act 2067
Taiwan	● All spent fuels will be stored in the nuclear reactor pool. ●The capacity of the pool as of March 2011 is 20,528 tons. (Meanwhile, the already stored amount of spent fuel is 15,278 tons. The occupancy rates of the spent fuel storage pools of 2 nuclear reactors at the Chinsan nuclear power plant exceed 85%.) ● Currently, the construction projects of dry-storage facilities at Chinsan Nuclear Power Plant and Kousheng Power Plant are on-going.	(No data)	● The spent fuel is directly disposed ● The Taiwan Power Company has been investigating the final disposal method of the spent fuel since 1986.		<Radioactive waste related> ● Radioactive Wastes and Material Administration Act、 ● LLW Final Disposal Siting Act ● Basic Environment Act (December 11, 2002)
Singapore	(No data)	(No data)		The government is intending to collaborate with other ASEAN countries (particularly, Malaysia) that are going to introduce nuclear reactors, instead of introducing the reactors in Singapore.	
Brazil	The spent fuel is stored at the Angra Nuclear Power Plant. The decision of reprocessing or direct disposal is still pending. (Source: WNA)	(No data)		The government is intending to self-supply enriched uranium for their own power generation plants. As for reprocessing, the government's decision is pending.	
Argentine	● Atucha SF Storage Facility: 986 t HM ● Embalse SF Storage Facility: 2,000 t HM	(No data. The pilot plant (5t HM/y) in Ezeiza has been postponed.)		● HWR is used with natural uranium fuel. Although the scale is small, the country possesses conversion, enrichment, fuel production and heavy water production facilities. ● The country possesses an enrichment facility in order to retain enrichment right as well as to provide enrichment services in the future.	
Israel	(No data)	There is a reprocessing facility in Dimona.		Currently, there is no nuclear power program for commercial use. Although the country mentioned its intention to have plant collaboration with Jordan in 2010, there has been no response.	
Pakistan	● The spent fuel is stored in each power plant's pool. A long-term dry-storage is proposed. (Source: WNA)	● 80 km away from Chashuma, there is a reprocessing factory for military purpose.	● There is a proposal to establish the Nuclear Waste Fund (NWF) and construct radioactive waste management centers in Karachi and Chashuma. (Source: WNA) ● It is still an open question whether the spent fuel will be reprocessed or not.	● The current nuclear power program is small, but the country is planning to expand it significantly. ● In response to the IAEA safeguards, the Pakistan Nuclear Power Committee	

		It is also reported that the second reprocessing factory is under construction. ● The government has not yet decided whether they begin reprocessing for commercial use in the future or not.		announced in 2006 that they were preparing for establishing the Pakistan Nuclear Fuel Complex that includes conversion for commercial use, enrichment, and fuel manufacturing plant. These facilities are completely separated from the existing facilities. However, the country cannot obtain necessary uranium due NSG Guidelines, and there has been no program on the said-Complex.	
EU, excluding UK and France, and others	● Germany: Under operation: 16 sites, total 22,681t HM ● Belgium: Under operation: 2 sites, total 3,860t HM ● Bulgaria: Under operation: 1 site, total 600t HM ● Czech: Under operation: 2 sites, total 1,940t HM ● Finland: Under operation: 3 sites, total 1,742t HM ● Hungary: Under operation: 1 site, total 850t HM ● Lithuania: Under operation: 1 site, total 98 Cask-Bund. ● Rumania: Under operation: 1 site, total 36,000 (Bundle/year) ● Slovakia: Under operation: 1 site, total 1,690t HM ● Spain: Under operation: 1 site, total 1,680 Cask-Bund. ● Sweden: Under operation: 1 site, total 8,000t HM ● Switzerland: Under operation: 1 site, total 2,500t HM ● Ukraine: Under operation: 2 sites, 2,518t HM + 9120 Cask-Bund		● Finland: The spent fuel is handled via direct disposal. At the end of 2000, the government decided to construct a geological disposal site in Olkiluoto. From 2004, the construction of the Underground Characterization and Investigation Facility (ONKALO) began for a detailed study in Olkiluoto. According to the plan, the application for the approval of the disposal site construction will be submitted in 2012 and the operation of the disposal site will begin in 2020 (The application states that the maximum disposal amount will be 12,000t). ● Sweden: The spent fuel is handled via direct disposal. The government selected Forsmark in Est Hanmal municipality as the disposal site. SKB is planning to apply for the approval of siting and constructing the disposal facility in March 2011. ● Germany: The high-level radioactive waste and spent fuel are handled via geological disposal in the salt dome. Based on the policy to dispose high-level radioactive waste via geological disposal method in the salt dome in Gorleben, exploration had been carried out since the1970s. The exploration was temporary frozen since 2000. However, the center-right alliance, which was established as a result of the general election in the fall of 2003, presented a policy to remove the freeze of exploration. Currently, preparation is on-going for resuming the exploration on the Gorleben site. ● Switzerland: Since 2001, the government has been intensively using interim storage in Zwilag to store the high-level radioactive. Since 1983, the Grimsel Test Site has been carrying out high-level radioactive waste disposal research. ● Belgium: There is an intensive storage facility in Dessel. The government is aiming to begin construction of a disposal site from around 2035. ● Spain: The government is aiming to begin intensive interim storage in Trillo. The decision of the geological disposal research will be done after 2010.		

Sources/references: IAEA INFCIS Database, World Nuclear Power Plants 2010, Home Pages of Radioactive Waste Management Funding and Research Center (RWMC), World Nuclear Association (WNA), ATOMICA, Atomic Energy Commission, Japan Atomic Industrial Forum, etc.

8. Examination of feasibility of the proposed international framework

8.1 Examination of laws and regulations

The determinants of feasibility and sustainability of MNAs would be; global circumstances surrounding world security, nuclear non-proliferation, peaceful use of nuclear energy, and incentives to participate in a MNA for nuclear weapon states and nuclear supplier states. Equally important to these determinants are the laws and regulations related to the MNA. It is the key for a MNA that an international framework with multiple member states does not conflict with any existing international treaties and agreements. Or even if there is a conflict, it is critical for the establishment and sustainability of a MNA to avoid conflicts or to identify solutions to overcome such conflicts. If the solutions exist, they will become a driving force to facilitate the realization of sustainable MNA.

An example of such international treaty related to "nuclear non-proliferation" is the Nuclear Non-proliferation Treaty (NPT).

Article IV of the NPT stipulates the peaceful use of nuclear energy is an inalienable right of NPT member states. It is generally understood that the right includes SNT. Meanwhile, as for the "supply assurance" which is positioned as Label B in this study, the Nuclear Threat Initiative (NTI), an original proposer of the IAEA fuel bank, was initially proposing to add a condition that the nuclear fuel receiving states (recipient states) should not to pursue the SNT and facilities in return[7]. This proposal was severely criticized especially by the Non-Allied Movement (NAM) states, etc., which are the potential nuclear fuel recipient states, as a violation of the NPT Article IV. Eventually, in the proposal[8] for the establishment of the IAEA nuclear fuel bank, this condition was dropped.

In 8.1.1 of this report, the international treaties, agreements, etc. that are related to MNA's label (Label A to L) of this study are listed, and the conflicts or potential conflicts are examined. Simultaneously, the report discusses the agreements, etc. that will potentially contribute to facilitating nuclear non-proliferation purpose in the MNA, such as regional safeguards. Then, in 8.1.2., the report tries to propose solutions that enable to avoid the conflict or solve the conflict.

8.1.1 International treaties, agreements, etc. related to the MNA Labels

8.1.1.1 International treaties, agreements, etc.

In our study, the elements necessary for the MNA Framework (Label A to L) are listed in order to construct a new MNA Framework including enrichment, SF storage, reprocessing and MOX storage facilities. Then, we listed the existing treaties, agreements, etc. that correspond to each Label. In principle, the requirement to be a member state of the MNA Framework is that they need to be a member of these treaties or agreements or they need to have met the equivalent requirements of the

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7 "Nuclear Threat Initiative Commits $50 Million to Create IAEA Nuclear Fuel Bank", NTI press release, 19 September 2006

8 GOV/2010/67, 26 November 2010, IAEA

treaties and agreements. The international treaties, agreements, etc related to each label are as follows:

Table 8.1 International treaties, agreements, etc. related to each label

Evaluation element (label) and its contents			Related treaties, agreements, etc.
A	Nuclear non-proliferation	General	Treaty on the Non-Proliferation of Nuclear Weapons (NPT)
		Safeguards	Comprehensive Safeguards Agreement (INFCIRC/153)
			Additional Protocol (AP)(INFCIRC/540)
			Regional safeguards agreement (e.g. EURATOM、ABACC)
		Nuclear material protection, nuclear security	The Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225 Rev.5)
			Convention on the Physical Protection of Nuclear Material (INFCIRC/274)
			International Convention for the Suppression of Acts of Nuclear Terrorism
		Export control	Nuclear Suppliers' Group Guideline for Nuclear Transfers (INFCIRC/254 Part 1) Nuclear Suppliers' Group Guideline for Transfers of Nuclear-Related Dual-Use Equipment, Material and Related Technologies (INFCIRC/254 Part 2)
			United Nations Security Council Resolution 1540
		Bilateral nuclear energy cooperation agreement	e.g. Bilateral nuclear cooperation agreement with the US
B	(Nuclear fuel) Supply assurance		e.g. IAEA nuclear fuel bank, LEU storage at International Uranium Enrichment Center (IUEC) in Angarsk, Russia.
C	Selection of host states (Only the case where Asian states are the member states)		Southeast Asian Nuclear Weapon Free Zone Treaty (Bangkok Treaty) [9]
			Treaty on a Nuclear Weapon Free Zone in Central Asia (Treaty of Semei)[10]
			Mongolia Nuclear Weapons-Free Zone
			Korean Peninsula Non-Nuclear Weapon Declaration
D	Access to technologies		-
E	Degree of involvement in multinational initiative		-
F	Economics		-
G	Transportation		IAEA recommendation regarding physical protection of nuclear material (INFCIRC/225 Rev.5)
			Convention on the Physical Protection of Nuclear Material (INFCIRC/274)
			Regulations for the Safe Transport of Radioactive Material (TS-R-1, IAEA Transport Regulations)
			A code of practice on the international transboundary movement of radioactive waste (INFCIRC/386)
H	Safety		Convention on Nuclear Safety
			Convention on Early Notification of Nuclear Accidents

[9] Signed in 1995 and became effective in 1997. The member states are: Laos PDR, Myanmar, Malaysia, Brunei, Viet Nam, Thailand, Cambodia, Singapore, Indonesia, and the Philippines (10 ASEAN states)

[10] Singed in 2006 and became effective in 2009. The member states are: Kazakhstan, Kirgizstan, Tajikistan, Turkmenistan, and Uzbekistan (5 states).

		Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency
		Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
I	Liability	Vienna Convention on Civil Liability for Nuclear Damage
		Paris Convention on Nuclear Third Party Liability
		Convention on Compensation for Nuclear Damage
J	Political and social acceptance	-
K	Geopolitics	-
L	Legal regulations	-

The international treaties and agreements in the above, however, table do not necessarily cover all relevant treaties and agreements. In our study, the MNA member states must basically assure conditions set forth in above international treaties and agreements.

8.1.1.2 Conflicts with international treaties, agreements, etc.

Label A: "Nuclear non-proliferation"

Concerning "nuclear non-proliferation" (Label A), the INFCIRC/640 points out that the nuclear proliferation risks associated with nuclear facilities include:

a) diversion of nuclear materials,

b) breakout scenarios and clandestine parallel program,

c) diffusion of sensitive technologies, and

d) security risks,

and says that a MNA must come up with countermeasures against these risks.[11]

In order to establish a MNA equipped with the countermeasures against the above-mentioned risks, our study first selected four elements, namely, nuclear non-proliferation in general, safeguards, nuclear security, and export control, as elements of MNA Label A. The international treaties and agreements related to Label A include the NPT, safeguards agreements with the IAEA (Comprehensive Safeguards Agreement, Additional Protocol) and regional safeguards agreement, the IAEA recommendation concerning nuclear material (INFCIRC/225 Rev.5) and the Convention on the Physical Protection of Nuclear Material (INFCIRC/274), and the NSG Guidelines for nuclear transfers and transfers of nuclear-related dual-use equipment, material and related technologies.

Our study selected export control, which is not specifically taken up in the INFCIRC/640, as one of the elements for nuclear non-proliferation. Even though NSG Guidelines does not oblige the member states to adhere to and implement the provisions in the Guidelines (so-called gentleman's agreement) they cover not only nuclear materials and related equipment but also more general products as the control subjects to be exported from nuclear supplier states to non-nuclear weapon states. We believe that these facts indicate that the Guidelines are contributing to strengthening nuclear non-proliferation scheme, with a focus on the NPT, and this is why our study included

[11] Paragraph 99, INFCIRC/640

"export control" in the elements for nuclear non-proliferation.

Article III of the NPT stipulates that, as an obligation for peaceful use of nuclear energy by non-nuclear weapon states, all nuclear related activities shall be subject to safeguards based on the Comprehensive Safeguards Agreement with the IAEA. The NPT, however, does not have a specific provision for nuclear security as well as export control. This means that nuclear security and export control play a role to augment and strengthen the nuclear non-proliferation scheme based on the NPT from outside of the NPT framework. Thus, our study included the international treaties and agreements related to the three elements, namely, safeguards, nuclear security and export control, as requirements to be a member state of the MNA Framework based on the premise that if they function effectively, the impact for nuclear non-proliferation will be enhanced.

Furthermore, in addition to the above three elements, our study included "Bilateral agreement on the peaceful use of nuclear energy (nuclear cooperation agreement)" as an element of Label A. For example, in the bilateral nuclear agreements between the US, the US demands various actions for nuclear non-proliferation to its partner state, based on the US Atomic Energy Act (revised Nuclear Nonproliferation Act of 1978: NNPA).

With regards to the IAEA safeguards, as is described above, the NPT Article IV stipulates that all parties to the NPT have the right for peaceful uses of nuclear energy, while the NPT Article III stipulates that non-nuclear weapon states must accept the comprehensive safeguards by the IAEA.

However, views by states remain apart whether the AP, which allows the IAEA to identify undeclared nuclear materials and nuclear energy activities, is included as part of the safeguards for all nuclear energy activities, etc. of the non-nuclear weapon states as is demanded by the NPT.

As of July 2011, countries such as Pakistan, Argentine, Brazil, Syria, Egypt, and Saudi Arabia have not signed on the AP[12]. Brazil, for example, has not signed on the AP because, the AP is literally the "additional" protocol to comprehensive safeguards, according to its interpretation of the AP. Brazil says unless nuclear-weapon states show clear progress towards nuclear abolition, they will not accept any more restriction on the NPT[13]. Countries such as India, Iran, Iraq, Malaysia and Viet Nam have already signed on the AP but they have not entered it into force yet[14].

Thus, the above countries are in general against the idea of making ratification of the AP as a requirement to be a member of the MNA Framework. As is described later, the current NSG Guidelines, in principle, ask for recipient states to ratify the AP. However, the AP is not a requirement for the nuclear fuel recipient states in the IAEA nuclear fuel bank approved by the IAEA Board of Governors.

As for the regional safeguards, the organizations that facilitate safeguards at the unit of a region or multiple states include the European Atomic Energy Community (EURATOM) and the ABACC.

The nuclear facilities in EU need to follow the safeguards regulations under the EURATOM

[12] "STATUS LIST, Conclusion of safeguards agreements, additional protocols and small quantities protocols, as of 21 June 2011", IAEA Home Page

[13] From New National Defense Strategy of Brazil, 2008

[14] "Conclusion of Additional Protocols: Status as of 27 July 2011", IAEA Home Page

Treaty and their corresponding regulations[15], as well as the IAEA Safeguards based on an agreement between the EURATOM and the IAEA. The purpose of the EURATOM safeguards is to check and verify if the declared nuclear materials are not used for anything other than the declared purposes. The EURAOM safeguards differ from the IAEA safeguards in the sense that the former targets all nuclear facilities in EU, including civilian facilities of nuclear weapon states, UK and France, for their inspection. Furthermore, unlike the IAEA safeguards, the EURATOM safeguards stipulate sanction in case of violation of safeguards related provisions in the Treaty.

Nuclear facilities in Brazil and Argentine are also under safeguards by the ABACC and the IAEA, based on 4 parties' agreement between Brazil, Argentine, the ABACC and the IAEA. Although both Brazil and Argentine have not signed on the Comprehensive Nuclear Treaty based on the NPT (INFCIRC/153 type), it is considered that they meet the requirements of NPT Article III by signing the 4 parties' agreement. It should be noted that in this agreement, the nuclear materials to be used for nuclear-propelled submarine, etc are exempted from the safeguards application.

The safeguards measures specific to the region or multiple states are not to conflict against the NPT, etc. but are to contribute to confidence building and strengthening nuclear non-proliferation in the region. For example, when considering a MNA in the North East Asia where nuclear proliferation is unstable, the measures such as giving safeguards function within a MNA or establishment of safeguards organization specific to Asian region may be effective.

As for the relation between NSG Guidelines and Article IV of the NPT, the NSG Guidelines before the revision in July 2011 (INFCIRC/254/Rev.10/Part 1, 26 July 2011) stipulated only that the supplier must "exercise restraint" in exports of sensitive nuclear facilities, technologies, materials and equipment from nuclear supplier states to non-nuclear weapon states.

In February 2004, US President Bush (at that time) appealed followings in his speech at Defense University;

1) there is a need to block loopholes of the NPT related to peaceful uses of nuclear energy under Article IV of the NPT,
2) the enrichment and reprocessing technologies shall not be transferred to the states that do not posse such technologies, and
3) the NSG Guidelines shall state that nuclear materials and equipment will only be transferred on the condition that the state sign and respect for the AP because the enrichment and reprocessing are not necessary required for the states that use nuclear energy for peaceful purposes.

Based on the Bush's proposal, since 2004, the NSG had been discussing the tightening of regulations for transfer of enrichment and reprocessing items. However, many states were opposed to the proposal on the ground that it may fixate the existing states with SNT. As an alternative proposal, these opposing states instated so-called "Criteria-based Approach", in which technologies can be transferred to only the states that meet certain pre-defined criteria. In the NPT review

15 Commission Regulation (EURATOM) No 302/2005 of 8 February 2005 on the application of EURATOM Safeguards

conference in 2005, Argentine, Brazil, Egypt, France, Iran and NAM states voiced opposition to Bush's proposal on the ground that it would be against the right for peaceful uses of nuclear energy[16].

In July 2011, paragraphs 6 and 7 of the NSG Guidelines were amended, which allowed the nuclear supplier states to transfer sensitive items to the non-nuclear weapon states if they satisfy certain criteria as stipulated in the Guidelines. This was a change of direction for nuclear supplier states from "exercising restraint" in exports of sensitive facilities, technologies, materials and equipment to "approval of transfer of SNT, etc." as long as the recipient states satisfy the criteria. It can be said that this change made the NSG Guidelines to follow the intention of the rights for peaceful uses of nuclear energy among the NPT member states. In this sense, our study applies the recipient states' requirement in the amended NSG Guidelines to the requirements to participate in the MNA Framework.

The nuclear non-proliferation requirements (criteria) for the recipient states when they receive enrichment and reprocessing items are as follows (Paragraph 6 (a))[17].

The recipient states must

- be a Party to the Treaty on the Non-Proliferation of Nuclear Weapons and is in full compliance with its obligations under the Treaty;
- have not been identified in a report by the IAEA Secretariat which is under consideration by the IAEA Board of Governors, as being in breach of its obligations to comply with its safeguards agreement, nor continues to be the subject of Board of Governors decisions calling upon it to take additional steps to comply with its safeguards obligations or to build confidence in the peaceful nature of its nuclear program, nor has been reported by the IAEA Secretariat as a State where the IAEA is currently unable to implement its safeguards agreement.
- adhere to the NSG Guidelines and have reported to the Security Council of the United Nations that it is implementing effective export controls as identified by Security Council Resolution 1540;
- have concluded an inter-governmental agreement with the supplying states including assurances regarding non-explosive use, effective safeguards in perpetuity, and retransfer;
- have made a commitment to the supplying states to apply mutually agreed standards of physical protection based on current international guidelines; and
- have committed to the IAEA safety standards and adheres to accepted international safety conventions.

In relation to the above-mentioned AP of the IAEA safeguards, the paragraph 6 (C) of the NSG

[16] "The Nuclear Fuel Cycle", Nuclear Files, org Home Page

[17] "Concerning the agreement on strengthening regulation for transferring nuclear materials and technology among NSG", Japan Atomic Energy Agency, Nuclear non-proliferation news, No.0163 2011-08/04

Guidelines says that one of the criteria for the recipient states is that “the recipient has brought into force a Comprehensive Safeguards Agreement, and an Additional Protocol, or pending this, is implementing appropriate safeguards agreement in cooperation with the IAEA (including a regional accounting and control arrangement for nuclear materials) as approved by the IAEA Board of Governors.” Basically, it requires the recipient states to bring into force the AP. Also, although the “appropriate safeguards agreement” is not defined, based on the fact that “regional accounting and control arrangement for nuclear materials” is cited as an example, this paragraph seems to avoid excluding Brazil and Argentine, which have not signed on the AP but have concluded a Safeguards treaty among four parties including the IAEA and the ABACC, from qualification as recipient states[18]. Thus, it approves the export of sensitive technology such as enrichment and reprocessing to Brazil and Argentine, which have not signed on the AP, as long as they satisfy other criteria.

The paragraph 7 of the NSG Guidelines states regulations (a) to (f) as special arrangements for enrichment facility, equipment and technology, and it says that the application of the special arrangements must be consistent with NPT Article IV. It also says that any application by the supplying state of the special agreements may not abrogate the rights of the states meeting the criteria in the paragraph 6. Furthermore, in the paragraph 7 (b), for a transfer of an enrichment facility based on an existing enrichment technology, supplying state should “avoid, as far as practicable, the transfer of enabling design and manufacturing technology associated with such items” and “seek from recipients an agreement to accept enrichment facility, equipment, or technologies under conditions that do not permit or enable replication of the facilities.” Thus, it promotes the transfer with a so-called black-box method.

Furthermore, although this is not the one that was added after the amendment, the same paragraph 6 (e) states that “for a transfer of enrichment or reprocessing facilities, equipment or technology, supplying states should encourage recipient states to accept, as an alternative to national plants, supplying state’s involvement and/or other appropriate multinational participation in the facility to be transferred. The supplying states should also promote international (including the IAEA) activities concerned with multinational regional fuel cycle centers”. It is worth paying attention that the Guideline is encouraging a MNA.

Perhaps the largest challenge for the establishment of sustainable and feasibility MNA is to come up with ways to avoid or overcome conflicts with individual regulation in the bilateral agreements that each member state individually conclude to be included the new MNA regulations .

For example, Japan, a country with few natural resources, purchases natural uranium from Canada, UK, Australia, etc and purchases enriched uranium from USEC Inc., AREVA Inc., URENCO Limited, and TENEX[19]. Furthermore, the Rokkasho Reprocessing Plant in Japan was

[18] “Agreement to strengthen regulations concerning export of sensitive nuclear material, equipment and technology among NSG”, Japan Atomic Energy Agency, Nuclear Non-proliferation News, No.0163 2011-08/04

[19] Current situation concerning nuclear fuel cycle. New general framework development meeting (4th),

built with a technology from SGN (SGN, COGEMA, and currently AREVA NC) in France. The purchase of natural or enriched uranium or introduction of technologies are based on the contracts between the business operators of respective states in accordance with the nuclear cooperation agreement which are concluded between supplier states such as the US, Canada, Australia, France and EURATOM and the Japan.

In the bilateral nuclear cooperation agreements, the supplier states attach the following requirements to the materials to be exported (transported) to Japan to ensure non-proliferation of nuclear materials. It should be noted, however, that which items should be required to what extent would be varied, depending on the individual nuclear cooperation agreement.

1) Ban of using the respective nuclear materials, etc. for nuclear explosive devices and military purposes
2) Application of the IAEA Comprehensive Safeguards
3) Prior consent/approval concerning transfer of nuclear materials, etc. to outside its jurisdiction
4) Prior consent/approval concerning change and storage of the form/contents of plutonium, uranium 233, and enriched uranium
5) Prior consent/approval concerning enrichment over 20%
6) Measures in case of violation against safeguards agreement or in case of nuclear explosion
7) Transfer of SNT
8) Implementation of nuclear materials protection measures

Japan currently has nuclear energy cooperation agreements with the US, UK, Canada, France, Australia, China and EURATOM, among the main nuclear supplier states. Therefore, Japan has a possibility to receive controls for the above 1) to 8) x 7 states for the nuclear materials imported from these states (However, in reality, not all agreements demand for 1) to 8)).

A MNA is composed of multiple member states. Therefore, if we assume that each member state is resource-limited like Japan and has similar bilateral nuclear agreement with supplying states, there will be number of regulations that is the multiplies of the number of MNA member states, number of bilateral nuclear agreements for each member state, and the above elements 1) to 8). And a MNA needs to have measures to avoid or overcome the conflicts with those regulations.

Furthermore, as for the transfer of nuclear materials and equipment and derived nuclear materials to a third state, many states have policies that require to have an agreement with the exporting state for the transfer of such items to a third state as well as a nuclear energy cooperation agreement with the third state concerned. For example, suppose if state B enriches natural uranium supplied by stated A, and state C produces fuel, and the fuel is used at a nuclear reactor in state D, and the waste is reprocessed in state E. In this case, state E must have bilateral nuclear agreement with states A to

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Information material No. 2-1, Feb. 21, 2011, Office for Atomic Energy Policy, Cabinet Office

D, individually for the transfer of spent fuel from state D to state E. Furthermore, it also requires prior agreements from states A to C for such transfer.

The situation in each state is also different. Japan has enrichment and reprocessing facilities, while its neighboring state, South Korea, cannot have such facilities because of the 1991 "Joint Declaration of the Denuclearization of the Korean Peninsula" which prohibits North Korea and South Korea to possess enrichment and reprocessing facilities. Furthermore, most of the SF in South Korea is originated from the US, and the current US-South Korea nuclear cooperation agreement requires joint determination by both states for the application of effective safeguards to reprocessing the spent fuel. However, the US has not agreed the reprocessing of SF from South Korea. In case of Taiwan, taking into consideration a sensitive political relationship with China, it is only the US that has nuclear energy cooperation agreement with Taiwan, including application of safeguards[20]. Thus, without some type of interference from the US, the IAEA safeguards will not be applied and the safeguards concerning transfer of nuclear materials are not secured. Therefore, in order for a nuclear supplier state to secure application of the IAEA safeguards for nuclear material transfer, etc. in Taiwan, the involvement of the US is inevitable.

Section 123a., paragraph (1) through (9) lists nine criteria that an agreement with a non-nuclear weapon state (NNWS) must meet unless the President determines an exception is necessary. These include guarantees that:

1) safeguards on transferred nuclear material and equipment continue in perpetuity;
2) full-scope IAEA safeguards are applied in NNWS;
3) nothing transferred is used for any nuclear explosive device or for any other military purpose;
4) the United States has the right to demand the return of transferred nuclear materials and equipment, as well as any special nuclear material produced through their use, if the cooperating state detonates a nuclear explosive device or terminates or abrogates an IAEA safeguards agreement;
5) there is no retransfer of material or classified data without U.S. consent;
6) physical security on nuclear material is maintained;
7) there is no enrichment or reprocessing by the recipients state of transferred nuclear material or nuclear material produced with materials or facilities transferred pursuant to the agreement without prior approval;
8) storage for transferred plutonium and highly enriched uranium is approved in advance by the United States; and
9) any material or facility produced or constructed through use of special nuclear technology transferred under the cooperation agreement is subject to all of the above requirements[21]

[20] Agreement for cooperation between the Government of the United States of America and the Government of the Republic of China concerning Civil Uses of Atomic Energy, 15 March 1974

[21] "Nuclear Cooperation with Other Countries: A Primer", Paul Kerr, Mary Beth Nikitin, August 11, 2011, Congressional Research Service

The above points 6), 7) and 8) require the prior approval / consent by the US. Such approval / consent is often done based on the global trend for nuclear non-proliferation as well as safeguards issues surrounding individual recipient state and its political situation with its neighboring state (e.g. Korea against DPRK, Taiwan against China, the UAE, which is adjacent to Israel). In case of the US, in accordance with the regulations in the Atomic Energy Act, the Secretary of Energy, with an approval from the Secretary of State, needs to discuss with the Defense Department and the Nuclear Regulatory Commission (NRC) and determine whether the action is in compliance with the national security and safeguards. Furthermore, if the action includes transfer of the nuclear items to the state outside of jurisdiction for the purpose of reprocessing, the matter shall be discussed by the Congress. Thus, the action can be easily influenced by the political will and trend of the Administration and Congress. Furthermore, it is anticipated that if an emergency case such as the 9.11 terrorist attacks in the US occurs, the politics concerning safeguards, national security, nuclear non-proliferation, security, etc. will be fundamentally reviewed, and stronger demand on nuclear nonproliferation will be imposed on the peaceful uses of nuclear energy.

However, with a MNA framework, it is necessary to avoid an unstable situation where it is unforeseeable that the prior approval from the US can be obtained or not. Without avoiding such a situation, a sustainable and feasible MNA cannot be established.

As for Asia, the advanced states such as Japan, South Korea, and Taiwan have nuclear cooperation agreements with the US, and they received nuclear material and equipment from the US based on the agreements in the beginning of the nuclear energy usage. In this context, as for the spent fuel, all of them in Taiwan and most of them in South Korea are under jurisdiction of the US[22]. Therefore, the prior approval from the US is needed for reprocessing them or transferring them to the outside of jurisdiction. In case of Japan, 73.3% of plutonium and 73% of enriched uranium are originated from the US[23]. Thus, even Japan needs prior consent form the US, although it is provided 30-year advance consent for the transfer of spent fuel from Japan to Europe for reprocessing.

Rights for peaceful uses of nuclear energy under NPT Article IV for Label A "Nuclear Non-proliferation" and Label B "Nuclear fuel supply assurance"

As described earlier, since the proposal by Former Director General of the IAEA, ElBaradei was published on the Economist[24] in 2003, there were approximately 12 proposals[25] concerning nuclear fuel supply assurance. The purposes of these proposals are to facilitate nuclear non-proliferation,

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[22] "Consideration for International Storage of SF and High Level Wastes, Consideration for US Approval to Ship SF with US-Origin Uranium to Russia for Storage and Disposal", Alex R. Burkart, Radwaste Solutions, 2002.9-10

[23] "US's New Approach towards Bilateral Nuclear Agreement: The Significance and Limitation of US-India Agreement and UA-UAE Agreement", T. Yamamura. Research on Disarmament, Mar. 2010, Vol.1, Japan Association of Disarmament Studies.

[24] "Towards a Safer World", 16 October 2003, the Economist

[25] "Fuel for Thoughts", Tariq Rauf and Zoryand Vovchok, IAEA Bulletin 49-2, March 2008 p59-63

especially, prevention of proliferation of sensitive technologies and facilities. It is also intending to establish a system, as a back-up of existing nuclear fuel market, where substitute nuclear fuel supply can be received in case of supply disruption due to the political reasons other than technical and commercial reasons. If such a system is established, nuclear energy can be used without concerns about disruption of nuclear fuel supply or without owning enrichment facilities, etc. As a result, it contributes to nuclear non-proliferation. The 12 proposals are as follows:

1) Reserve of LEU which is down-blended from 17.4 HEU by the US (later, its name was changed to American Assured Fuel Supply (AFS)).
2) Proposal to create a system of international centres that provide uranium enrichment services and enriched uranium by Russia.
3) Global Nuclear Energy Partnership (GNEP) program by the US
4) Proposal to ensure security of supply in the international nuclear fuel cycle at the World Nuclear Association (WNA)
5) Concept for a multinational mechanism for reliable access to nuclear fuel by 6 nuclear fuel supplying states including the US, UK, France, Netherland, Germany and Russia.
6) IAEA Standby Arrangements System for the Assurance of Nuclear Fuel Supply (proposed by Japan)
7) IAEA nuclear fuel bank based on the Nuclear Threat Initiative (NTI) proposal[26]
8) Uranium enrichment bond (Later its name was changed to Nuclear Fuel Assurance (NFA).)[27]
9) International Uranium Enrichment Center (IUEC) in Angarsk, Russia, and reserve of LEU at the Center[28]
10) Multilateral enriched sanctuary project (proposed by Germany)
11) Multilateralization of the Nuclear Fuel Cycle (proposed by Austria)
12) Nuclear Fuel Cycle (EU non-paper)

Among the above proposals, the proposals 3), 4), 5), and 7) were originally seeking the abandonment of enrichment and reprocessing to the nuclear fuel recipient states. However, such a request was criticized mainly by NAM states as a conflict against the right for peaceful uses of nuclear energy under NPT Article IV. Thus, later, the proposals removed the request for the abandonment (GNEP was terminated after Obama Administration took office). The proposals 8) and 9) do not ask for the abandonment enrichment and reprocessing.

As for the proposal 1), initially, it was asking the recipient states to abandon enrichment and reprocessing. According to the press release[29] by the US DOE, the down-blending of HEU to LEU

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26 GOV/2010/67, 26 November 2010, IAEA

27 INFCIRC/707, 4 June 2007, GOV/INF/2009/7, 31 August 2009, and INFCIRC/818, 27 May 2011, IAEA

28 INFCIRC/708, 8 June 2007, INFCIRC/748, 1 April 2009, INFCIRC/776, 23 November 2009, and GOV/2009/81, 27 November 2009, IAEA

29 "DOE, NNSA announce availability of reserve stockpile of nuclear fuel from down-blending of surplus weapons-usable uranium", August 18, 2011, DOE/NNSA Press Release

is planned to be completed by 2012 and 230 tones of LEU will be stockpiled for supply assurance. However, the press release did not clearly mention the abandonment.

As was mentioned earlier, the "Possible Framework" submitted by the IAEA Secretariat to its Board of Governors in June 2007 indicated the possibility that the ratification of the AP by recipient states as a requirement for receiving nuclear fuel[30]. However, the proposal approved by the IAEA Board of Governors does not include ratification of AP as a requirement for the recipient states.

Label C "Selection of host states"

Deciding the states where MNA facilities are built is one of the important issues for the establishment of a sustainable and feasible MNA.

The selection criteria for the host states for the MNA facilities include domestic political stability, good relationships with neighboring states, easiness of securing transport routs for nuclear materials, etc., nuclear energy related infrastructure status both in terms of soft and hard aspects, and past and current nuclear non-proliferation performances. The international treaties and agreements that should be considered as criteria from the regulatory perspective are Nuclear Free Zone Treaty, Non-nuclear Weapon (non-nuclear) Declaration, and Denuclearization Declaration which was declared based on securing the regional safeguards perspective.

The characteristics of Nuclear-Weapon-Free Zone Treaty are the ban of production, acquisition, possession, installment and management of nuclear weapons in a state of a specified area and to ratify protocol to pledge that the nuclear-weapon states will not attack the non-nuclear weapon states in the area with nuclear weapons. In terms of the relations with the nuclear fuel cycle facilities under a MNA, it should be noted that the Nuclear-Weapon-Free Zone Treaty, in principle, prohibits the import of radioactive wastes (disposal, processing) from other states, unless the state of concern is agreed. Thus, these states, in principle, cannot be the host states of the radioactive wastes disposal facilities under a MNA. The Nuclear-Weapon-Free Zone Treaty, however, does not stipulate any provision for the interim storage of radioactive wastes.

Up to September 2012, there are 5 Nuclear-Weapon-Free Zone Treaties ratified in the world as follows;

- Treaty for the Prohibition of Nuclear Weapons in Latin America and Caribbean (so-called Treaty of Tlatelalco, singed in 1967, effective in 1968),
- South Pacific Nuclear Free Zone Treaty (so-called Treaty of Rarotonga, signed in 1985, effective in 1986),
- Southeast Asian Nuclear-Weapon-Free Zone Treaty (so-called Treaty of Bangkok, signed in 1995, effective in 1997),
- African Nuclear Weapons Free Zone Treaty (so-called Treaty of Pelindaba, signed in 1996, effective in 2009), and

[30] Paragraph 40, "Possible New Framework for the Utilization of Nuclear Energy: Options for Assurance of Supply of Nuclear Fuel", Report by the Director General, GOV/INF/2007/11, 13 June 2007, IAEA

・ Treaty on A Nuclear Weapon Free Zone in Central Asia (so-called Treaty of Semei, signed in 2006, effective in 2009) [31].

Among them, the treaties related to Asia are the Treaty of Bangkok and Treaty of Semei.

The member states are of the Treaty of Bangkok are 10 states in South East Asia, including Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Singapore, Thailand, Viet Nam, and the Philippines. Concerning the disposal of radioactive wastes and other nuclear materials, the Treaty's Article 3, paragraph 3(b) says that each party to Treaty is not allowed to "dispose radioactive material or wastes on land in the territory of or under the jurisdiction of other States except as stipulated in Article 4, paragraph 2(e)". Meanwhile, as an exception, the Article 4, paragraph 2(e) says that each party to Treaty shall undertake "to dispose radioactive wastes and other radioactive material in accordance with the IAEA standards and procedures on land within its territory or on land within the territory of another state which has consented to such disposal". Thus, it is regulated that the disposal of radioactive wastes within the region is not violating the peaceful uses of nuclear energy and such action is not denied.

5 states in Central Asia, including Kazakhstan, Kirgizstan, Tajikistan, Turkmenistan, and Uzbekistan are the members of the Treaty of Semei. The Article 3, paragraph 2 of the Treaty prohibits the disposal of radioactive wastes from the other states on the land of member states. Therefore, for example, Kazakhstan is not allowed to dispose other states' radioactive wastes within Kazakhstan.

President Ochirbat of Mongolia declared a "Non-nuclear weapon state of Mongolia" in 1992 at the UN General Assembly, and in December 1998, the "Nuclear-weapon-free-zone" was approved at the UN General Assembly. The declaration prohibits development, production, acquisition, installation and transition of nuclear weapons within Mongolia, and it prohibits disposal or processing of weapon-grade radioactive substance or nuclear wastes within Mongolia[32]. The "Law of Mongolia on its nuclear-weapon-free status[33]" which was adapted in March 2000 stipulates a similar content.

In May, 2011, Mainichi newspaper reported an article about Japanese "Ministry of Economy, Trade, and Industry confidentially promoted a plan to establish the world's first international storage

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[31] In addition, in the following treaties, the nuclear-weapon-free zones are regulated: Antarctic Treaty (Signed in 1959, effective in 1961), Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty, signed in 1966, effective in 1967), Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Seabed and Ocean Floor and in the Subsoil Thereof (Seabed Treaty, signed in 1971, effective in 1972).

[32] "NUCLEAR-WEAPON-FREE STATUS OF MONGOLIA", Inventory of International Nonproliferation Organizations and Regimes, Center for Nonproliferation Studies, Last Updated:1/20/2011, NTI Home Page, http://www.nti.org/e_research/official_docs/inventory/pdfs/mongol.pdf

[33] Law of Mongolia on its nuclear-weapon-free status, adopted on 3 February 2000, http://www.opanal.org/NWFZ/Mongolia/Mlaw_en.html

and processing facility for SP fuels, etc., in Mongolia since last year (Note: 2010) autumn[34]". However, the governments of Mongolia, US and Japan denied the article shown above.

In January 1992, North Korea and South Korea signed on the "Joint Declaration of the Denuclearization of the Korean Peninsula"[35]. The Declaration states that both states will only use the nuclear energy for peaceful purposes, prohibits testing, manufacturing, receiving, possessing, storage, installing and using nuclear weapons. Furthermore, it states that both states will not possess reprocessing and uranium enrichment facilities. However, due to suspicion of nuclear development in North Korea which later, the Declaration is practically no longer enforced. The Declaration does not mention SF and radioactive wastes.

8.1.2 Proposal for solution

As was described earlier, a big challenge for the establishment of a MNA is how to avoid or overcome conflicts with individual regulations in the bilateral agreements that each MNA member state has with other states. In order to materialize a highly-equal MNA, there is a need to have exemption from bilateral agreements in terms of prior agreement with supplying states, measures in case of violation of agreements, and handling of SNT and information concerning exporting nuclear materials within and outside of their jurisdiction, enrichment and reprocessing, changes in the form and contents of plutonium, and storage. In order to achieve it, a MNA needs to present equivalently high and effective nuclear non-proliferation measures.

A potential solution is to adapt existing regional safeguards including Regional System of Accounting for and Control of nuclear material (RSAC) such as EURATOM and ABACC in the MNA framework, in addition to the existing IAEA safeguards and Additional Protocol, as a measure to strengthen nuclear non-proliferation. With this measure, nuclear non-proliferation can be stronger than the nuclear non-proliferation just targeting one state. Furthermore, if the control of facilities is under a MNA, the concept will not target just one state anymore. Thus, we believe that it is possible to demand for exemption of bilateral agreements, etc.

Another potential solution is to add the NSG Guidelines' SNT exporting requirements to the MNA's requirements for the partner states. The NSG Guidelines were revised in July 2011. According to the revised Guidelines, only the recipient states that meet the criteria stipulated in the Guidelines are allowed to receive enriched and reprocessed items. This requirement is much tighter than the transferring of nuclear reactor or general nuclear materials and technology. Therefore, if we set the requirements for the MNA partner states to be equivalent to the NSG Guideline's criteria, it would be easier to obtain understanding from the supply states.

It is also a solution to include uranium producing and uranium enrichment states, which do not have

[34] "Nuclear processing facility: Construction plan in Mongolia. Japan and the US had been negotiating since last autumn, aiming at the expansion of nuclear energy business." Mainichi newspaper, on May 9, 2011. Morning edition for Tokyo region.

[35] Joint Declaration on the Denuclearization of the Korean Peninsula

tight requirements for nuclear non-proliferation in the MNA framework. If enriched uranium supply from these supplier states occupy a large portion of the uranium supply within MNA, it will not be easy for the states which had been demanding stronger non-proliferation via bilateral agreements to have the same level of demands to the MNA member states. This does not mean, however, that the MNA will loosen nuclear non-proliferation. Incorporating Japan, which has nuclear fuel cycle facilities, uranium producing states, and states that have enrichment or conversion facilities in the MNA framework will create a possibility that they can be handled within the MNA framework in the future.

8.2 Examination of economy

In this chapter, the result of economy study for internationalization of nuclear fuel cycle on which scale effect is focused, although further studies on economy for Nuclear Fuel Cycle, i.e., storage of SF & transportation of nuclear materials including fresh fuel, SF, and waste should be incorporated in to the studies. (It will be followed in FY2012).

8.2.1. Introduction

Many study groups have been discussing the internationalization of nuclear fuel cycle management[36,37,38]. Their studies demonstrate that the multinational approach has an advantage of nuclear non-proliferation as well as an advantage of cost effectiveness. Particularly from the economic perspective, the previous studies point out that the multinational approach has larger economies of scale as the multinationally administered facilities have larger production scale than that of a single state. However, although the qualitative analysis for the advantages of economies of scale has been carried out in the previous studies, there has been no study that quantitatively analyzes the advantage.

There have been many studies on the cost evaluation of nuclear fuel cycle[39,40,41,42], and one of the studies[49] was about the economic evaluation of the multinational approach. LaMontagne[49] compared the costs of multinational and single state approach and demonstrated that the cost for a uranium enrichment factory for multinational case is 10% of the cost for single case. If LaMontagne model is used to evaluate our study's scenario, it is possible to compare Type A and Type B or Type C. However, it is difficult to evaluate expansion of market scale or economics of scale such as Type B and Type C with the model.

Therefore, in this section, we extend the LaMontagne model by modeling the market principle

[36] V. Meckoni, R.J. Catlin, L.L. Bennett, "Regional nuclear fuel cycle centres: IAEA study project," Energy Policy, 5, 267-281 (1977).

[37] IAEA (International Atomic Energy Agency), "Multilateral approaches to the nuclear fuel cycle," Expert Group Report to the Director General of the IAEA, Vienna (2005).

[38] T. Adachi, M. Akiba, M. Tazaki, J.-S. Choi, S. Tanaka, A. Omoto, Y. Kuno, "Multilateral Simulation on Various Models for Internationalization on Nuclear Fuel Cycle," Proceeding of GLOBAL 2011, forthcoming

[39] OECD/NEA (Nuclear Energy Agency), "The economics of the nuclear fuel cycle." OECD/NEA, Paris (1994).

[40] M. Bunn, S. Fetter, J.P. Holdren, B. van der Zwaan, "The economics of reprocessing vs. direct disposal of spent nuclear fuel," Project on Managing the Atom, Belfer Center for Science and International Affairs. John F. Kennedy School of Government, Harvard University, Cambridge, MA (2003)

[41] E.A. Schneider, M.R. Deinert, K.B. Cady, "Cost analysis of the US spent nuclear fuel reprocessing facility," Energy Economics, 31, 627-634 (2009)

[42] S.A. LaMontagne, "Multinational approaches to limiting the spread of sensitive nuclear fuel cycle capabilities," Belfer Center Programs or Projects: International Security; Preventive Defense Project, Belfer Center for Science and International Affairs. John F. Kennedy School of Government, Cambridge, MA (2005)

and the effect of economies of scale. In particular, the analysis adapts overnight cost which does not take into account discount rate that reflects temporal value and risks. By using this evaluation model, we analyze the production capacity against cost and effect of production scale. Furthermore, we analyze the impact of the change of uranium price on the cost.

8.2.2. Evaluation model

In this section, a model to evaluate economics of a multinational approach is derived. Particularly, in this evaluation, we focus on frontend and carry out cost analysis using overnight costs for uranium feed, chemical conversion, enrichment, and fabrication. Furthermore, in order to evaluate each scenario proposed in this report, we incorporate the market principle and effect of economies of scale in the evaluation model.

Overnight cost

First, evaluation model concerning overnight cost is derived. The ratio of uranium feed to enriched product, R is:

$$R = \frac{x_p - x_t}{x_f - x_t}, \tag{1}$$

Here, x_p, x_f, and x_t are concentration of uranium in enriched product, concentration of the feed, and concentration of enriched tails, respectively. Using the ratio of uranium feed to enriched uranium, R, the quantity of uranium feed is:

$$Q_f = R(1 + f_f), \tag{2}$$

Here, f_f is fractional loss during fuel fabrication. The uranium oxide requirement is:

$$R_{UO} = Q_f(1 + f_c), \tag{3}$$

Here, f_c is fractional loss during chemical conversion. Similarly, the enrichment requirement is:

$$R_{SWU} = V(x_p) - V(x_t) - Q_f(V(x_f) - V(x_t)), \tag{4}$$

Here, $V(x) = (2x - 1)\ln\frac{x}{1-x}$ is separate potential. From formulas (3) and (4), the costs for uranium feed, chemical conversion, and enrichment are:

$$C_{UF} = R_{UO}P_{UO}, \tag{5}$$

$$C_c = R_{UO}c_c, \tag{6}$$

$$C_E = R_{SWU}P_{SWU} \,, \tag{7}$$

Here, P_{UO}, c_C, P_{SWU} are price of uranium oxide, unit cost of conversion, and price of separate work units, respectively. In addition to these costs, fuel fabrication cost, C_F, and spent fuel removal charge cost, C_{RC}, are included.

On the other hand, the total quantity of fuel is given in the following formula (8).

$$Q_F = \frac{Q_e \alpha T}{\eta B} \,, \tag{8}$$

Here, Q_e is electricity power output, α is capacity factor of the power plant, T is lifetime of the plant, η is thermal efficiency of the reactor, and B is fuel burnup.

Based on the above formulas, the formula for the total overnight costs is given as follows:

$$C_{TO} = Q_F(C_{UF} + C_C + C_E + C_F + C_{RC}) \,. \tag{9}$$

Market principle

The Type B scenario in this report is "a framework in which fuel cycle service is carried out without transferring the ownership of existing or new facilities to MNA". In other words, in this scenario, multiple facilities provide services within the same framework, and the market principle will take effect. Thus, it is expected that as production level increases (here, it is hypothesized as equivalent as production amount), the cost will decrease. Therefore, in this section, we introduce the following inverse demand function[43].

$$C_{TO} = cQ_F^{-\frac{1}{\xi}} \,, \tag{10}$$

Here, c is constant and ξ is elasticity of demand. In this section, the formula (10) is considered as the effect of market principle in Type B.

Economies of scale

As is mentioned in the previous studies, the multinational approach has larger cost effectiveness by economies of scale, as compared with single state approach. Thus, in this section, for the scenario

43 F.L. Aguerrevere, "Real options, product market competition, and asset returns," *Journal of Finance*, 64, 957-983 (2009).

of Type C, we assume the existence of economies of scale. Based on the reference[48], the relationship between the cost and production amount in relation to economies of scale is given as follows:

$$\frac{C_R}{C_0} = \left(\frac{Q_R}{Q_0}\right)^{\gamma}, \tag{11}$$

Here, γ is a scaling factor.

8.2.3. Value analysis

In this section, using the evaluation model derived in the previous section, we evaluate the scenarios of each Type. First, explanation on the parameters used for analysis is given. Then, value analysis is carried out based on which each scenario is discussed.

Parameters

Table 8.2 Basic Case Parameters

Concentration of uranium in enriched product	x_p	-	0.0450
Concentration of the feed	x_f	-	0.0072
Concentration of enriched tails	x_t	-	0.0030
Fractional loss during fuel fabrication	f_f	-	0.010
Fractional loss during chemical conversion	f_c	-	0.005
Price of uranium oxide	P_{UO}	$/kgU	130.0
Unit cost of conversion	c_c	$/kgU	10.0
Price of separate work units	P_{SWU}	$/kgU	145.0
Total quantity of electricity	Q_E	MWe	1,000
Facility utilization rate	α	-	0.9
Lifetime of a plant	T	d	365×40
Thermal efficiency	η	-	0.33
Burnup	B	MWd/kgHM	50.0
Elasticity of demand	ξ	-	1.6
Scaling factor	γ	-	0.95

In this section, the base case values of parameters in the reference[49] are used (Table 8.2). In order to reflect the current situation, we use the data in the reference[44] for the uranium price and SWU

[44] Ux Consulting Company, UxC Nuclear Fuel Price Indicators, http://www.uxc.com/index.aspx

price. The prices are US$130.0 /kgU and US$145/kgU, respectively. Based on these parameter values, the SWU per 1GW per year is computed to be 124,597SWU/GW/yr. This value is very close to 120,000SWU/GW/yr, which is mentioned in the reference[45].

Furthermore, the total overnight cost for the base case is US$ 2,260 million, which is US$ 2,839/ kgHM. Thus, in our analysis, we use US$ 2,839/ kgHM as a benchmark cost. The constant c in the formula (10) is computed based on this benchmark cost.

For the elasticity of demand ξ, we use 1.6 as is used in the reference[50]. Furthermore, for the scaling factor concerning economies of scale, we use typical values of 0.6 to 1.

In the reference[48], recent preceding studies demonstrate that it is more rational to use 0.9 as scaling factor for a large facility. Therefore, in this section, in order to make an analysis with a conservative value, we adapt 0.95 as scaling factor.

Results and discussion

Because the total capital cost of a uranium enrichment factor is US$ 1 to 2 billion[52] and it is considerably capital intensive, the cost effectiveness of Type A, which is proposed in this report, is relatively small. Therefore, the following evaluations are limited to Types B and C.

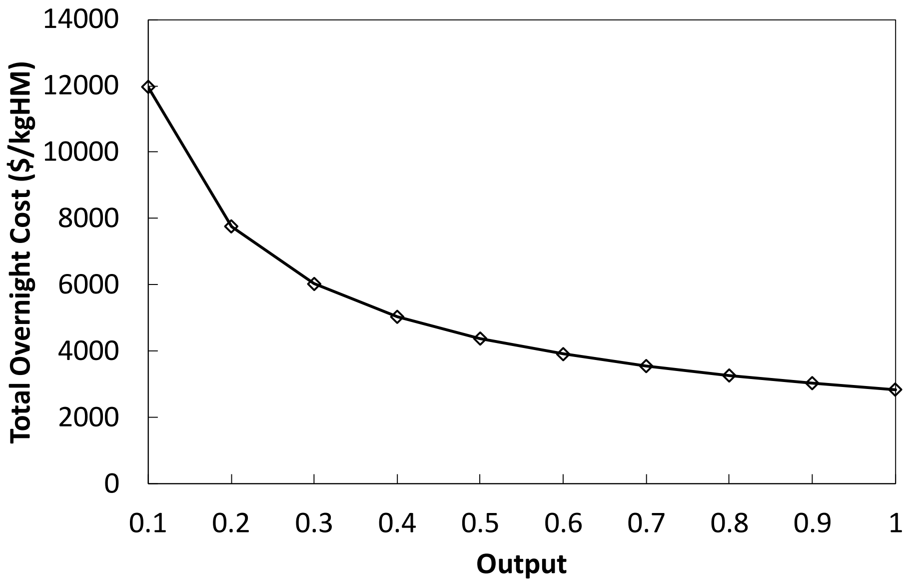

Figure 8.1 Relationship between total overnight cost and output

Figure 8.1 shows the effect of the output against total overnight cost per kgHM. The "Output" corresponds with the capacity of total facilities that provide services in Type B. As shown in figure 8.1, the cost decreases as the output increases, based on an effect of market principle. For example, if

[45] G. Rothwell, "Market power in uranium enrichment," *Science & Global Security*, 17, 132-154 (2009)

the market principle (output) is one-third of the base case, the overnight cost will be twice, around US$6,000.

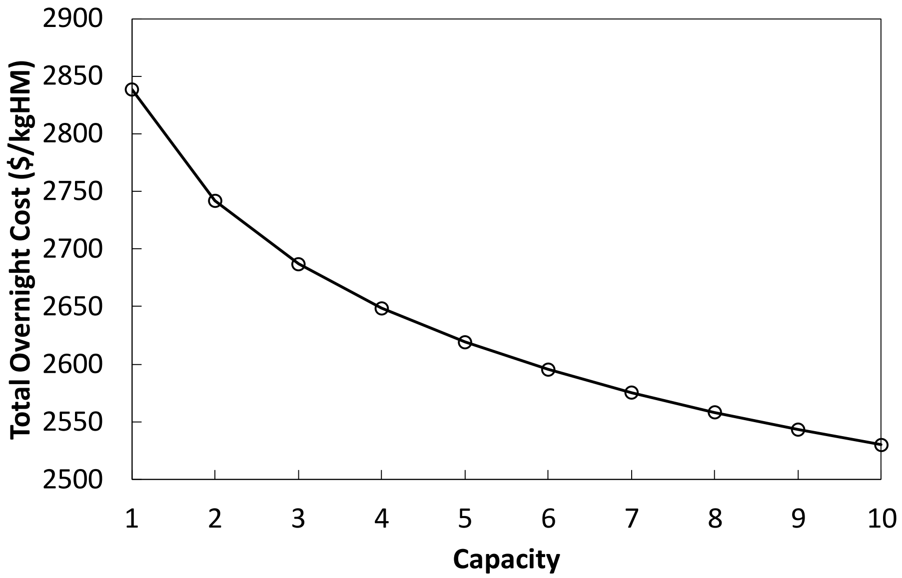

Figure 8.2 Relationship between capacity and total overnight cost

In order to analyze the effect of economies of scale, Figure 8.2 shows the relationships between capacity and overnight cost. As shown in Figure 8.2, the overnight cost decreases as the capacity increases. For example, the cost of a facility that has 10 times larger capacity than the base case would be US$2,530/kgHM, which is around US$300 per kgHM lower than the base case.

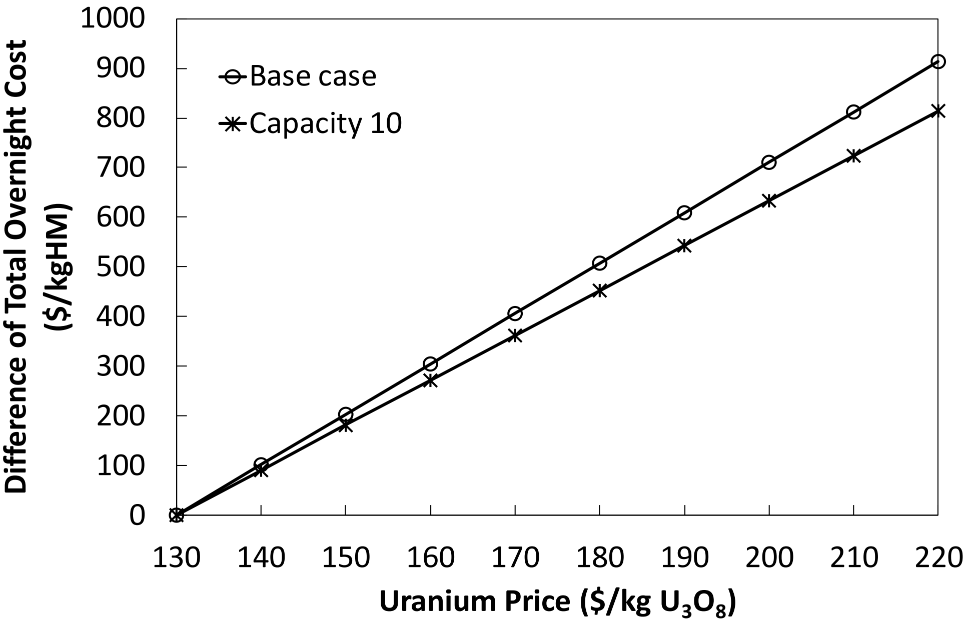

Figure 8.3 Relationship between uranium price and total overnight cost

Because the cycle cost depends on uranium price, there is a need to analyze the impact of uranium price on total cost and economies of scale. Figure 8.3 shows the difference of total overnight costs for each uranium price between benchmark case and the case with 10 times larger capacity. For both cases, as the uranium price increases, the total costs increase, and the difference becomes larger. Namely, the effect of economies of scale will become larger as the uranium price increases.

8.2.4. Conclusion and future challenges

In this section, the basic model of the nuclear fuel cycle cost was presented and basic economics for the three scenarios proposed in this report were evaluated. As a result, with the Type B scenario, it was demonstrated that the cost would be reduced in an effect of market principle. Furthermore, with the Type C scenario, we managed to quantitatively show the cost reduction as a result of economies of scale, which was mentioned in the preceding studies.

Furthermore, our study undertook economic evaluations using overnight cost, in other words, static evaluations without taking into account temporal development. However, in reality, fuel is produced over a certain amount of time at each facility for uranium feed, chemical conversion, enrichment, and fabrication. The time lag at these facilities and between the facilities would be different between multilateral approach and single state approach. Therefore, in the future, we are planning to carry out economic evaluation including temporal development by introducing present discount value.

An economics tradeoff exists between multilateral and single state approaches. For example, as has been mentioned in the preceding studies, the facilities with multilateral approach, which are expected to be large scale, will have the larger economic benefit from economies of scale as compared with a single state approach. However, from the fuel transport perspective, the transport cost per unit fuel will be less expensive for a single state approach, as compared with multilateral approach. Particularly, if backend is evaluated, the transport of SF will largely affect the cost. This means that, when economics evaluation of multilateral approach is carried out, there is a need to take into account disadvantages of fuel transport while considering the advantages of economies of scale. According to a reference[46], the transport cost of spent fuel by trucks and rails would be US$70 to 100 per kgHM. Using this figure, we are planning to compare economics evaluation of multilateral and single state approaches, taking into account the cost of spent fuel.

Furthermore, when economics of the entire multilateral approach is evaluated, it is also essential to evaluate the expenses that are required for transportation of nuclear materials and backend such as international storage and reprocessing. There is a need to study this point in the future.

[46] D. E. Shropshire, K. A. Williams, W. B. Boore, J. D. Smith, B. W. Dixon, M. Dunzik-Gougar, R. D. Adams, D. Gombert, and E. Schneider, "Advanced Fuel Cycle Cost Basis." INL/EXT-07-12107. Idaho Falls: Idaho National Laboratory (2008)

8.3 Examination of nuclear non-proliferation, safety and nuclear security

1) Nuclear non-proliferation

As risk factors of nuclear proliferation, INFCIRC/640 determines as follows:

Nuclear non-proliferation under a MNA (Label A)

a) Diversion of nuclear materials
b) Breakout scenarios and clandestine parallel programs
c) The extent to access sensitive technologies
d) Security risks (physical protection)

This means that the countermeasures against the risks factors of nuclear proliferation are comprehensive safeguards, activities based on Additional Protocol, limitation in access to the SNTs, and nuclear security system.

Furthermore, INFCIRC/640 states that under the framework of a MNA, the use of the SNTs should be limited and the framework shall be designed to reduce proliferation and concerns over safety and security, while assuring supply of nuclear fuel cycle services (i.e. uranium enrichment, spent fuel reprocessing, spent fuel disposal and spent fuel storage service). However, this idea has been severely criticized by the non-member states on the ground that it infringes on the rights for peaceful uses of nuclear power under the NPT Article IV and the NSG Guidelines that approve transfer of the SNTs under the condition where certain requirements such as the safeguards and nuclear security are met. We believe that this is one of the main reasons why many MNAs have not been actually implemented up to this day.

Therefore, in this study, taking into account the perspective of universality (equality) which had been proposed in the previous studies by the University of Tokyo, we determined that the effective and efficient nuclear non-proliferation can be established by appropriate regional safeguards and nuclear security under a MNA as well as export control by the NSG Guidelines, instead of limiting the possession of the SNTs in return of assuring nuclear cycle service. In other words, our approach does not necessarily limit the possession of the SNTs if a state meets certain requirements (e.g. regional safeguards, nuclear security, NSG Guideline) (criteria-based approach).

The normal safeguards to each state are as follows (Figure 8.4):

- Nuclear material accounting by a facility operator and material accounting data check and report to the IAEA by a state; and
- Inspection activities by the IAEA

Meanwhile, the regional safeguards for Type A and Type B under a MNA of our study are as follows (Figure 8.5):

- Nuclear material accounting by a facility operator and material accounting data check and report to the IAEA by a state and a MNA; and
- Inspection activities by the IAEA and a MNA member states.

The regional safeguards for Type C are as follows (Figure 8.6):

- Nuclear material accounting by a MNA facility operator and material accounting data check and report to the IAEA by a MNA; and

- Inspection activities by the IAEA and MNA member states.

The complementary access based on the Additional Protocol will be based on the information shared by multiple states. Thus, the highly transparent and effective safeguards can be achieved, as compared to the conventional a state safeguard.

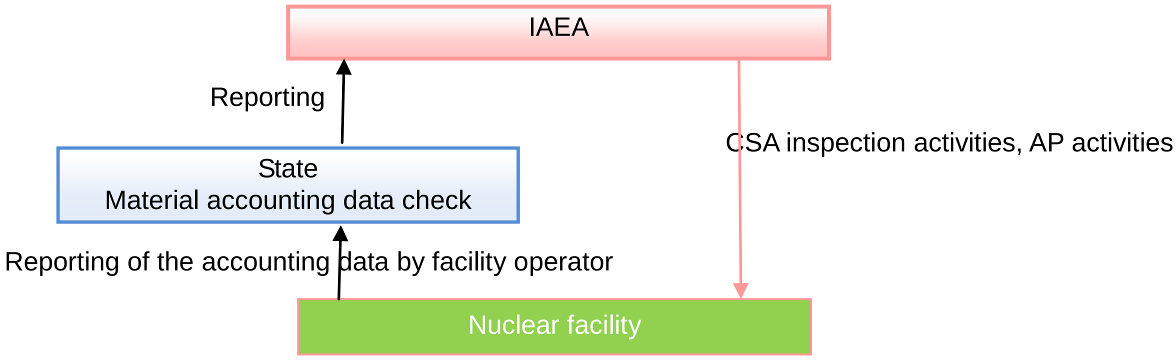

Figure 8.4 Conventional Safeguards System to a State

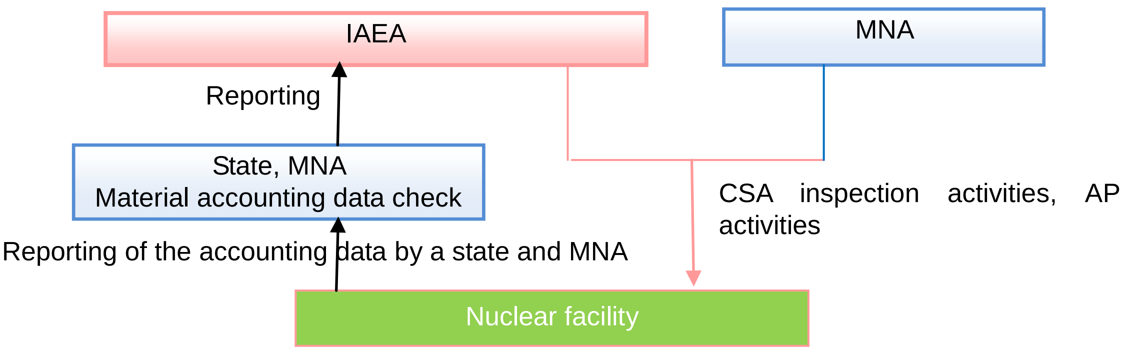

Figure 8.5 Regional Safeguards System (Type A, B)

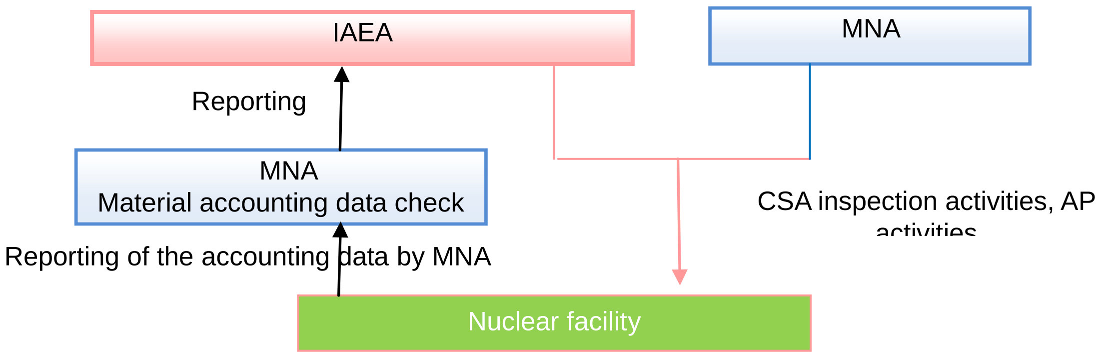

Figure 8.6. Regional Safeguards System (Type C)

The export control of SNTs is basically in line with the NSG Guideline (INFCIRC 254/Part1). This means that if a recipient state does not satisfy at least all the following criteria, the supplying state shall not permit to export enrichment and reprocessing facility, equipment and technology.

(i) The recipient must be a member state of NPT and appropriately satisfy the obligations under the Treaty;
The safeguards here indicate the regional safeguards.

(ii) The states have not been identified in a report by the IAEA Secretariat which is under consideration by the IAEA Board of Governors, as being in breach of its obligations to comply with its safeguards agreement, nor continues to be the subject of Board of Governors decisions calling upon it to take additional steps to comply with its safeguards obligations or to build confidence in the peaceful nature of its nuclear program, nor has been reported by the IAEA Secretariat as a state where the IAEA is currently unable to implement its safeguards agreement.

(iii) To respect for the NSG Guidelines;

(iv) To have an intergovernmental agreement with a supplying state including use for non-explosive purpose, permanent and effective safeguards, and assurance of re-transfer;

(v) To agree with a supplying state to adapt mutually agreed standards that are in accordance with the current international guidelines to protect nuclear materials; and

(vi) To follow the IAEA safety standards and respect for the Convention on Nuclear Safety.

Only if a recipient state effects the comprehensive safeguards agreement or an additional protocol based on model additional protocol, or in case the additional protocol is not determined, only if the recipient state implements appropriate safeguards agreement in collaboration with the IAEA including regional material accounting which is approved by the IAEA Board of Governors, the export shall be permitted.

The subjective criteria of the NSG Guideline would not be taken into consideration.

With the above requirements, we believe that the adequately high level of nuclear non-proliferation is ensured while basically allowing each state to posses the SNTs in accordance with the NPT Article IV. Therefore, our approach maintains the equality of each state.

1) Nuclear security/nuclear power safety

In Label A (nuclear non-proliferation under MNA) of our proposal, the nuclear security (d) is one of the critical requirements. In addition, we included a proposal of nuclear power safety in Label H (from 2011 of our study). This is a result of re-acknowledging the fact after the Fukushima Nuclear Power Plant accident that there is no border for nuclear power disaster.

After the accident in Fukushima, IAEA Ministerial Conference on Nuclear Safety was held (June, 2011). In the Conference, all member states agreed on the necessity of strengthening nuclear power safety and the central role of IAEA. On the other hand, the opinions were split over the points such as right and wrong of revising nuclear power safety related treaties, right or wrong of mandatory the IAEA safety standards, and right or wrong of mandatory checking all existing power reactors under severe conditions (so-called stress test) and mandatory checking by IAEA safety evaluation mission.

As for the safety evaluation of nuclear reactors and the IAEA safety standard, many member states carried out comprehensive tests (so-called stress test) to evaluate the vulnerability of their nuclear power plants. Meanwhile, there is also a need to harmonize evaluation among the states, and the IAEA Secretariat is currently developing evaluation methods for safety of nuclear power plants. The IAEA Secretariat is also investigating the IAEA safety standards in relation to the accident in Fukushima, Japan. However, as the site investigation group of IAEA reported, even the best standard will not be useful without its implementation (A statement by Mr. Flory, IAEA Head of Department of Nuclear Safety and Security, in December 2011, at JAEA-UT-JIIA Nuclear Security Forum).

The improvement of safety is an urgent task, while it is not easy to ensure implementation of the globally uniformed safety standards. Under this circumstance, we believe that the regional framework approach would be one of the strong driving forces.

As for the nuclear security, international actions have been taken including strict nuclear material control through containment/monitoring/audit based on the safeguards treaties and additional protocols, adaptation of United Nations Security Council Resolution 1540 (April, 2004), effectuation of International Convention for the Suppression of Acts of Nuclear Terrorism[47] (July, 2007), and adaptation of Convention on the Physical Protection of Nuclear Material[48] (July, 2005). The IAEA supports the actions by member states by issuing Physical Protection of Nuclear Material and Nuclear Facilities INFCIRC/225/Rev.4 (Corrected) and series of nuclear security documents that stipulates the principles of nuclear security (in January 2011, INFCIRC/225/Rev.5 was issued). Furthermore, the momentum towards nuclear security strengthening is rising very high as is seen in the promotion of strengthening international nuclear security, appealed by US President Obama. Under this circumstance, the accident at the Fukushima Nuclear Power Plant highlighted the need of improving nuclear power facilities (measures to prevent attacks from outside). At the same time, the similarity in terms of securing nuclear power safety and nuclear security is more and more recognized. Therefore, the needs for the international measures to secure nuclear security, same as

[47] International Convention for the Suppression of Acts of Nuclear Terrorism controls possession or use of radioactive materials with the intent to cause death, bodily injury, or substantial damage to property or nuclear weapons for criminal actions, and regulates agreement for punishment and extradition of criminals. It came to effect in July 2007. Japan signed on it in August, 2007. As of March 4, 2011, 115 states have signed and 76 ratified.

[48] In addition to the "protection of nuclear materials during international transportation" in the Convention on the Physical Protection of Nuclear Material before the amendment, the amended Convention regulates "protection of nuclear materials for their use/storage/transport in a state to be used at nuclear facilities or for peaceful purposes and criminalization of interference and destruction acts against nuclear materials and nuclear power facilities". It was adapted in July 2005 at the "Conference to review and adapt amendments" (Vienna). However, it did not come to effect because it did not satisfy the requirements for effect (96 states: 2/3 of 145 signatory states to the Convention on the Physical Protection of Nuclear Material) (as of December 30, 2010, 45 signatory states).

nuclear power safety, (in some cases, the measures that combine both concepts) are being discussed.

Our study includes the followings in the Agreement for establishing the MNA framework in Asia: the IAEA safety standards which are continuously revised and nuclear security series such as basic documents, advisory documents, implementation guidelines, and technical guidelines by the IAEA. At the same time, our study proposes to implement mutual support and auditing within the framework. As is shown in the Basic Agreement, we propose to establish Asian Multilateral Nuclear Approach Organization (AMNAO) and AMNAO 3S Control Center (AMNAO-3SCC) to facilitate the implementation of the above. In Figures 8.4 and 8.5, MNA is shown as an organization that implements safeguards. The AMNAO-3SCC is an extended version of this. It is expected that this system will inevitably secure 3S in nuclear power emerging states.

9. Role of industry

As related to nuclear-related services, private corporate entities are operating services related to the frontend (uranium fuel supply) as well as supply of reactors. We listed the resource supplying states and the corporate entities in the world that are currently involved in conversion, enrichment, and fuel fabrication in the Tables 9.1 to 9.4 below[49].

As shown in the Tables, it can be said that the frontend services are managed by the market mechanism and some consortiums. On the other hand, as to the backend (especially interim storage and disposal of wastes), a few corporate entities offer such services.

A MNA framework can be established by involvement of corporate entities. We believe that these corporate entities must create standards of conduct to take responsibility as nuclear services suppliers and consider offering services to the entire fuel cycle related to the backend pursuant to those standards of conduct.

On September 15, 2011, the world's major nuclear power plant manufacturers issued the "Nuclear Power Plant Exporters' Principles of Conduct" (hereinafter referred to as "Principles of Conduct"). The Principles of Conduct has characteristics of activity standards that the individual corporations have promised to voluntarily observe when exporting nuclear power plants. The Principle of Conduct is the fruit of discussions which had been carried out, led by Carnegie Endowment for International Peace, a think-tank in the US, with support from experts in various fields since October 2008.

The "Principles of Conduct" presents the principles in six fields (Safety, Health and Radiation Protection; Physical Security; Environmental Protection and Handling of Spent Fuel and Wastes; Compensation for Nuclear Damage; Nuclear Non-Proliferation and Safeguards; and Ethics) that the plant manufactures (=Venders) should consider when exporting nuclear, in addition to the responses to the above mentioned backend issues. Therefore the "Principles of Conduct" is an integration of the standards and the best practices that have so far been internationally established in various fields.

<u>Principle 1: Safety, Health and Radiation Protection</u>

Before entering into a contract to supply a nuclear power reactor to a customer, the Venders shall expect that the Customer State:

- ✓ Is a party to the NPT or has indicated its intention to become a party of the NPT before the beginning of the operation of the nuclear reactor. (1.1)

Before entering into a contract to supply of a nuclear power reactor to a customer, the Venders will have made a reasonable judgment that Customer State has:

- ✓ A legislative, regulatory and organizational infrastructure that is required for implementing a safe nuclear power program with due attention to safety either in place

[49] Note: Date within Table 9.1 – 9.4 are slightly different from those of Appendix I and II of Chapter 7, due to the difference of sources

or under development following the guidance provided in the IAEA Safety Standard "Establishing Safety Infrastructure for Nuclear Power Program"; (1.2)

- ✓ Either an existing industrial infrastructure to support safe long-term operation or a trustful plan to establish such an infrastructure before operation of the nuclear reactor begins; and (1.3)
- ✓ Taken into account international operation experiences and severe accident considerations. (1.4)

Supply manufactures shall commit:

- ✓ Export safe nuclear reactor that follows IAEA Safety Standards, etc; (1.5)
- ✓ Exchange information with the scientists and experts of the Customer State, as needed, to assist plant designers in adequately understanding the site-specific environmental and other circumstances affecting nuclear safety so as to adapt the design as necessary to local conditions; (1.6)
- ✓ Include the following items in the contractual assignments between the manufactures and the Customer State: provision of safety documentation and validated safety analysis reports, promotion of high safety culture, assurance that the systems, structures, and components of the plant are constructed or manufactured and installed to meet the requirements in the specified standard, requirements for subcontractors, and human resource development of the Customer State; and (1.7)
- ✓ Collaborate with Customer State to improve the elements of the Customer State's national infrastructure that influence safe nuclear reactor operation (e.g. development of local skills needed to maintain the nuclear reactor in safe operational conditions, and development of a comprehensive plan for emergency situation). (1.8)

<u>Principle 2: Physical Security</u>

In designing nuclear power plants, Venders will:

- ✓ Incorporate design provisions made for security; (2.1)
- ✓ Ensure security design provisions are consistent with the safety and emergency responses requirements; (2.2)
- ✓ Collaborate with the Customer to incorporate Design Basis Threat of the Customer State; and (2.3)
- ✓ Incorporate within design provisions the potential for damage from security threats in accordance with the Design Basis Threat of the Customer State. (2.4)

Before entering into a contract to supply nuclear power plant, the Venders will have made a reasonable judgment that the Customer State has or will have in a timely manner:

- ✓ Provided information to supply manufacturer concerning the analysis results of Design Basis Threat; (2.5)

- ✓ Become a party to the IAEA's Convention on the Physical Protection of Nuclear Material; (2.6)
- ✓ Participated in the International Convention for the Suppression of Acts of Nuclear Terrorism; and (2.7)
- ✓ Establish national legislative and regulatory infrastructure for nuclear security. (2.8)

Supply manufacturers will provide relevant information and guidance to the Customer State and the Customers to help establish:

- ✓ Security measures based on the established standards; (2.9)
- ✓ Routine evaluations of sufficiency of security response capabilities; (2.10)
- ✓ Integrated organization that oversees safety and security; (2.11)
- ✓ Continuous improvement and coordination with law enforcement, other Customer State agencies, plant security (2.12)

<u>Principle 3: Environmental protection and handling of spent fuel and waste</u>

Before entering into a contract to supply a nuclear power plant to a Customer, the Vender will have made a reasonable judgment that the Customer State either has or will have in a timely manner:

- ✓ Enacted national nuclear laws or developed a regulatory framework that 1) formalizes and keeps current a credible national strategy and/or a plan to store, treat or manage spent fuel and radioactive waste, decommission closed-down nuclear facilities, and dispose of all radioactive wastes, and 2) addresses safeguards obligations, safety, security, human health, etc.; and (3.1)
- ✓ Ratified, accepted, or apply the principles of "The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management". (3.2)

Venders will seek to design plants that:

- ✓ Enhance environmental benefits and minimize impact on environment; (3.3)
- ✓ Provide for safe and secure on-site storage of spent fuel; and (3.4)
- ✓ Facilitate ultimate decommissioning of plant (3.5)

In contracting to sell a nuclear power plant, Venders will seek to:

- ✓ Address the responsible management of spent fuel and other radioactive materials and radioactive waste by the Customer. (3.6)

Venders will provide relevant information and guidance to the Customer States and the Customers to help promote:

- ✓ Protection of the environment through the responsible use of natural resources, reduction of waste and emissions, and minimization of harmful impacts on the environment; (3.7)

- ✓ A precautionary approach to the environment consistent with the definition provided in the UN Global Compact and Rio Declaration on Environment and Development; and (3.8)
- ✓ Development of long-term management systems of spent fuel and radioactive waste that are rational, economic, safe and secure and consistent with the Customer States' safeguards obligation. (3.9)

Principle 4: Compensation for nuclear damage

Before entering into a contract to supply a nuclear power plant to a Customer, the Vender will independently make a reasonable judgment that the Customer State has in force, or will have in force before fuel is delivered in the Customer State's territory, a legal regime providing adequate and prompt compensation for the public in the unlikely event of an accident, with protection in effect equivalent to one or more of the following best practices:

- ✓ Legal regime for compensation and nuclear liability that contains adequate liability limits and financial protection, is backed by the Customer State guarantees, ensures that the claims for compensation will be channeled to the operator of the nuclear power plant(s) that would be strictly and exclusively liable, etc.; (4.1)
- ✓ To treaty relationship with the Supply State under the IAEA's Vienna Convention on Civil Liability for Nuclear Damage or Paris Convention on Third Party Liability in the Field of Nuclear Energy; and/or (4.2)
- ✓ To be a party to the IAEA's Convention on Supplementary Compensation for Nuclear Damage (CSC). (4.3)

Principle 5: Nuclear non-proliferation and safeguards

The Venders are committed to the followings as a manifestation of their strong commitment to peaceful uses of nuclear power and non-proliferation:

- ✓ Pay special attention to and promote highly proliferation-resistant designs and take IAEA safeguards into account in design (5.1)
- ✓ Pay special attention to the exclusively peaceful use of the items on the NSG Guidelines' trigger list and sensitive dual-use items delivered by the Vender; (5.2)
- ✓ Seek to obtain a commitment from the Customer to implement at the facility a System of Accounting for and Control of Nuclear Materials and a safeguards approach in accordance with the IAEA obligations; (5.3)
- ✓ In form in a timely manner the appropriate authority of the Vender State and, as appropriate, other Venders adhering to these Principles, of any serious non-proliferation concerns over equipment, materials, and technology provided by the Vender to the Customer; and (5.4)

- ✓ Consult closely with the Vender State and act in accordance with its instructions upon being informed by the Vender State or becoming directly aware of actions or events that would raise serious concerns about compliance with the global nonproliferation regime. (5.5)

In addition to the above, Venders welcome the inclusion by Vender States of provisions in bilateral nuclear agreements requiring a Customer State to implement effective nuclear export controls and to have an IAEA Additional Protocol in force.

<u>Principle 6: Ethics</u>

Venders seek in their activities to:

- ✓ Respect for high ethical business standards when interacting with Customers; (6.1)
- ✓ Communicate with good faith and in the spirit of transparency about these Principles; (6.2)
- ✓ Promote worker safety and protect public health and the environment; (6.3)
- ✓ Take into account the principle of sustainable development, including the effects of projects on environment and society; (6.4)
- ✓ Proactively collaborate with Customers to inform and consult in participatory manner with nearby communities; (6.5)
- ✓ Establish internal program to discourage corruption and encourage compliance with anticorruption laws; (6.6)
- ✓ Respect the basic rights of workers; (6.7)
- ✓ Respect human rights; and (6.8)
- ✓ Encourage the people who are involved with nuclear power plant industry such as subcontractors to demonstrate the same respect for these ethical commitments. (6.9)

Because nuclear power generation is associated with risks in terms of safety, security, nuclear nonproliferation, etc., the supply states and venders of nuclear equipment shall have interests and responsibilities for ensuring that the nuclear power generation in a recipient state would not be exposed to the risks. At the government level, the supply state of nuclear power equipment asks for commitment for nuclear non-proliferation, nuclear material protection, etc. from the recipient state by entering into nuclear power collaboration agreement. From the perspective of securing fair competition for nuclear power trade, it is desirable that the differences among the supply states are smaller in terms of the commitment that they ask from the recipient states. Therefore, the NSG Guidelines are trying to standardize the commitment to a certain degree.

On the other hand, there has been no common rule for the venders when they export nuclear power equipment to the nuclear power agency of a recipient state under the Nuclear Power Collaboration Agreement. The agreed “Principles of Conduct” covers the field that has not been regulated in the NSG Guidelines, such as safety, spent fuel, management of wastes, nuclear power damage compensation, and ethics in great details in each field.

In the future, it is hoped that the canonicity will be enhanced by fulfilling the Principles of Conduct, and similar actions will be spread in the entire nuclear power industry including enrichment manufactures, fuel production manufactures, etc.

Table 9.1 Global Uranium Production Capacity

Country	2007	2008
Canada	9476	9000
Kazakhstan	6637	8521
Australia	8611	8430
Namibia	2879	4366
Russia (est)	3413	3521
Niger	3153	3032
Uzbekistan	2320	2338
USA	1654	1430
Ukraine (est)	846	800
China (est)	712	769
South Africa	539	566
Brazil	299	330
India (est)	270	271
Czech Repub.	306	263
total world	**41 282**	**43 764**
tonnes U_3O_8	**48 683**	**51 611**

Source: World Nuclear Association, http://www.wna.org

Table 9.2 Global Uranium-Conversion Capacity

Country	Owner /Controller	Plant Name /Location	Capacity [MTU/year]
Brazil	IPEN	São Paulo	90
Canada	Cameco	Port Hope, Ontario	10,500
China	CNNC	Lanzhou	400
France	COMURHEX (100% Areva)	Pierrelatte	14,000
	Areva	Pierrelatte TU5	350
Iran	AEOI	Isfahan	193
Russia	Rosatom	Ekaterinburg	4,000
		Angarsk	20,000
United Kingdom	British Nuclear Fuels, Ltd.	Springfields, Lancashire	6,000
United States	Converdyn (50% Honeywell Int. Inc., 50% GA)	Metropolis, Illinois	17,600
Total			**73,133**

Source: World Nuclear Association, http://www.wna.org

Table 9.3 Global Uranium Enrichment Capacity

Country	Owner/Controller	Plant Name/Location	Capacity [1000 SWU/year]
Gaseous Diffusion Plants			
China	CNNC	Lanzhou	900
France	EURODIF	Tricastin	10,800
United States	U.S. Enrichment Corp.	Paducah, Kentucky	11,300
		Portsmouth, Ohio (closed since May 11, 2001)	(7,400)
Subtotal			**23,000**
Centrifuge Plants			
China	CNNC	Hanzhong	500
		Lanzhou	500
Germany	Urenco Deutschland GmbH	Gronau	2,750
India	DAE Nuclear Fuel Complex	Ratnahalli, Karnataka	4.5
Japan	JNC	Ningyo Toge	200
	Japan Nuclear Fuel Limited (JNFL)	Rokkasho-mura	1,050
Netherlands	Urenco Nederland BV	Almelo	4,400
Pakistan	Pakistan Atomic Energy Commission	Kahuta	5
Russia	Rosatom	Urals Electrochemical Integrated Enterprise (UEIE) , Novouralsk	7,000
		Siberian Chemical Combine (SKhK), Seversk	4,000
		Electrochemical Plant (ECP), Zelenogorsk	3,000
		Angarsk Electrolytic Chemical Combine (AECC), Angarsk	2,600
United Kingdom	Urenco UK Ltd.	Capenhurst	5,050
Subtotal			**31,059.5**
Total			**54,059.5**

Source: http://www.wise-uranium.org

Table 9.4 Global Uranium Fuel Production Capacity

Country	Owner/Controller	Plant Name/Location	Capacity [MTU/year]
Belgium	FBFC (49% COGEMA, 51% Framatome)	Dessel	750
Brazil	FEC (INB)	Resende	100
China	CNNC	Yibin	400
France	FBFC (49% COGEMA, 51% Framatome)	Romans-sur-Isère	820
	SICN (100% COGEMA)	Veurey-Voroise (closed)	(150)
Germany	Advanced Nuclear Fuels (66% Areva , 34% Siemens)	Lingen	650
Japan	Japan Nuclear Fuel Co., Ltd.	Yokosuka City	750
	Mitsubishi Nuclear Fuel Co. Ltd. (30% Areva - planned)	Tokai-Mura	440
	Nuclear Fuel Industries Ltd	Kumatori	284
		Tokai-Mura	200
Kazakhstan	Ulba Metallurgical Co (90% Kazatomprom)	Ust-Kamenogorsk	2,000
South Korea	KEPCO Nuclear Fuel Co., Ltd. (KNFC)	Taejon	400
Russia	JSC TVEL	ELEMASH , Elektrostal	1,020
		NCCP, Novosibirsk	1,000
Spain	ENUSA	Juzbado	300
Sweden	BNFL/Westinghouse Atom	Västerås	600
United Kingdom	British Nuclear Fuels, Ltd.	Springfields, Lancashire	330
United States	Areva NP, Inc.	Lynchburg, Virginia	400
		Richland, Washington	700
	Westinghouse	Hematite, Missouri (closed)	(450)
		Columbia, S. Carolina	1,600
	Global Nuclear Fuel - Americas, L.L.C.	Wilmington, N. Carolina	1,200
Total			**13,969**

Source: http://www.wise-uranium.org

10. Conclusion and future approach

This study makes specific proposals including presentation of the potential member states based on the past cases analysis in order to establish a feasible and sustainable “Multilateral Approach Framework of Nuclear Fuel Cycle” in East Asia. The study period is for 3 years from 2010.

Our priorities for the Framework are the followings: “to eliminate inequality from the perspective of peaceful uses of nuclear power”, “to be attractive to the member states (motivation) – member states, industry”, “to have nuclear non-proliferation capacity of the current or higher level (including political and geopolitical perspectives)”, “to realize international standard for safety and security”, “to have higher economic potential for fuel cycle than a single state approach”, “to eliminate conflicts/inconsistency with existing laws and regulations”, and “to solve transport issues of nuclear fuel, etc.”.

This study included the following components which are the keys to establish the framework in the evaluation analysis: nuclear non-proliferation, examination of legal system, economic potential, transport issue, effect for safety/nuclear security, role of industry, and geopolitical examination (some parts of the study will be carried out in 2012.).

We believe that in the proposed MNA Framework, the following points are fulfilled by the Basic Collaboration Agreement (draft), etc.:

1) Basically, all member states shall have equal rights to become a host (or site) state for the nuclear fuel cycle that includes enrichment and reprocessing.
2) In order to achieve the above, all member states are required to fulfill the criteria as presented in the NSG Guidelines.
3) Member states other than the host (or site) states have rights to receive nuclear fuel cycle services (e.g. fuel supply, storage/reprocessing of SF, storage of MOX fuel) and shall have more economic advantage than implementing it on their own. (motivation for participation)
4) Host (or site) states have economic advantage by providing their services (remuneration as a business).
5) When accepting the request for storage services of SF or reprocessed HLW, host (or site) states that handle SF shall ensure to have measures to limit duration of the service (to avoid keeping it forever).
6) If there are existing regulations (e.g. bilateral agreement) that may conflict with the functionality of the regional MNA, similar measures in the MNA agreement shall enter into force as a replacement of the requirements that the bilateral agreements, etc. are intending to achieve such as nuclear non-proliferation (it is expected that the conflicting items will be exempted from the bilateral agreement, etc.).
7) Political and geopolitical aspects shall be reflected in the regulations, etc. for enticement and selecting sites of SNT facility under the equal rights as shown in the above 1).

8) In order to remove concerns over nuclear non-proliferation in the host (site) states that have SNT facilities, there should be clear withdrawal regulations.
9) To achieve international standards/international guidance of safety and nuclear security.
10) To regulate mutual collaboration between member states when exporting nuclear fuel etc. in order to give functionality to the Framework.
11) To develop technical measures that will allow the member states to overtake high-active waste in the future and to work on recycling use of nuclear fuel within the region based on energy security perspectives (e.g. advanced reprocessing, MOX stockpile).

As a next step, we will further examine the options A to C from effectiveness, feasibility and sustainability perspectives and present the priority options, carry out economic evaluation and evaluation of important factors such as legal issues, nuclear non-proliferation, safety/securities, etc. and complete the proposal. We will also further study the international nuclear fuel cycle entity model (including the 3S perspective including handling of SF) and complete our study on the entity model that is effective from the organizational management point of view. Simultaneously, in order to pursue feasibility, we will analyze/summarize incentives and challenges of all the stakeholders of MNA, in particular, the industry by exchanging opinions with others who have strong connection with the nuclear power industry.