博士論文

Study on feasible frameworks of multilateral approaches to nuclear fuel cycle

（実現可能な核燃料サイクル多国間管理の枠組みに関する研究）

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Chapter 1

Introduction

1.1 Background of the Study

By reason of the inherent duality of nuclear energy, the world has been struggling to explore various ways to promote its peaceful applications in nuclear power reactors, while limiting further proliferation of its military applications in nuclear weapons. The latter includes controlling the unnecessary spread of the nuclear weapon usable material of highly enriched uranium (HEU) and plutonium, as well as of enrichment and reprocessing (ENR) technologies and facilities.

Figure 1 [1] briefly describes international efforts for nuclear non-proliferation by establishing legal frameworks including treaty and conventions, together with voluntary approaches.

Among the former frameworks, the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) is the heart of it and is underpinned by the three pillars of peaceful use of nuclear energy, nuclear non-proliferation and disarmament.

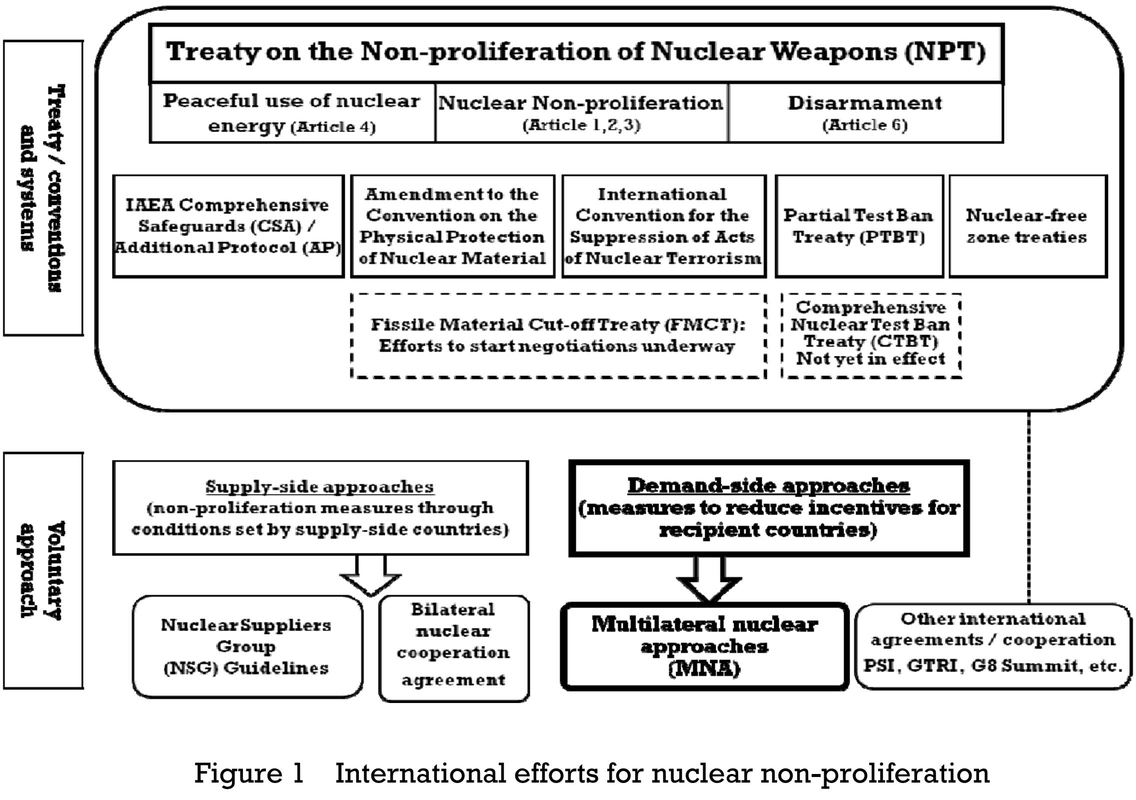


Figure 1 International efforts for nuclear non-proliferation

Regarding voluntary approaches, traditionally such efforts have been mainly initiated by nuclear supplier states (NSSs) by requiring various nuclear non-proliferation conditions of recipient states (RSs) in return for their supplies of nuclear material, equipment, facilities and technologies (nuclear-related items). It is particularly worth pointing out that the main NSSs of enriched uranium and uranium enrichment service are nuclear weapon states (NWSs) under the NPT. These approaches are so-called "supply-side approaches" and typical examples of them are the Nuclear Suppliers Group Guidelines (NSG Guidelines) [2] and nuclear cooperation agreements (NCAs) concluded between NSSs and RSs. For example, the NSG Guidelines are not legally binding, but most NSSs follow the Guidelines and require RSs satisfy nuclear non-proliferation conditions in the event of transfers of nuclear-related items.

However, these approaches have been gradually changing in accordance with the circumstances surrounding nuclear energy utilization in the world. Heading into the 21st century, many non-nuclear energy states of the 20th century in the Asian region and the Middle East have taken a keen interest in nuclear energy utilization and are preparing to construct new nuclear reactors in their territories, as emerging nuclear energy states in the 21st century. Nuclear reactors require enriched uranium as nuclear fuel and it is natural that these states would start thinking of acquiring enrichment capabilities by themselves. Some emerging nuclear energy states insist that nuclear non-proliferation conditions required by NSSs under the NSG Guidelines create another discrimination between "haves" of ENR technologies and facilities, and "have-nots" of them, in addition to the discrimination which has already existed under the NPT between "haves" of nuclear weapons as NWSs and "have-nots" of them as non-nuclear weapon states (NNWSs), although the Article 4 of the NPT stipulates rights of NPT members to use nuclear energy for peaceful purposes.

Regarding NCAs, especially, the US has concluded NCAs with many states since Eisenhower's Atoms for Peace Address in 1953 and supplied reactors and enriched uranium under the NCAs with nuclear non-proliferation conditions. However, currently the US is no longer the dominant enriched uranium supplier and it is not as easy to require strict non-proliferation conditions, including abandonment of ENR capabilities in certain RSs, as it used to be. In addition, other nuclear supplier states, such as France and Russia, do not require RSs so strict nuclear non-proliferation as the US. Under such circumstances, instead of taking "supply-side approaches", NSSs now try to reduce RSs' incentives for acquiring capabilities of producing nuclear weapon usable materials, including ENR technologies and facilities. These approaches are called "demand-side approaches" and the Multilateral Nuclear Approaches (MNAs) are one such approach.

1.2 Definition of MNAs and Their Characteristics

There is no internationally-agreed definition of MNAs. For example, Yuri Yudin defines MNAs as "arrangements [that] are generally aimed at denationalizing sensitive fuel cycle activities by placing decisions on the operation of nuclear facilities, as well as on the disposition of their product, in the hands of a number of nations or international organizations rather than individual states" [3].

His MNA definition seems to be the minimum one, when compared with existing and past MNAs. In reality, a variety of MNA forms and/or combinations of forms are available. Table 1 describes examples of current and past MNAs and member states' involvements within these frameworks.

Table 1 Current and past MNAs and their member states' involvements

Current and past MNAs	Investment to the facility	Ownership of the facility	Access to sensitive technologies	Management of the facility	Operation of the facility	Decision makings
EURODIF	Member states	France, as enrichment technology holder and a host state of the facility				
URENCO	Member states	Member states (each state has one facility)	Member states	A host state of the facility (A member state)		Member states
EUROCHEMIC	OECD/NEA Member states	A consortium, as a representative of member states	Member states	A consortium, as a representative of member states		

EURODIF (European Gaseous Diffusion Uranium Enrichment Consortium. It is now a subsidiary of AREVA SA.) was formed in 1973 by France, Italy, Spain, Belgium and Sweden, but only a French operator exclusively holds enrichment technology, operates the facility, and dominates decision making [4]. In this case, other member states' involvement in the MNA is limited only to investment.

URENCO is invested in by companies in Germany, the Netherlands, and the UK and they equally share facility ownership, operation, and decision-making in URENCO. Since each state has one enrichment facility, each facility respectively follows its host state's legislation on nuclear energy [5]. In this case, each member state equally shares rights and responsibilities of each facility and enrichment technologies.

The EUROCHEMIC (European Company for the Chemical Processing of Irradiated Fuels) reprocessing facility was created in 1959 and has been operated by a consortium of member states of the Nuclear Energy Agency of the Organization for Economic Co-operation and Development (OECD/NEA) from 1966 to 1975 [6]. The main purpose of the EUROCHEMIC plant was joint demonstration of reprocessing technologies. Although ownership, management, operation and decision making is done by a consortium, as a representative of its member states, in principle all member states share rights and responsibilities equally, the same as with URENCO.

Analyzing Table 1, member states' involvements in MNAs vary with each MNA. This involvement includes investment, ownership, operation and management of MNA facilities, access to sensitive technology and decision making. As for membership of the MNA, it is worth noting that NWSs are always included in all three of the above MNAs, as ENR technology holders.

In addition, member states of all the above MNAs belong to the European Atomic Energy Community (EURATOM) created by the EURATOM Treaty signed in 1957 [7]. Under the EURATOM Treaty, EURATOM has the following characteristics to ensure both peaceful use of nuclear energy and non-proliferation, together with nuclear safety [8].

- The EURATOM Supply Agency (ESA) observes all nuclear related trades including flows of nuclear material within EURATOM, and between EURATOM states and other states outside EURATOM, in order to ensure member states' regular and equitable supply of ores and nuclear fuels.

- In addition to the ESA, EURATOM (regional) safeguards apply to nuclear facilities within member states, in conjunction with IAEA Safeguards, in order to ensure that nuclear materials have not been diverted to other purposes (military purposes). Furthermore, with EURATOM safeguards, the Regional System of Accounting for and Control of nuclear material (RSAC) has been implemented. In this respect, regulations, systems and an organization for ensuring non-proliferation are well prepared in the EURATOM. In other words, in order to ensure MNA's nuclear non-proliferation characteristic, roles of such regional safeguards and the RSAC are important and inevitable.

- EURATOM contributes to enhancing its member states' nuclear safety by establishing uniform nuclear safety standards.

Therefore, the existence of MNAs has been carefully arranged and well backed by EURATOM's own nuclear non-proliferation system of regional safeguards and the RSAC. In this respect, such MNAs maintain much strengthened non-proliferation and nuclear safety characteristics, compared with a nation based nuclear facilities in non-EURATOM states.

As for the advantages of MNAs, compared with a nation based facility, Yudin also describes MNAs as having "a substantial potential to ensure that the benefits of nuclear energy are made available to all countries, while further strengthening the nuclear nonproliferation regime, ensuring safe and secure management of the nuclear fuel cycle, and reducing incentives to build new nuclear fuel cycle facilities in countries that do not now have them" [9]. His notion is true in the cases of EURODIF and EUROCHEMIC, where each member state's own nation based facility was integrated into one MNA facility. In this respect, MNAs contribute to preventing proliferation of ENR technologies. In addition, nuclear non-proliferation is more ensured in EURODIF, compared to the other two, since enrichment technology is dominated only by France and is not shared with other member states.

On the other hand, a state's participation in MNAs is completely voluntary; therefore, MNAs cannot necessarily prevent nuclear proliferation by non MNA member states. In addition, MNAs have a high correlation with international politics and security, since nuclear energy itself can be utilized also for non-peaceful purposes and the nuclear weapon has still played a large role in maintaining NWSs' and their allied states' national security. Bruno Pellaud focused on this political aspect of MNAs and stated that "MNAs are powerful confidence-building endeavors. By applying the general definition of "confidence-and-security-building measures"

(CSBM) proposed by UNIDIR (United Nations Institute for Disarmament Research), one could say that *a nuclear fuel cycle CSBM would seek to introduce transparency and thereby predictability in relations between States by clarifying national intentions, reducing uncertainties about national activities, and/or constraining national opportunities for surprise*" [10].

His notion is also observant that in URENCO and EUROCHEMIC, each member state is able to observe the other states' activities since all members, including NWSs, jointly engage in facility management and operation. On the other hand, as will become apparent in chapters 7, it is undeniable that MNA's close correlation with international politics holds potential to prevent the MNAs themselves from successful establishment.

1.3 Purposes of the Study

Historically, in parallel with the development of nuclear energy utilization in 1940s, establishment of MNAs has also been explored. The US especially has initiated these discussions, but such efforts have not borne fruit. One reason for this lack of success is that there have been insufficient in-depth systematic discussions on MNA fundamentals, including the necessary and sufficient features of MNAs.

Based on this fact and in order to establish functional and feasible MNAs, the purpose of this study is to identify necessary and sufficient features of MNAs (MNA features), and clarify their measures, which enable to satisfy functional and feasible MNA's three requirements of (i) accomplishing MNA's essential purposes, (ii) ensuring MNA's smooth functions and (iii) contributing MNA's practical feasibility. Details of these three MNA's requirements of (i), (ii) and (iii) will be future elaborated in chapter 2.

In order to accomplish above study purpose, the study takes three steps.

The first step is to systematically identify MNA features, based on analysis of past efforts for establishing MNAs. Then those features are categorized as "essential features", "functional features" and "practical features", in accordance with above mentioned three MNA's requirements.

The second step is to clarify detailed measures of each MNA feature, which enable to satisfy above three MNA's requirements. Those clarifications are made based on analysis of existing MNAs as models. In addition, legal viewpoints, which are imperative for the purpose of establishing a feasible MNA, have a particular emphasis placed on them since both the peaceful use of nuclear energy and nuclear non-proliferation have already been established in and are carefully regulated by international, regional and national legal systems.

The third step is to carry out case studies assuming that several existing states in a certain region form a MNA, in order to discuss the applicability of MNA features and detailed measures extracted under the 1st and the second steps.

Through the above three steps, features and their detailed measures to establish functional and feasible MNAs will be identified and clarified.

As to scope of this study, discussion of final disposal sites of high-level radioactive waste and spent fuel without reprocessing is not be included in MNAs.

1.4 Structure of Thesis

With the study purpose mentioned in section 1.3 in mind, this thesis consists of eight chapters. The first chapter is the introduction of the thesis. In the second chapter, twelve necessary MNA features are identified and then categorized as essential, functional and practical features, in accordance with three MNA's requirements. The third chapter discusses detailed measures of three essential features, which enable to (i) accomplish MNA's purpose of promoting peaceful use of nuclear energy and nuclear non-proliferation. The forth and the fifth chapters discuss detailed measures of two functional features, which enable to (ii) promote MNA's smooth functions. The forth chapter focuses on measures to harmonize MNAs and NCAs, while the fifth chapter focuses on nuclear third party liability systems in MNAs. The sixth chapter discusses detailed measures of practical MNA features, which enable to (iii) contribute MNA's feasibility. The seventh chapter discusses the applicability of the proposed features through three case studies assuming the establishment of different MNAs consisting of existing states in the Asian region and the Middle East. The eights chapter concludes the thesis and future works will be also mentioned in this chapter.

Chapter 2 MNA Features

Chapter 2
MNA features

MNAs are both an old and current subject which date back from the 1940s to the present time. As partly shown in Figure 2 [11], many proposals for establishing MNAs have been presented, however, very few proposals have so far been realized, except for EURODIF, URENCO and EUROCHEMIC, and the IAEA Fuel Bank which is currently on its way to being established in Kazakhstan [12]. MNAs have rarely been established, compared with the number of proposals that have been presented so far.

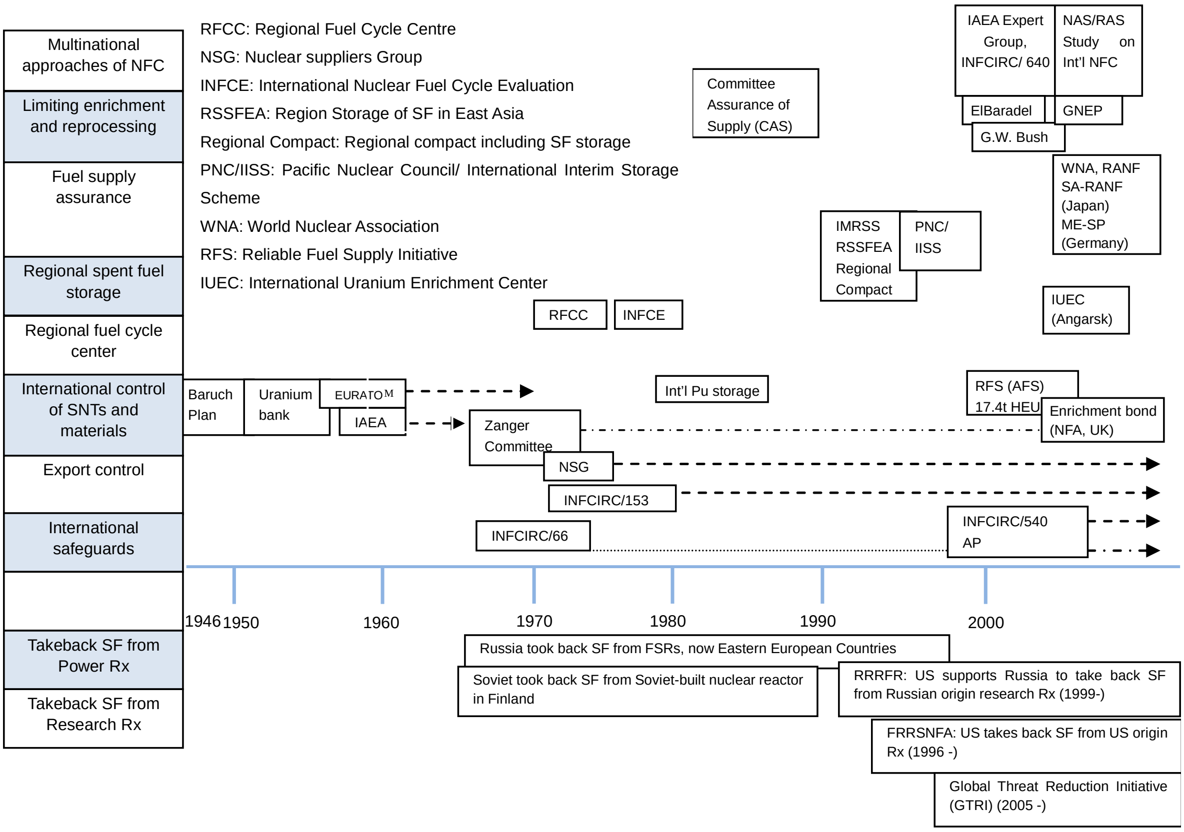


Figure 2 International efforts for establishing frameworks for peaceful use of nuclear energy and nuclear non-proliferation, including MNAs

In this chapter, various MNA proposals from the 1940s to the present have been reviewed and then analyzed, in order to extract MNA features.

2.1 Historical Review and Analysis of Efforts for Establishing MNAs

2.1.1 Efforts from 1940s to 1980s

Table 2 shows descriptions of proposals and initiatives for establishing MNAs and their results from the 1940s to the 1980s. MNA features which could be extracted from proposals and initiatives are also indicated in the right column of the table.

Table 2 MNA Proposals and initiatives from 1940s to 1980s

Proposals / initiatives	Description / → results	MNA features
A Report on the International Control of Atomic Energy (Acheson-Lilienthal Report) (1946) [13]	• Proposed international control of nuclear energy by an international organization called the "Atomic Development Authority" (ADA). • The ADA exclusively deals with all the "dangerous activities" of nuclear energy from a nuclear nonproliferation perspective and allocates its products of nuclear fuel to states devoting it only to "safe activities". → The general theory of the report was inherited by the Baruch Plan with modifications.	• Non-proliferation • Assurance of supply of nuclear fuel and nuclear fuel cycle services • Access to technology • Nuclear cooperation agreements (NCAs) • Multilateral involvement
Baruch Plan (1946) [14]	Followed but modified the Acheson-Lilienthal Report by adding prohibition of the development of nuclear-weapons capability by new states and punishment for violations. → Failed to gain support from the Soviet Union, since the U.S. intended to maintain its nuclear weapons monopoly.	
President Eisenhower's "Atoms for Peace" Address (1953) [15]	• Proposed an international control of nuclear energy for peaceful purposes through the International Atomic Energy Agency (IAEA). • The governments principally involved were expected to make joint contributions from their stockpiles of uranium and fissionable materials to the IAEA. → Led to the establishment of the IAEA which acts as an "intermediary" of nuclear materials and service supplies. However, this function has not been utilized as effectively as was expected. Instead, the U.S. and the Soviet Union provided nuclear reactors and fuel to their allied nations, based on bilateral nuclear cooperation agreements (NCAs).	

Proposals / initiatives	Description / → results	MNA features
Regional Nuclear Fuel Cycle Centers (RFCC) 1975–1977 [16]	• Identified the economic, safety, safeguards and security aspects of a multinational approach to nuclear fuel cycle facilities. • Study group reported several possible nonproliferation, economic and operational advantages. → No follow-up action was taken, since fears of a plutonium economy had eased.	• Economics • Nuclear safety • Non-proliferation (Safeguards, Nuclear security • Multilateral involvement • Access to technology
International Nuclear Fuel Cycle Evaluation (INFCE) 1977–1980 [17]	Regarding MNA, • As a short and medium term mechanism, backup or safety net arrangements including a uranium emergency safety network and an international fuel bank were discussed. • As a long term mechanism, MNA could make a contribution to fuel service assurances, provided a solution can be found for avoiding possible interferences by the host government. • MNA were evaluated from the six features of economics, resource utilization, non-proliferation, security of supply, environmental impact, and special needs of developing countries. [18]. → Due to the disinclination of some countries to give up national control over nuclear fuel cycle, and the general lack of political will, INFCE studies resulted in no further pursuit of multilateral approaches.	• Non-proliferation • Assurance of supply of nuclear fuel and nuclear fuel cycle services • Multilateral involvement • Access to technology • Economics • Siting – choice of host state • Access to technology

Proposals / initiatives	Description / → results	MNA features
International Plutonium Storage (IPS) 1978–1982 [19]	• Explored IAEA-supervised management, storage and release of plutonium in excess. • Technical, legal and institutional aspects, including safeguards and plutonium buffer stocks, were discussed. → No consensus was reached as states were unwilling to renounce sovereign control over nuclear technology and fuel based on Article 4 of the NPT.	• Non-proliferation • Assurance of supply of nuclear fuel and nuclear fuel cycle services • Multilateral involvement • Access to technology • Siting – choice of host state • Transportation
Committee of Assurance (CAS) 1980–1987 [20]	Discussed measures to ensure the reliable supply of nuclear material, equipment and technology, principles for international cooperation in the field of nuclear energy, emergency back-up mechanisms and an IAEA role. → Unable to reach a consensus on principles for international co-operation on nuclear energy and for nuclear nonproliferation, as RSs were unwilling to renounce sovereign control over nuclear technology and fuel based on the Article 4 of the NPT.	
International Spent Fuel Management (ISFM) 1979–1982 [21]	Discussed key elements about the international agreements which would need to be drawn up for an international spent fuel venture. They included technology, cost, and legal aspects related to spent fuel storage and transportation. → Could not proceed, since specific storage locations could not be identified.	

By analyzing proposals and initiatives in Table 2, the following facts can be extracted;

- The US has tried to ensure nuclear non-proliferation by limiting other states' access to ENR technologies, while ensuring supply assurance of their nuclear fuel and nuclear fuel cycle services.
- Political conflicts between the US and the Soviet Union prevented MNAs from being established.
- Instead of utilizing the IAEA's role as "intermediary" of nuclear fuel supply among its member states, the US and the Soviet Union directly supplied nuclear material to their own allied states through NCAs. In other words, as an alternative to international control, the US and the Soviet Union each respectively and directly controlled their nuclear material. However, such a nation based control system holds potential to cause conflicts with MNAs, since MNA are multilateral approaches and different from nation based control. This issue will be further elaborated in chapter 4.
- There have been conflicts among states on sovereign control over ENR technologies. "Haves" of such technologies require "have-nots" to renounce their sovereign control over the technologies, but the latter are against it.

Considering the above facts, the following features are highlighted as MNA features.

- Nuclear non-proliferation (Safeguards, Nuclear security)
- Assurance of supply of nuclear fuel and nuclear fuel cycle services
- Nuclear safety
- Nuclear cooperation agreements (NCAs)
- Siting - choice of host state
- Multilateral involvement
- Access to technology
- Economics
- Transportation

2.1.2 Efforts from 1990s to Early 2000s

The Berlin Wall came down and the Cold War ended in 1989. The First Strategic Arms Reduction Treaty (START-I) was signed and the Soviet Union collapsed in 1991. Under these circumstances, accumulation of highly enriched uranium (HEU) and plutonium from excess nuclear weapons became potential sources of nuclear proliferation concerns. In order to avoid further accumulation of separated plutonium from civilian reprocessing, many proposals on spent fuel management have been presented since the 1990s. This is a characteristic of MNA proposals in this period and Table 3 [22] describes some of these proposals.

Table 3 MNA proposals from 1990s to early 2000s

Proposals	Description / → results	MNA features
International Monitored Storage System (IMRSS) Mid-1990s	• A concept of international storage of spent fuel and plutonium under international supervision. • Spent fuel could be retrieved at any time for peaceful use or disposal. → No actual negotiations took place.	• Non-proliferation • Political and public acceptance • Siting – choice of host state • Transportation
Proposal by Marshall Islands 1994–1999	• A proposal initiated by the Marshall Islands for disposing spent fuel and High Level Waste (HLW) in its territory. • Revenue was to be used for nuclear test site remediation. → The initiative was terminated by strong opposition from the U.S. and other Pacific states.	
Wake Island/Palmyra Island 1990s	• A proposal initiated by U.S. Fuel and Security with a Russian partner. • Spent fuel storage and excess plutonium on Palmyra and Wake Island. → Faced with strong opposition from the U.S. government ant. Abandoned in favor of a proposal by Non-Proliferation Trust.	
Non-Proliferation Trust 1998	• A proposal by Non-Proliferation Trust with a Russian partner. • Long-term disposal of foreign-origin spent fuel in Russian territory. • Revenue was to be used for waste storage, clean-up of Russian nuclear sites and for Russian citizens. → Russia initiated its own proposal including reprocessing and this proposal lost its momentum.	

Proposals	Description / → results	MNA features
Pangea Project 1990–2000	A proposal led by Pangea Resources, a U.K.-based joint venture of British Nuclear Fuels Limited, Golder Associates and Swiss radioactive waste management entity Nagra, for disposing spent fuel and HLW in Western Australia. → Pangea Resources abandoned the Project in 2000, due to opposition from the state of Western Australia and the Australian Federal Parliament. The Western Australian parliament passed a bill to make it illegal to dispose of foreign high-level radioactive waste in the state without specific parliamentary approval.	• Non-proliferation • Assurance of supply (spent fuel take-back) • NCAs • Siting – choice of host state • Multilateral involvement • Transportation • Political and public acceptance
A Russian technical storage or reprocessing facility 2001 [23]	• The Russian Ministry of Atomic Energy would commercially import, temporarily store, reprocess foreign-origin spent fuel in Russian territory and repatriate it to its generating states. • Since the Russian Environment Protection Law was amended in 2001 to allow foreign-origin spent fuel import for technical storage and reprocessing, Russia is able to initiate such an initiative. →The U.S. did not give authorization for U.S.-origin spent fuel exports to Russia, due to its opposition to reprocessing and Russian support for Iran's nuclear program. (The U.S. controls some 80% of the world's spent fuel. Under the U.S. Atomic Energy Commission (AEC), U.S.-origin spent fuel can neither be transferred for storage nor reprocessing to a third country without U.S. consent.)	

By analyzing proposals in Table 3, the following facts can be extracted;

- MNA facilities, especially spent fuel storage, need to be politically and publically accepted. Without such acceptance, MNA facilities cannot be established, although this fact also applies to a nation based spent fuel storage.
- Differences in nuclear non-proliferation policy, especially on reprocessing, between the US and Russia prevented MNAs from being established. The US prevented the establishment of a Russian proposed MNA by not giving its consent for retransfer and reprocessing of US-origin nuclear material under NCAs between the US and RSs.

Considering the above facts, the following features are highlighted as MNA features.

- Nuclear non-proliferation
- Assurance of supply (spent fuel take-back)
- Nuclear Cooperation Agreements (NCAs)
- Siting - choice of host state
- Multilateral involvement
- Transportation
- Political and public acceptance

2.1.3 Efforts from 2000 to the Present

Heading into the 21st century, in the era of Nuclear Renaissance, many new and existing states, especially in the Asian region, have declared their ambitious nuclear energy utilization plans in order to satisfy the energy demands of rapid economic growth as well as being necessary to reduce emissions of greenhouse gases. On the other hand, nuclear proliferation concerns have increased with nuclear activities in the DPRK, Iran and Syria, and by non-state actors', such as the nuclear black market. Under such circumstances, former IAEA Director General ElBaradei proposed a MNA in 2003 [24]. Since then, various proposals, mainly focused on the assurance of nuclear fuel supply, have been initiated by NSSs as described in Table 4. Among them, the establishment of the IAEA fuel bank was approved by the IAEA Board of Governors in 2010 and the bank has been on its way to establishment in Kazakhstan [25].

Table 4 MNA Proposals from 2000 to the present

Proposals	Description	MNA features
"Multilateral Approaches to the Nuclear Fuel Cycle: an expert group's report on MNA submitted to the Director General of the International Atomic Energy Agency" (INFCIRC/640, so called "Pellaud Report") [26]	• Experts appointed by ElBaradei, former IAEA director-general, identified five suggested approaches to MNAs for a possible MNA for the front-end and back-end of the nuclear fuel cycle for strengthening nuclear nonproliferation, without disturbing market mechanisms. • The Pellaud Report presents 7 "Labels" as MNA assessment elements including (a) non-proliferation, (b) assurance of supply, (c) siting-choice of host country, (d) access to technology, (e) multilateral involvement, (f) special safeguards provision, and (g) non-nuclear inducements.	(See Table 5)
Reserve of nuclear fuel [27] (renamed as American Assured Fuel Supply (AFS))	• A proposal by the U.S. Department of Energy (DOE) of creating a LEU reserve down-blended from 17.4 metric tons of HEU dismantled from the U.S.'s excess nuclear weapons. The reserve assures reliable fuel supply for states that forgo enrichment and reprocessing. • A notice of availability of AFS was put on the federal register on 3 December 2013 [28].	• Non-proliferation • Assurance of supply of nuclear fuel and nuclear fuel cycle services • Multilateral involvement • Access to technology
Russia global nuclear power infrastructure (GNPI) [29]	A proposal from the Russian Federation including the creation of international centers providing uranium enrichment services on a non-discriminatory basis and under the control of the IAEA.	

Proposals	Description	MNA features
U.S. Global Nuclear Energy Partnership (GNEP) [30]	• A U.S. DOE proposal including developing proliferation-resistant reprocessing technology, and advanced fast reactors, minimizing nuclear waste and establishing reliable fuel supply and spent fuel take-back (fuel-leasing) services. • A consortium of nations with advanced nuclear technologies would ensure that countries who agree to forgo their own investment in enrichment and reprocessing technologies will have reliable access to nuclear fuel. • The initiative was canceled by President Obama's administration in June 2009.	• Non-proliferation • Assurance of supply of nuclear fuel and nuclear fuel cycle services (Fuel leasing) • Siting- choice of host state • Multilateral involvement • Access to technology
Ensuring Security of Supply in the International Nuclear Fuel Cycle [31]	• A World Nuclear Association (WNA) proposal of a three-level mechanism to ensure enrichment services. • The proposal originally had a precondition for RSs to forgo domestic development of sensitive technologies and facilities, but later it abandoned such precondition.	
Concept of Multilateral Mechanism for Reliable Access to Nuclear Fuel [32]	A proposal by six enrichment services supplier States (US, UK, Russia, France, Germany and Netherlands) for two levels of enrichment assurance for customer states that have chosen to obtain suppliers on the international market and not to pursue sensitive fuel cycle activities.	

Proposals	Description	MNA features
IAEA Fuel Bank	• A proposal by the Nuclear Threat Initiative (NTI) to create a LEU stockpile with extraterritorial status owned and managed by the IAEA that could be made available should other supply arrangements be disrupted. • "Having the right to receive LEU from the guaranteed supply mechanism shall not require giving up their right to establish or further develop a national fuel cycle or have any impact on it" [33]. • For the establishment of the Bank, other than the NTI, the US, Kuwait and Norway had donated to the IAEA for the establishment of the bank, while the UAE and European Union have pledged their donations [34]. • The IAEA Board of Governors approved the establishment of the bank in 2010. Kazakhstan was decided on to host the bank and as of May 2014, "to finalize the decision on selecting the site, the IAEA and the Government of Kazakhstan are discussing the relevant technical matters" [35].	• Non-proliferation • Assurance of supply of nuclear fuel and nuclear fuel cycle services • Multilateral involvement • Access to technology • Siting- choice of host state (extraterritorial status) • Political and public acceptance
Enrichment Bonds [36] (renamed as Nuclear Fuel Assurance (NFA) [37])	• A U.K. proposal, a bonding principle that would, in the event that the Agency determines that specified conditions have been met: (a) guarantee that national enrichment providers would not be prevented from supplying enrichments services; and (b) provide advance consent for export assurances. • RSs are not required to give up their rights to develop an indigenous fuel cycle by receiving alternate nuclear fuel.	

Proposals	Description	MNA features
International Uranium Enrichment Center (IUEC) at Angarsk and its LEU Reserve [38]	• A Russian proposal to establish an International Uranium Enrichment Centre (IUEC), including a LEU reserve. In November 2009, the IAEA Board of Governors authorized the IAEA Director General to sign and implement an agreement with Russia to establish the LEU Reserve. The agreement was signed in March 2010 and the LEU reserve was established in December 2010 [39]. • RSs are not required to give up their rights to develop an indigenous fuel cycle by receiving nuclear fuel from the stockpile.	• Non-proliferation • Assurance of supply of nuclear fuel and nuclear fuel cycle services • Multilateral involvement • Access to technology (black box) • Siting- choice of host state (extraterritorial status)
Multilateral Enrichment Sanctuary Project (MESP) [40]	• A German proposal for an international enrichment center established by a group of interested states, with extraterritorial status, operating on a commercial basis as a new supplier in the market under IAEA control providing enrichment services. • An enrichment plant would have to be constructed as a 'black box' and would therefore only be accessed and maintained by the enrichment technology holder.	

By analyzing proposals in Table 3, the following facts can be extracted;

- In contradiction to proposals in the 20th century, most proposals in the 21st century do not require RSs to renounce their ENR capabilities. This is a change in NSSs' approaches to RSs. They have recently been trying to reduce RSs' incentives to have such capabilities. This is the "demand-side approach" mentioned in chapter 1.
- A proposal to establish the IAEA Fuel Bank could successfully obtain approval from the IAEA Board of Governors. Different from the 20th century, both the US and Russia jointly agreed to the idea. Currently both states also have their own LEU reserves (US's AFS and the Russian's fuel reserve at IUEC).
- It is also partly due to the fact that enough funds for the IAEA Fuel Bank was ensured by the NTI, US, EU, Kuwait, UAE and Norway. Compared with the fact that almost no RSs, including states in the Middle East, had agreed to the idea of MNAs in the 20th century, this is one new change in the 21st century.

Considering the above facts, the following features are highlighted as MNA features.

- Non-proliferation, safeguards, security
- Assurance of supply of nuclear fuel and nuclear fuel cycle services (fuel-leasing)
- Safety
- Siting - choice of host state
- Multilateral involvement
- Access technology
- Economics
- Political and public acceptance

It is worth noting that the US GNEP and the Russian GNPI included the spent fuel take-back (fuel-leasing) concept as one measure for promoting both nuclear energy utilization and nuclear non-proliferation. However, the Obama administration terminated both the GNEP and the Yucca Mountain nuclear waste repository project in 2009. Therefore, the US in principle cannot accept spent fuel from other states' thermal reactors, even if such fuel is US-origin.

2.1.4 Short Summary of Section 2.1

As described in Table 2, an international organization, such as IAEA, controlled MNAs focused on both front-end and back-end of nuclear fuel cycle were explored to be established from 1940s to 1980's. As shown in Tables 3 and 4, efforts for MNA establishments focused on storage and / or disposal of spent fuel and / or waste (back-end of nuclear fuel cycle) from 1990s to early 2000s, while efforts from 2000's to the present focus on nuclear fuel (front-end of nuclear fuel cycle). In this way, needs for MNAs vary depend on time and its political environment on nuclear non-proliferation and nuclear energy utilization in the world, but as universally common features, the following 10 features were highlighted as MNA features.

- Nuclear non-proliferation
- Assurance of supply of nuclear fuel and nuclear fuel cycle services
- Nuclear safety
- Nuclear cooperation agreements (NCAs)
- Siting - choice of host state
- Multilateral involvement
- Access to technology
- Economics
- Transportation
- Political and public acceptance

Among above 10 features, the first 2 features, namely nuclear non-proliferation and supply assurance of nuclear fuel and nuclear fuel cycle services, they certainly appear in every MNA proposals, for ensuring (i) MNA's purposes of promoting peaceful use of nuclear energy and nuclear non-proliferation.

Regarding NCAs, for example, as the US-origin spent fuel could not be transferred to Russia due to an absence of US's consent for transfers under NCAs, they served as a factor in preventing (ii) smooth function of MNAs. In this respect, some measures to harmonize between MNAs and NCAs need to be implemented for smooth function of MNAs.

As for the last 6 features, their characteristics are slightly different from the first 4 features, by involving (iii) practical feasibility of MNA's establishments, rather than conceptual and functional aspects of MNAs of the first 4 features.

Furthermore, in addition to the above ten features, two more features can be highlighted from the successful MNA cases of the IAEA fuel bank, EURODIF and URENCO as well as reasons of current discussion on supply assurance of nuclear fuel. One feature is "nuclear third party liability (TPL)" and the other feature is "geopolitics".

As to the former feature of "nuclear third party liability (TPL)", in the first place, without setting a proper nuclear TPL system as well as preparing financial security for compensation for nuclear damage, nuclear facilities can start neither construction nor operation. Second, the accident at Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Plant Station in March 2011 (the Fukushima nuclear accident) caused recognition of the importance of nuclear TPL systems. Third, Kazakhstan, a host state of the IAEA fuel bank and EURATOM member states all participate in one international nuclear TPL convention and enact necessary domestic legislation on nuclear third party liability. As further mentioned in chapter 5, by this international convention on TPL, transboundary damage are to be compensated based on common role on nuclear TPL, without discrimination based on nationality, domicile or residence. In the same way, MNAs consisting of multilateral states need to implement such arrangements and such arrangements lead to ensure (ii) smooth function of MNAs.

Regarding "geopolitics" feature, especially discussion on MNAs in the 21st century stemmed from international efforts to discourage uranium enrichment activities in Iran and the DPRK, for fear of a potential cause of nuclear arms race in the politically unstable Middle East and the Korean Peninsula. This is an issue of geopolitics and nuclear non-proliferation, and in this context, geopolitical consideration is required for establishing MNAs. In addition, currently, importance of ensuring transport security has been actively discussed in Nuclear Security Summits, from nuclear non-proliferation viewpoint. Considering the fact that long-distance, mass and frequent nuclear transports are anticipated among MNA member states, due to limited number of MNA-ENR facilities, geopolitical consideration is inevitable for deciding transportation routes. Such geopolitical considerations support a (iii) practical goal of establishing MNAs.

Therefore, together with nuclear TPL and geopolitics features, in total twelve features can be highlighted from past efforts for establishing MNAs. As mentioned above, twelve features either serve (i) MNA's purposes, (ii) functions or (iii) practical feasibility. In other words, it can be interpreted that those (i), (ii) and (iii) are all MNA's requirements and MNA features need to satisfy such requirements.

2.2 Analysis of MNA Features

2.2.1 Features in Past Studies on MNAs

There have already been a few studies on MNAs which have analyzed MNA features. Among them, the Pellaud Report used seven "Labels" as key assessment elements of MNAs. Those Labels from A to G are briefly shown in Table 5. According to the Pellaud Report, among these seven Labels, Label A and B are "primary deciding factors in the consideration of multilateral approaches" [41].

Table 5 Seven elements of assessment in the Pellaud Report

Labels	Values	Contents
Label A	Nuclear non-proliferation	Proliferation risks include: (a) Diversion of materials, (b) Breakout scenarios and clandestine parallel programs, (c) Diffusion, and (d) Security risks
Label B	Assurance of supply	Assurance includes: (a) Guarantees, (b) Economics, (c) Political and public acceptance and (d) Security and safety
Label C	Siting- choice of host county.	Host states of MNA facilities are categorized as: (a) Special arrangements – legal structures limiting national jurisdiction on the site of MNA fuel cycle facilities ("extra-territorial" status), (b) States that are already technology holders, and (c) States that are not technology holders.
Label D	Access to technology	Access varies: (a) Full access, (b) Assembly and maintenance know-how, (c) Operational know-how and (d) None
Label E	Multilateral involvement	Involvement varies: (a) Supply-only arrangement (minimum access), (b) Ownership, (c) Management,

		(d) Operation, and (e) Joint research and development, design and construction of facilities (maximum access)
Label F	Special safeguards provisions	Safeguards varies: (a) Expanded facility-specific safeguards agreement, (b) Additional Protocol, (c) Special safeguard arrangements, and (d) Continuity of safeguards
Label G	Non-nuclear inducements	Non-nuclear inducements. Such inducements includes: (a) Trade benefits, (b) Security arrangements (regional / international), (c) Security guarantees / assurance (d) Assistance in the development of the (non-nuclear) energy sector

As shown in Table 6, among past studies on MNAs, the EU paper on Nuclear Fuel Cycle presented that MNAs need the four features of proliferation resistance, assurance of supply, consistency with equal rights and obligations of suppliers, companies, consumer states and the IAEA, and market neutrality [42]. T. Suzuki clarified that MNAs need three features in addition to nuclear non-proliferation and supply assurance: universality (nondiscrimination between haves and have-nots), transparency (IAEA Additional Protocol (AP) or equivalent safeguards) and economic viability (consistency with global nuclear fuel market activities and economic rationale) [43].

2.2.2 MNA Features

Table 6 summarizes features extracted from past efforts analyzed in section 2.1 as well as from past studies mentioned above.

Table 6 MNA features extracted from past efforts and studies on MNAs

MNA features extracted from past efforts for establishing MNAs	MNA features, including elements of assessment of MNAs, through past studies on MNAs		
	Pellaud Report	EU Paper	T. Suzuki
(A) Nuclear non-proliferation	←(A) Non-Proliferation	←(A)Proliferation resistance	• ←(A)Non-proliferation • ←(A)Transparency: IAEA Additional Protocol (AP) or equivalent safeguards)
(B) Assurance of supply (of nuclear fuel and nuclear fuel cycle services)	←(B)Assurance of supply	←(B)Assurance of supply	←(B)Assurance of supply
(C) Nuclear safety			
(D) Nuclear cooperation agreements (NCAs)			
(E) Nuclear third party liability (TPL)			
(F) Siting - choice of host state	←(F) Siting - choice of host state		
(G) Multilateral involvement	←(G) Multilateral involvement		
(H) Access to technology	(H) ←Access to technology	←(H)Consistency with equal rights and obligation of suppliers, consumer states and the IAEA	←(H)Universality: (non discrimination between haves and have-nots
(H) Economics		←(I)Market neutrality	←(I)Economic: consistency with global nuclear fuel market activities and economic rationale
(I) Transportation			
(J) Geopolitics	(K), (L)←Non-nuclear inducement		
(K) Political and public acceptance			

As indicated by arrows in Table 6, all features presented in the past studies can be incorporated into the twelve features analyzed in section 2.2.

2.3 Categorization of MNA Features

As briefly mentioned in section 2.1.4, in order to establish functional and feasible MNAs, each MNA feature needs to satisfy one of following three MNA's requirements.

(i) To accomplish MNA's essential purposes of promoting both nuclear non-proliferation and peaceful us of nuclear energy.
(ii) To promote MNA's smooth functions, such as smooth and timely supplies of nuclear fuel and nuclear fuel cycle services within MNA member states
(iii) To contribute MNA's practical feasibility for establishing MNAs.

In this study, MNA features satisfying an above (i) requirement are called "essential features", while features satisfying an above (ii) requirement are called "functional features". MNA features satisfying an above (iii) requirement are called "practical features".

The twelve MNA features extracted in the previous section can then be categories as following Table 7.

Table 7 Categorization of twelve MNA features

categories	Features
(i) Essential features	(A) Nuclear non-proliferation (including safeguards, nuclear security and export control) (B) Assurance of supply (of nuclear feel and nuclear fuel cycle services) (C) Nuclear Safety
(ii) Functional features	(D) Nuclear cooperation agreements (NCAs) (E) Nuclear third party liability (TPL)
(iii) Practical features	(F) Siting - choice of host state (G) Multilateral involvement (H) Access to technology (I) Economics (J) Transportation (K) Geopolitics (L) Political and public acceptance

The first category is “essential features” which enables MNAs to accomplish MNA’s purposes of promoting peaceful use of nuclear energy and nuclear non-proliferation. (A) Nuclear non-proliferation, (B) assurance of supply features and (C) nuclear safety features are included in this category.

Regarding features (A) and (B), as mentioned in chapter 1, Yudin describes MNAs that have “a substantial potential to ensure that the benefits of nuclear energy are made available to all countries, while further strengthening the nuclear nonproliferation regime, ensuring safe and secure management of the nuclear fuel cycle, and reducing incentives to build new nuclear fuel cycle facilities in countries that do not now have them” [44]. In other words, MNAs have a potential to reduce incentives to build new sensitive facilities, such as ENR facilities, in countries that do not now have them, by providing (B) assurance of supply of nuclear fuel and nuclear fuel cycle services to RSs. In this context, MNAs must have this (B) assurance of supply feature and this explains why this (B) is one of the essential features of MNAs. It is no wonder that the MNAs alone cannot reduce every nuclear proliferation concern; however, they at least have a potential to reduce such incentives through supply assurance.

As for (C) nuclear safety, originally, (c) is not necessarily treated as a purpose of the MNA. However, considering the following facts show that (C) is closely interrelated and interdependent with (A) nuclear non-proliferation and (B) assurance of supply features, it should be one of the purposes of MNAs, the same as (A) and (B).

- The Fukushima nuclear accident revealed the fact that nuclear safety vulnerabilities could also be nuclear security vulnerabilities, and vice versa. For example, nuclear accidents can be caused not only by system failures of nuclear facilities and/or operators’ human error, but also by terrorists’ attacks and/or sabotage. Whatever the reasons for nuclear accidents, the result of the accidents are the same. Therefore, risk mitigation, preventive measures and emergency preparedness against nuclear accidents need to be well considered from aspects of both (A) nuclear non-proliferation, especially nuclear security, and (B) nuclear safety.
- Every nuclear facility, including MNA facilities, is required to maintain nuclear safety. Without safety, no facilities are allowed to start and/or continue their operations.

- By ensuring nuclear safety, risks of nuclear accidents can be reduced. Safety facility operations directly lead to sustainable, economical and efficient facility operations and to support (B) assurance of supply of nuclear fuel and nuclear fuel cycle services.

Detailed measures of these essential features which satisfy a MNA's requirement of accomplishing MNA purposes will be further discussed in chapter 3.

The second category is "functional features" and these features promote the smooth functioning of the MNA by ensuring smooth supply of nuclear fuel and nuclear fuel cycle services within MNA member states and/or between MNA member states and non-members. Features of (D) nuclear cooperation agreements (NCAs) and (E) nuclear third party liability (TPL) are included in this category.

For example, regarding (D) NCAs, as already explained in sections 2.1.2 and 2.1.4, smooth supplies of nuclear fuel and services among MNA member states can be prevented without being granted necessary advance consent from NSSs under NCAs between MNA and NSSs, when utilizing NSSs-origin nuclear material in MNA facilities. Therefore, harmonization between the MNA and the (D) NCAs is necessary to maintain the MNA's functionality.

As to (E) Nuclear TPL, as already mentioned in section 2.1.4, nuclear accidents disturb nuclear facility operation and consequently secure and smooth supplies of nuclear fuel and nuclear fuel cycle services would be disrupted. As the same as a nation based nuclear facilities, the MNA needs to establish a robust nuclear third party liability system which enables to offer timely and appropriate compensation for nuclear damage, including transboundary damage, caused by nuclear accidents within MNA facilities.

Detailed measures of these functional features which satisfy a MNA's requirement of ensuring MNA's smooth function will be further discussed in chapters 4 and 5.

The last category is "practical features" and they contribute to MNA's practical feasibility. The seven features of (F) Siting - choice of host state, (G) Multilateral involvement, (H) Access to technology, (I) Economics, (J) Transportation, (K) Geopolitics and (L) Political and public acceptance are included in this category.

For example, in order to practically establish MNAs, (F) host states of MNA facilities, and how far each MNA member state involves in MNA facilities (G) and access to technology (H), as well as (J) transportation routes, need to be well decided among MNA member states in advance, from perspectives of either supporting or not disturbing both essential and functional features. As to other MNA features of (I) Economics, (K) Geopolitics and (L) Political and public acceptance, their characteristics and roles within MNAs are slightly different from other practical features of (F), (G), (H) and (J). They are rather ones of primary deciding factors in discussing other MNA features of (F), (G), (H) and (J). From this viewpoint, practical features are interrelated and interdependent each other for supporting MNA's practical feasibility.

Detailed measures of these practical features which satisfy a MNA's requirement of contributing MNA's feasibility will be further discussed in chapter 6.

In principle, MNAs satisfying these twelve features in three categories are able to be established.

2.4 Summary of Chapter 2

From past efforts for establishing MNAs and studies on MNAs, twelve MNA features from (A) to (L) are extracted. They are (A) Nuclear non-proliferation, (B) Assurance of supply (of nuclear material and nuclear fuel cycle services), (C) Nuclear safety, (D) Nuclear cooperation agreements (NCAs), (E) Nuclear third party liability (TPL), (F) Siting - choice of host state, (G) Multilateral involvement, (H) Access to technology, (I) Economics, (J) Transportation, (K) Geopolitics and (L) Political and public acceptance.

Each MNA feature needs to satisfy one of following three MNA's requirements of

(i) Accomplishing MNA's essential purposes of promoting both nuclear non-proliferation and peaceful us of nuclear energy, as essential features,

(ii) Promoting MNA's smooth functions, such as smooth and timely supplies of nuclear fuel and nuclear fuel cycle services within MNA member states, as functional features, or

(iii) Contributing MNA's practical feasibility for establishing MNAs, as practical features.

(A), (B) and (C) are categorized as essential features, while (D) and (F) are categorized as functional features. Features from (F) to (L) are categorized as practical features.

In principle, MNAs satisfying these twelve features are expected to be able to be established.

Chapter 3 Essential Features

Chapter 3
Essential Features

Essential features include (A) Nuclear non-proliferation, (B) Assurance of supply and (C) Nuclear safety. In this chapter, detailed measures of these essential MNA features which enable to satisfy one of MNA requirements of accomplishing MNA's purpose of promoting peaceful use of nuclear energy and nuclear non-proliferation are discussed.

3.1 Nuclear Non-Proliferation

The MNA needs to maintain a robust nuclear non-proliferation characteristic, since one of the MNA's purposes is nuclear non-proliferation. The NSG Guidelines as described below and nuclear cooperation agreements (NCAs) in the chapter 4 also require this characteristic.

As mentioned in chapter 1, the NSG Guidelines are the guidelines of nuclear suppliers for nuclear-related exports and set out nuclear non-proliferation criteria which nuclear supplier states (NSSs) should follow when exporting their nuclear-related items to recipient states (RSs). Regarding transfers of ENR facilities, equipment and technology (ENR-related items), Paragraph 6(a) of the current Guidelines [45] sets out the following six criteria which "suppliers should not authorize the transfer of enrichment and reprocessing facilities, and equipment and technology therefore if the recipient does not meet, at least, all the following criteria:"

- (i) Is an NPT member state and in full compliance with its obligations under the Treaty,
- (ii) Has 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 programme, nor has been reported by the IAEA Secretariat as a state where the IAEA is currently unable to implement its safeguards agreement,
- (iii) Is adhering to the NSG Guidelines and has reported to the Security Council of the United Nations that it is implementing effective export controls as identified by Security Council Resolution 1540,

(iv) Has concluded an inter-governmental agreement with the supplier including assurances regarding non-explosive use, effective safeguards in perpetuity, and retransfer,

(v) Has made a commitment to the supplier to apply mutually agreed standards of physical protection based on current international guidelines, and

(vi) Has committed to IAEA safety standards and adheres to accepted international safety conventions.

These comprehensive criteria are the "objective criteria" and they are categorized as nuclear non-proliferation-(i), safeguards-(ii), export control-(iii), nuclear security-(v), nuclear safety-(vi) and bilateral NCAs-(iv) provisions.

Those objective criteria can be also understood as if RSs satisfy these criteria, in principle they are recognized to have a nuclear non-proliferation characteristic which is strong enough to be transferred ENR-related items, except for nuclear suppliers' "subjective criteria" that suppliers take "into account at their national discretion, any relevant factors as may be applicable" (the Paragraph 6(b) of the Guidelines).

In this context, if ENR activities, including ENR transfers, are expected within the MNA, MNA member states are also required to satisfy the above requirements in Paragraph 6(a) of the Guidelines.

In this section, based on the above requirements, detailed measures to enhance the (A) Nuclear non-proliferation feature are discussed, from aspects of non-proliferation-(i), safeguards-(ii), export control-(iii), nuclear security-(v). Nuclear safety-(vi) and NCAs-(iv) will be discussed in section 3.3 and chapter 4 respectively.

In principle, these nuclear non-proliferation measures should be tailor-made depending on each MNA member state, since the nuclear non-proliferation circumstances surrounding each state are different from others. However, in this section, common and minimum measures, especially from a legal viewpoint are the focus. In addition, EURATOM's legal measures and procedures for nuclear non-proliferation are referenced, since both EURODIF and URENCO, as existing examples of MNAs, belong to EURATOM.

3.1.1 Treaty on the Non-Proliferation of Nuclear Weapons

First of all, MNA member states need to be NPT members, since the MNA aims to ensure nuclear non-proliferation and the NPT is the core of the nuclear non-proliferation regime.

Article 3 of the NPT stipulates NNWSs' obligation to accept IAEA comprehensive safeguards and will be further discussed in section 3.1.2.

Article 4 of the NPT prescribes MNA members' inalienable right to use nuclear energy for peaceful purposes. This provision also needs to be respected and NWSs (most of them are NSSs) and NNWSs (most of them are RSs) need to be treated equally without discrimination. As mentioned in chapter 2, history shows that efforts for establishing MNAs with infringements on Article 4 are heavily criticized by RSs and NNWSs and have hardly been established. In addition, as participation in the MNA is fully voluntary, RSs would be reluctant to participate in a MNA under this kind of requirement and treatment.

3.1.2 Safeguards

First, if MNA member states are NNWSs, they are required to conclude a comprehensive safeguards agreement (CSA) with IAEA and all their nuclear activities need to be placed under the IAEA Safeguards, as required by Article 3 of the NPT.

Second, in addition to the CSA, MNA member states' nuclear non-proliferation characteristic is significantly strengthened through enhancing transparency of their nuclear activities, by application of the IAEA Safeguards Additional Protocol (AP) [46]. The AP, however, is literally additional, and current NCAs between NSSs and RSs do not necessarily require the latter AP ratification. On the other hand, Paragraph 6(c) of the NSG Guidelines requires RSs' AP ratification or "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" [47] for ENR transfers. In this respect, it is understood that in the case of ENR transfers, the RSs are required to ratify the AP or to have a safeguards system which is internationally recognized as equivalent to the AP, such as regional safeguards of the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC).

Third, as mentioned in chapter 1, EURODIF's and URENCO's nuclear non-proliferation characteristics are supported by EURATOM's regional safeguard system and the Regional System of Accounting for and Control of nuclear material (RSAC).

John Carlson emphasizes the regional safeguards have the following advantages: [48]

- Enhance mutual confidence in their respective regions, by providing for additional non-proliferation commitments
- Promote transparency by providing mechanisms for dissemination of information
- Enhance confidence by providing mechanisms for seeking clarifications of Parties' activities
- Support non-proliferation regime and IAEA Safeguards

The ABACC is another existing organization for a regional safeguards system and according to the ABACC, it "serves as an international model of transparency and confidence building" [49].

Therefore, if these internationally-recognized, including recognition by the IAEA, regional safeguards are established within a MNA, the MNA itself will also contribute to enhancing nuclear non-proliferation characteristics by transparency of nuclear activities with a "neighbors checking neighbors" [50] system, together with confidence-building.

Figure 3 [51] briefly describes safeguards by the IAEA plus regional safeguards for MNA facilities (Case 2), compared with those of a nation based facility (Case 1). It is easy to understand that an additional layer of safeguards and nuclear material accounting checks are provided by regional safeguards agencies such as EURATOM and ABACC.

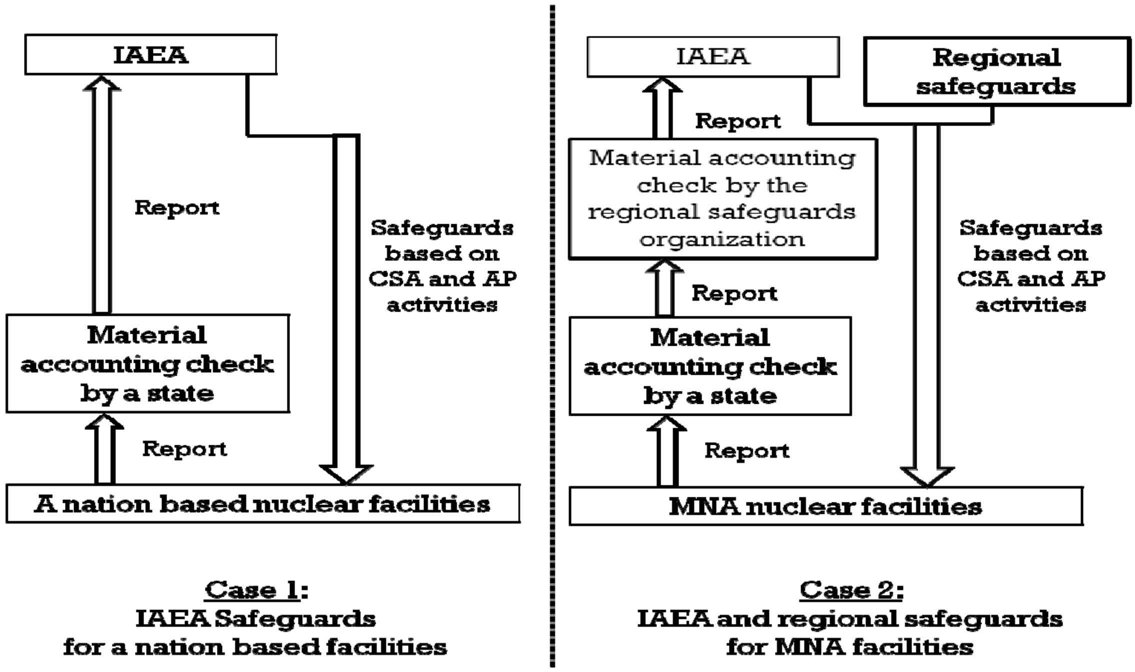


Figure 3 IAEA Safeguards for a nation based facilities and IAEA plus regional safeguards for MNA facilities

In addition, it is worth noting that considering the fact that the ABACC supports verification activities of the Agency for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (OPANAL), an inter-governmental agency created by the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (Treaty of Tlatelolco), the establishment of these regional safeguards organizations has the potential for future establishment of a Nuclear Weapons Free Zone (NWFZ).

3.1.3 Nuclear Security

Concerning nuclear security, the September 11 terrorist attacks in New York and the Fukushima nuclear accident in March 2011 reminded the world nuclear community of the urgent need to strengthen security measures for nuclear materials and facilities, together with nuclear safety. In this context, there are international conventions on nuclear security and the IAEA issues various nuclear security guidelines.

Therefore, if MNA member states participate in and follow these conventions and guidelines, MNAs are equipped with robust nuclear security characteristics.

- Convention on the Physical Protection of Nuclear Material (CPPNM, INFCIRC/274) and its Amendment (the Amendment has not yet entered into force, as of May 2014)
- International Convention for the Suppression of Acts of Nuclear Terrorism
- IAEA Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Rev.5)
- IAEA Nuclear Security Series (Nuclear Security Fundamentals, Recommendations, Implementing Guides, Technical Guidance)

In addition, due to the international nature of the MNAs, MNA facilities would consist of international staff of various nationalities. Therefore, measures against internal threats involving nuclear material and facilities, including the theft of fissile material and sensitive information and sabotage, have to be implemented.

As for EURATOM's role in nuclear security for its member states, contrary to its role on nuclear safety which will be mentioned in section 3.3, the EURATOM Treaty does not expressly mention its role on nuclear security. Although "the EU has made a commitment to implement the highest international standards in the field of nuclear security" [52], the Ad Hoc Group on Nuclear Security indicated that "there is an international consensus that responsibility for nuclear security within a State rests entirely with that State as it is a matter of national security" [53]. Therefore, currently there are no specific common standards on nuclear security, however, it was suggested that "the significant expertise, budgets and financial instruments, and frameworks for internal and external action that exist at the EU level should be used to strengthen nuclear security" [54].

As for MNAs, the same as with EURATOM it would not be easy to set up common nuclear security standards from the very beginning, but at least setting up the bare minimum of nuclear security guidelines would not necessarily be impossible.

3.1.4 Export Control

As already mentioned in section 3.1, MNA member states need to follow NSG Guidelines, including satisfying the "objective criteria" of Paragraph 6(a) of the Guidelines. By doing so, MNA member states are in principle recognized to have strong nuclear non-proliferation characteristics, which is enough to be transferred ENR technologies.

In addition, as mentioned in the same Paragraph 6(a) of the Guidelines, MNA member states need to follow United Nations Security Council Resolution (UNSCR) 1540 [55], which sets out UN members' obligation to enforce effective measures for non-proliferation of nuclear, chemical and biological weapons, and their delivery systems.

In summary, for the (A) Nuclear non-proliferation feature of MNAs, based on the nuclear non-proliferation criteria in Paragraph 6(a) of the NSG Guidelines, MNA member states need to follow the NPT, IAEA Safeguards, conventions and guidelines on nuclear security as well as export control. In addition, the same as with EURODIF and URENCO, implementation of regional safeguards and RSAC contribute to enhance member states' nuclear non-proliferation characteristics through transparency of their nuclear activities. Also the same as EURATOM, common nuclear security guidelines among MNA member states are expected to contribute enhancing the nuclear security aspect of MNAs.

3.2 Assurance of Supply of Nuclear Fuel and Nuclear Fuel Cycle Services

Regarding the (B) "Assurance of supply" feature, from the perspective of MNA's aim to ensure nuclear non-proliferation and promote nuclear energy use, both ENR services and their products of nuclear fuel (low enriched uranium (LEU)) need to be assured by MNAs. Such supplies can be ensured not only by participations of states with such capabilities in MNAs, but also by purchases from non-MNA NSSs through concluding NCAs between MNAs as a whole and NSSs.

In addition, if the MNA also includes spent fuel storage and / or fuel-leasing services, it would make the MNA more attractive, since many states have been struggling with their own spent fuel management. As to fuel-leasing, the U.S. National Academy also points out that "arrangements that would provide assured return of spent nuclear fuel could provide a much more powerful incentive for countries to rely on international nuclear fuel supply than would assured supply of fresh fuel" [56]. However, the greatest hurdle is to find a specific location and a state which is able to provide spent fuel management services to other states.

In summary, for the (B) Assurance of supply feature of the MNA, from a nuclear non-proliferation viewpoint, the MNA needs to assure supplies of LEU and ENR activities. In addition, if the MNA is able to offer spent fuel storage and / or fuel-leasing services, it would make the MNA more attractive.

3.3 Nuclear Safety

Regarding the (C) Nuclear safety feature, as mentioned in section 2.3, it is not necessarily a purpose of the MNA. However, it needs to be treated as one of essential MNA features.

Unlike the IAEA Safeguards obligations under the NPT, there are no international obligatory nuclear safety systems. But as mentioned in section 3.1, Paragraph 6(a) of the NSG Guidelines requires states to commit to IAEA safety standards and to adhere to nuclear safety conventions for nuclear non-proliferation. In this context, MNA member states need to participate in international conventions on nuclear safety and enact the relevant nuclear safety regulations.

Currently there are the following nuclear safety related conventions and guidelines:

- Convention on Early Notification of Nuclear Accident (INFCIRC/335),
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (INFCIRC/336),
- Convention on Nuclear Safety (INFCIRC/449),
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (INFCIRC/546),
- IAEA Safety Standards Series (Fundamental, Safety Principles, Safety Requirements and Safety Guides).

As for EURATOM's role in nuclear safety, according to the EURATOM Treaty, EURATOM has a mission to "establish uniform safety standards to protect the health of workers and of the general public and ensure that they are applied" [57]. The EU made a proposal to amend the 2009 nuclear safety directive with the "Proposal for a Council Directive amending Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations" [58]. The proposal contains the following points for its efforts for nuclear safety [59];

- Introduces new EU-wide safety objectives;
- Sets up a European system of peer reviews of nuclear installations;
- Establishes a mechanism for developing EU-wide harmonized nuclear safety guidelines;
- Strengthens the role and independence of national regulators; increases transparency on nuclear safety matters; includes new provisions for on-site emergency preparedness and response;
- Increases transparency on nuclear safety matters; and
- Includes new provisions for on-site emergency preparedness and response.

Regarding peer reviews, it is worth pointing out for its member states obligations on nuclear safety, "The EU needs its own verification mechanism to ensure that common safety objectives are achieved. At least every 6 years nuclear installations would have to undergo specific assessments on one or more nuclear safety issues. The assessments would be submitted for EU- wide peer reviews" [60].

In the same way, if MNA member states, as a whole, also set out harmonized nuclear safety standards in accordance with international guidelines on nuclear safety and introduced peer review systems, the MNA's nuclear safety characteristics on nuclear safety, as a whole, would be much strengthened.

In summary, for (C) Nuclear safety features, MNA member states need to participate in nuclear safety related conventions and enact the relevant nuclear safety regulations, together with setting out harmonized nuclear safety standards and introducing peer review systems.

3.4 Summary of Chapter 3

(A) Nuclear non-proliferation feature

One of the purposes of MNAs is nuclear non-proliferation; therefore, the MNA itself needs to maintain a robust nuclear non-proliferation characteristic. Based on the nuclear non-proliferation criteria in Paragraph 6(a) of Part 1 of the NSG Guidelines, MNA member states need to follow the NPT, IAEA Safeguards, conventions and guidelines on nuclear security as well as export control.

At the same time, the same as with EURODIF and URENCO, implementation of regional safeguards and RSAC contribute to enhancing member states' nuclear non-proliferation characteristics through transparency of their nuclear activities.

In addition, common nuclear security guidelines among MNA member states are expected to contribute to enhancing the nuclear security aspect of the MNA.

(B) Assurance of supply of nuclear fuel and nuclear fuel cycle services

The MNA needs to ensure stable supplies of nuclear fuel (LEU) and nuclear fuel cycle services, such as ENR services. Such supplies can be ensured not only by participations of states with such capabilities in MNAs, but also by purchases from non-MNA NSSs through concluding NCAs between MNAs as a whole and NSSs. As many previous studies suggest, from a nuclear non-proliferation perspective, it would be desirable for the MNA to assure supply of spent fuel storage and / or fuel-leasing services including take-back of spent fuel.

(C) Nuclear safety

Originally nuclear safety is not necessarily a purpose of the MNA and ensuring nuclear safety is a responsible of each state. However, by ensuring nuclear safety, risks of nuclear accidents can be reduced and safety facility operations directly lead to sustainable, economical and efficient facility operations as well as to support (B) assurance of supply of nuclear fuel and nuclear fuel cycle services.

Therefore, the MNA member states need to comply with international conventions and standards on nuclear safety to maintain the MNA's robust nuclear safety characteristic. In addition, MNA member states need to establish common nuclear safety standards and carry out peer reviews on nuclear safety among MNA member states, which would significantly strengthen the MNA's nuclear safety characteristics.

Chapter 4 A Functional Feature - Harmonization between MNAs and Nuclear Cooperation Agreements -

Chapter 4

A Functional Feature - Harmonization between MNAs and Nuclear Cooperation Agreements -

One of functional features is (D) Nuclear cooperation agreements (NCAs) and in this chapter, detailed measures of this feature which enable to satisfy one of MNA requirements of ensuring MNA's function are discussed.

4.1 Necessity of Harmonization between MNAs and NCAs

When nuclear supplier states (NSSs) provide recipient states (RSs) with nuclear material, equipment, facilities and technologies, (nuclear-related items), both sides bilaterally conclude nuclear cooperation agreements (NCAs) and NSSs require RSs to satisfy certain nuclear non-proliferation conditions under the NCAs, in order to ensure that supplied nuclear-related items would be utilized only for peaceful purposes and not to contribute to nuclear proliferation. In addition, some NSSs such as the US require RSs to be granted their advance consent on retransfers, enrichment, reprocessing and/or alternation in form or content of nuclear material transferred or produced under the NCAs. In other words, without such consent, RSs cannot retransfer, enrich, reprocess and/or alter in form or content of NSSs-origin nuclear material.

If some MNA member states have not yet concluded NCAs with NSSs, principally, they need to conclude NCAs with NSSs, which are expected to take long time. In addition, in case of a MNA consisting of states having already utilized nuclear-related items supplied under NCAs, stable and smooth supplies of nuclear fuel and services within the MNA are to be prevented, if one MNA member state fails to obtain the necessary advance consent from NSSs. These facts explain why harmonization between MNAs and NCAs is necessary.

4.2 Current Status of NCAs and Non-Proliferation Conditions under NCAs

4.2.1 Current Status of NCAs

Table 8 [61] describes the current status on concluded and/or negotiations to conclude bilateral NCAs between NSSs and RSs. Among them, new introduction and expansion of nuclear energy utilization as well as resumption of nuclear power reactor operations are expected in the Republic of Korea (ROK), Vietnam, Saudi Arabia (KSA), the United Arab Emirates (UAE), Jordan and Japan.

Table 8 NCAs between NSSs and RSs

	USA	RUS	UK	FRA	CAN	AUS	EUR	KAZ	JPN	ROK	VNM	KSA	UAE	Jordan
USA		✓	*i*	*i*	✓	✓	✓	✓	✓	✓	✓ *ii*	⊙	✓	⊙
Russia (RUS)	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	⊙	✓	✓
UK	*i*	✓		✓	✓	✓			✓	✓		⊙	✓	✓
France (FRA)	*i*	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓
Canada (CAN)	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓
Australia (AUS)	✓	✓	✓	✓	✓		✓	✓	✓	✓			✓	
EURATOM (EUR)	✓	✓			✓	✓		✓	✓					
Kazakhstan (KAZ)	✓	✓		✓	✓	✓	✓		✓	✓	✓			
Japan (JPN)	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	⊙	✓	✓
Republic of Korea (ROK)	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓
Vietnam (VNM)	✓ *ii*	✓		✓	✓			✓	✓	✓				
Saudi Arabia (KSA)	⊙	⊙	⊙	✓					⊙	✓				✓
United Arab Emirates (UAE)	✓	✓	✓	✓	✓	✓			✓	✓				
Jordan	⊙	✓	✓	✓	✓				✓	✓		✓		

✓ NCAs have been concluded.

⊙ Memorandum of Understanding/Agreement/Cooperation and/or currently under negotiation for further cooperation.

i The NCA between the USA and EURATOM includes its members Australia, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the UK.

ii On May 8, 2014, the Obama administration has signed an agreement for civilian nuclear cooperation with Vietnam and submitted it to Congress for review.

As described in Table 8, many NCAs have already been concluded between NSSs and RSs. Among them, ROK, Vietnam, Saudi Arabia (KSA) and the UAE have neither natural uranium resources nor enrichment capabilities, therefore, in principle they have no choice but to acquire nuclear fuel under NCAs with natural uranium producer and enricher states, in order to maintain and/or initiate their nuclear reactor operations. In case of a turnkey nuclear project, nuclear fuel is to be provided along with a nuclear reactor by nuclear vendors, however, in principle even in such a project the nuclear non-proliferation conditions of the original natural uranium and/or enrichment service supplier states are still binding for RSs. Japan has enrichment capability, but it is insufficient to satisfy its domestic demand and it purchases natural uranium and enrichment services under NCAs with the US, Canada, Australia, Kazakhstan, and EURATOM. Jordan has natural uranium resources, but these resources have not been developed yet. Therefore, currently, most emerging nuclear energy states and existing nuclear energy states in the Asian region and the Middle East need to conclude NCAs with NSSs to be provided with fuel for their reactors.

4.2.2 Non-Proliferation Conditions under NCAs

As described in Table 8, there are a variety of NCAs, but nuclear non-proliferation conditions under NCAs vary in accordance with NSSs' nuclear non-proliferation policies as well as the non-proliferation circumstances surrounding RSs. Table 9 describes comparisons of requirements under NCAs between Japan and major NSSs.

Table 9 Comparison of requirements under NCAs between Japan and major NSSs.

	USA [62]	Canada [63]	Australia [64]	UK [65]	France [66]
Safeguards (applies to Japan)	IAEA comprehensive Safeguards (CSA)	IAEA CSA	IAEA CSA	IAEA CSA	IAEA CSA
Uranium Enrichment	Advance consent necessary for enrichment over 20%	Advance consent necessary for enrichment over 20%	Advance consent necessary for enrichment over 20%	-	-
Reprocessing	Advance consent necessary*	Advance consent necessary*	Advance consent necessary*	-	-
Alternation in form or content by irradiation	Advance consent necessary*	-	-	-	-
Storage of plutonium, uranium-233, HEU	Advance consent necessary*	Advance consent necessary	-	-	-
Cooperation on sensitive technologies	Impossible	Possible	Possible	-	Possible
Re-transfer beyond the Jurisdiction	Advance consent necessary*	Advance consent necessary*	Advance consent necessary*	Advance consent necessary	Advance consent necessary

Level of physical protection	• As a minimum, comparable to levels set out in Annex B. (Categorization of nuclear material is the same as that of CPPNM**) • Implies to satisfy the recommendations contained in INFCIRC/225./Rev.1***	• Comparable to levels set out in Annex A (Categorization of nuclear material is the same as that of Nuclear Suppliers Group (NSG) Guidelines) • All nuclear material in the facilities involved in reprocessing and storage and use of plutonium as well as transportation of nuclear material: INFCIRC/254 (NSG Guidelines)	• Comparable to levels set out in Annex A (Categorization of nuclear material is the same as that of NSG Guidelines) • Desirable to satisfy the recommendations contained in INFCIRC/225./Rev.1	As a minimum, comparable to levels set out in Annex B. (Categorization of nuclear material is the same as that of CPPNM)	As a minimum, comparable to levels set out in Annex A. (Categorization of nuclear material is the same as that of CPPNM)
Sanctions in the events of noncompliance and/or infringement of certain provisions within NCA	• Cease further cooperation and termination of NCA • Required to return supplied materials or special fissile material	-	• Required to return supplied materials or special fissile material	• Cease further cooperation and termination of NCA • Required to return supplied materials or special fissile material	• Required to return supplied materials or special fissile material

*: Programmatic advance consent was granted.

**: CPPNM: Convention on Physical Protection of Nuclear Material (INFCIRC/274);

***: INFCIRC/225: Nuclear Security Recommendation on Physical Protection of Nuclear Material and Nuclear Facilities.

According to Table 9, the following key non-proliferation conditions of NCAs can be determined:

- Safeguards:
  - ✓ If RSs are non-weapon states like Japan, NSSs require them to conclude comprehensive safeguards agreements (CSA) with the IAEA, as an obligation under the NPT.
- Re-transfer:
  - ✓ NSSs' advance consent is required for re-transfer of supplied material and plutonium produced through utilization of such supplies.
- Enrichment and reprocessing (ENR):
  - ✓ Canada, Australia, and the US require advance consent for uranium enrichment over 20% and reprocessing. The same provision was stipulated in a previous revision of the NSG Guidelines (Paragraph 7, INFCIRC/254/Rev.9/Part 1).
- Storage of plutonium, uranium-233, and HEU:
  - ✓ Canada and the US require RSs to be granted their advance consent for the storage of plutonium, uranium-233, and HEU.
- Physical protection:
  - ✓ Every NCA requires that nuclear material supplied, or special fissile material (plutonium), produced under the NCAs satisfy a certain level of physical protection. This level is incorporated into either the Convention on Physical Protection of Nuclear Material (CPPNM, INFCIRC/274) or the NSG Guidelines (INFCIRC/254). In addition, the US and Canada recommend RSs satisfy the IAEA's Nuclear Security Recommendation on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225).

As also shown in Table 9, among NSSs, the US stipulates the most stringent non-proliferation conditions which will be further mentioned in the next section. Together with the fact the US has supplied nuclear material to various states under NCAs since the "Atoms for Peace" address in 1953, how to construct MNAs which satisfy the US's nuclear non-proliferation conditions and how to obtain advance consent especially for ENR is a key to ensuring a smooth supply within MNAs.

4.2.3 The US's Nuclear Non-Proliferation Conditions under NCAs

In Section 123 a. of the US Atomic Energy Act (AEA) [67], the US stipulates nine nuclear non-proliferation criteria which other states (RSs) must commit under NCAs with the US [68].

- Nuclear material and equipment transferred to the country must remain under safeguards in perpetuity.
- Non-nuclear-weapon states partners must have full-scope IAEA safeguards, essentially covering all major nuclear facilities.
- A guarantee that transferred nuclear material, equipment, and technology will not have any role in nuclear weapons development or any other military purpose, except in the case of cooperation with nuclear-weapon states.
- In the event that a non-nuclear-weapon state partner detonates a nuclear device using nuclear material produced or violates an IAEA safeguards agreement, the United States has the right to demand the return of any transfers.
- U.S. consent is required for any re-transfer of material or classified data.
- Nuclear material transferred or produced as a result of the agreement is subject to adequate physical security.
- U.S. advance consent rights to the enrichment or reprocessing of nuclear material obtained or produced as a result of the agreement.
- Prior U.S. approval is required for highly-enriched uranium (HEU) and plutonium obtained or produced as a result of the agreement. An agreement permitting ENR using U.S. provided material requires separate negotiation.
- The above nonproliferation criteria apply to all nuclear material or nuclear facilities produced or constructed as a result of the agreement.

These criteria, however, are the minimum. Article 7 of the NCA between the US and the United Arab Emirates (UAE), signed in 2009 [69], contains the UAE's obligation to neither possess ENR facilities nor engage in ENR activities in its territory. The Obama administration announced, in 2012, that it had adopted a "case-by-case approach" and it would not require forgoing ENR capabilities in every future agreement [70]. This case-by-case approach is the US's traditional approach and, for example, the US has granted programmatic advance consent to Japan, EURATOM and currently India for their plutonium utilization programs, while it has not granted it to the ROK [71].

Regarding "advance consent" and "programmatic advanced consent", the US has already granted Japan the latter on transfer of irradiated nuclear material, reprocessing, alternation in form or content, and storage of plutonium, uranium-233, and HEU. Compared with the former, the latter provides RSs more flexibility, because in the latter case, RSs just inform the NSSs of their engagement in such activities, rather than asking consent for each engagement. Although the US AEA does not mention any criteria for granting its programmatic advance consent, the NCA between Japan and Canada requires that reprocessing, storage, transfer, or retransfer would take place within the framework of the description of the current and planned nuclear program, while the NCA between Japan and Australia requires that they would be made within the delineated and recorded Japanese Nuclear Fuel Cycle Program.

In this respect, for ensuring its stable and smooth function, the MNA needs to be granted programmatic advance consent for ENR activities, rather than just advance consent. And if granted such consent from Canada and Australia, spent fuel reprocessing within a MNA should be consistent with MNA member states' plutonium utilization plans and not have surplus plutonium in their territories.

4.2.4 The EURATOM's "Declaration of Common Policy"

Compared with the US AEA's nuclear non-proliferation conditions on nuclear fuel supplies, the EURATOM's conditions on transfers and retransfers of nuclear-related items among its member states are not as strictly regulated. The EURATOM's "Declaration of Common Policy" (INFCIRC/322) [72] prescribes transfers and retransfers of nuclear material, and installations and technology of sensitive nuclear activities or other installations created on the basis of such technologies, within its Member States. According to Article 2.1.1 of the Policy, "Plutonium and uranium enriched to more than 20% will be transferred by the Member States upon receipt of a certificate from the consignee specifying the final destination, the quantities, the approximate date of delivery, the timetable for utilization, the form in which delivery is to take place and the allocation of the material to one or other of the following uses: "

- Fuel supply for any power or research reactors in operation or under construction on the Member States' territory or under its jurisdiction;
- Fabrication on the territory of a Member State or under its jurisdiction for purpose of fuel supply to the reactors above;

- Research and development in any laboratory situated on the territory of Member State or under its jurisdiction or third-party State;
- Utilization in any other installation connected with an energy program or a research and development program.

And Article 2.1.3 of the Policy prescribes that "plutonium and uranium enriched to more than 20% will not be retransferred to a third State without mutual agreement between the Member State that has separated the plutonium or enriched and the Member State desiring to effect the retransfer, without prejudice to any other rights or advance consent that may exist".

As mentioned in Article 2.1.1 of the Policy, one of EURATOM's unique characteristics is that transfers of plutonium and uranium enriched to more than 20% to EURATOM member states require only "certificates" from the consignees. Different from the US AEA's nuclear non-proliferation conditions, the Policy requires neither advance consent nor agreements from the member states that have separated the plutonium or enriched uranium. In this respect, transfers of nuclear material within EURATOM territories are recognized and treated not as international transfers, but as domestic transfers. These arrangements are good models for MNAs, since EURATOM and MNAs are the same, in the context of multilateral participation.

On the other hand, it is worth recognizing that as mentioned in section 3.1.2, regional safeguards and RSAC have implemented in EURATOM states, in order to ensure nuclear non-proliferation among them.

4.3 Case Study for Requirements for Advance Consent under NCAs

Figure 4 [73] shows an example of the necessity for advance consent from NSSs under NCAs, although nuclear non-proliferation conditions vary according to the two states concerned. In general, the more states engage in the backend of the nuclear fuel cycle, the more they are anticipated to be granted advance consent from various NSSs.

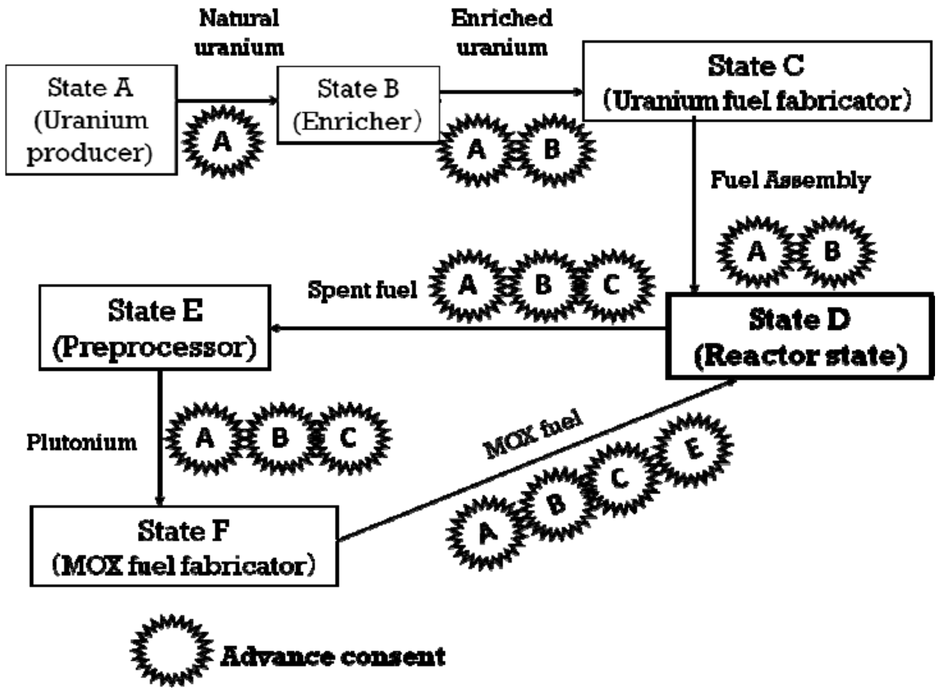


Figure 4 Necessity for advance consents from NSSs

In Figure 4, a nuclear operator in reactor state D purchased natural uranium from State A, enrichment services from State B, uranium fuel fabrication services from State C and MOX fuel fabrication services from State F. In this case, State D may need to be granted the following programmatic advance consents or advance consents;

- From State A for enrichment in State B,
- From States A and B for fuel fabrication in State C,
- From States A, B and C for reprocessing in State E,
- From States A, B, C, and E for MOX fuel utilization in State D

Assuming a MNA was established, for example, there would be multiple reactor states such as State D which have already concluded NCAs with various NSSs for obtaining nuclear fuel. Therefore, a number of programmatic advance consents or advance consents are anticipated to be necessary and if it either fails to be granted the necessary consents, or takes too long to be granted such consents, a stable and smooth supply of nuclear fuel and services cannot be ensured among MNA member states. In this respect, the MNA is inevitably required to have some internal arrangements, which enable either avoiding these necessities or not having any difficulties for each member state to individually obtain consent from each NSS under their individual NCAs.

4.4 Measures for Harmonizing between MNAs and NCAs

Case 1 of Figure 5 shows an example of the number of necessary NCAs and advance consents, when reactor States C and D reprocesses their spent fuel in State E.

In Case 1, States C and D are provided natural uranium from State A and enrichment services from State B, therefore, for their spent fuel to be reprocessed in State E,

- In total, 9 NCAs are necessary among States A, B, C, D, E.
- In total, 2 advance consents (from State A and B) are necessary.

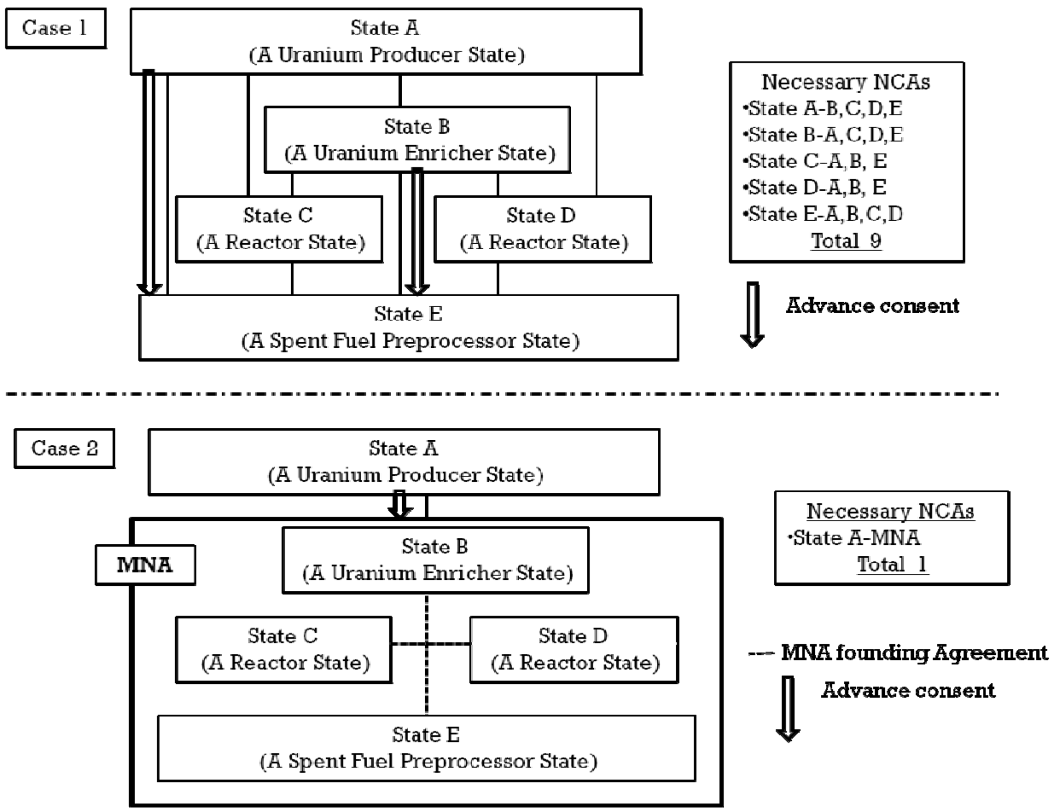


Figure 5 An example of the number of necessary NCAs and advance consents

On the other hand, as in Case 2 of Figure 5, provided that:

- States B, C, D, and E form a MNA,
- The MNA itself is recognized as one legal entity, such as EURATOM, representing all its member states, and
- Concludes a NCA with other non-MNA/NSS of State A,

Every MNA member state including States B, C, D and E is required neither to conclude NCAs with State A nor to be granted advance consent individually. In Case 2, in total one NCA between State A and the MNA and one advance consent are necessary. Generally, the more the number of necessary NCAs and advance consents from NSSs are reduced, the more stable and smooth the supply of nuclear-related items is expected among the MNA.

However, as with EURATOM, the non-proliferation characteristics of each MNA member state need to be strengthened through a MNA founding agreement, which are high enough to satisfy the non-proliferation conditions of NSSs.

It is worth noting that how EURATOM maintains its high non-proliferation characteristic to be recognized as one legal entity [74].

- Regional safeguards system: In order "to make certain that civil nuclear materials are not diverted to other (particularly military) purposes", the EURATOM safeguards are implemented in conjunction with those of IAEA under tripartite agreements concluded between the member states, the EU (European Community, at that time), and the IAEA (INFCIRC/193).
- Regional system of accounting for and control (RSAC) of nuclear material: The EURATOM member states establish and maintain a common system of accounting for, and control of, nuclear material subject to safeguards agreement [75].
- EURATOM Supply Agency (ESA): The ESA was established in order "to ensure that all users in the EU receive a regular and equitable supply of ores and nuclear fuels". In the event of infringement of EURATOM members' obligations, the European Commission may impose sanctions, including the total or partial withdrawal of source materials or special fissile materials, as the ESA is able to exercise the right of ownership conferred upon it with respect to special fissile material.

As mentioned in section 4.2.4, EURATOM's nuclear non-proliferation conditions within its member states are not as strict as those of the US, and transfers of nuclear material within EURATOM territories are not recognized and treated as international transfers. The above systems of regional safeguards and RSAC make such special arrangements possible.

In this respect, if the MNA needs to be given the same treatment as EURATOM, it is essential to have high nuclear non-proliferation characteristic, by implementing regional safeguards system, the RSAC and nuclear security guidelines, within the MNA, as detailed measures of (A) nuclear non-proliferation feature mentioned in chapter 3. If so, every MNA member state needs to neither conclude NCAs with NSSs separately nor be granted advanced consent for certain nuclear activities, since the MNA as a whole concludes NCAs with NSSs and is granted necessary advance consents from them. By reducing the number of necessary NCAs and advanced consents from NSSs, stable smooth supplies of nuclear fuel and services are expected among MNA member states.

4.5 Other Considerations

Assuming states which have already concluded NCAs with NSSs, including the US, constitute a MNA, a MNA founding agreement as described in Case 2 of Figure 5 needs to include enough provisions to not only maintain strong nuclear non-proliferation characteristics, but also to satisfy non-proliferation conditions under the NCAs, especially the requirements in Section 123 a. of the US AEA, if US-origin material is expected to be utilized within a MNA.

In this respect, the MNA founding agreement needs to include safeguards, nuclear security and export control provisions which have already been explained in sections 3.1.2, 3.1.3 and 3.1.4, as essential MNA features. However, these requirements are the minimum and other nuclear non-proliferation conditions could be needed as well, since the US sets different conditions for different NSSs (case-by-case" approach).

In addition, EURATOM's ESA functions, mentioned above, serve as a useful reference. Together with regional safeguards and the RSAC, with the agreement of all members of the MNA, if ownership of the material transferred or produced under the MNA is transferred to the MNA, then the MNA itself (or an organization within the MNA) can impose sanctions, including total or partial withdrawal of materials, in the case that MNA members abuse MNA systems. If so, a very robust nuclear non-proliferation characteristic is expected to be maintained.

4.6 Summary of Chapter 4

In this chapter, for the purpose of ensuring a stable and smooth supply of nuclear fuel and services within a MNA, measures to harmonize MNAs and NCAs were discussed. Instead of every MNA member state individually concluding NCAs and being granted programmatic advance consent or advanced consent from NSSs under NCAs, if the MNA, as a whole, can be recognized as one legal entity, such as EURATOM, representing all its member states, the necessary number of NCAs and consents can be reduced.

In order to make such an arrangement possible, the MNA member states as a whole need to have strong nuclear non-proliferation characteristics by adhering to the non-proliferation conditions mentioned in chapter 3 through the MNA founding agreement, including the regional safeguards system and RSAC.

Chapter 5 A Functional Feature - Nuclear Third Party Liability Systems in the MNA -

Chapter 5

A Functional Feature - Nuclear Third Party Liability Systems in the MNA -

One of functional features is (E) Nuclear third party liability (TPL) and in this chapter, detailed measures of this feature which enable to satisfy one of MNA requirements of ensuring MNA's function are discussed.

5.1 Necessity of Participation in the International Nuclear Third Party Liability Convention

Whether or not nuclear facilities are nation-based or MNA-based, any incidents in the facilities may have the possibility of causing transboundary damage to other states, including neighboring states. In order to ensure secure compensation for such damage, there are international nuclear TPL conventions, including the following:

- The Vienna Convention on Civil Liability for Nuclear Damage (the Vienna Convention) [76] and the Protocol to Amend the Vienna Convention [77]
- The Paris Convention on Third Party Liability in the Field of Nuclear Energy (the Paris Convention) [78] and the Protocol to Amend the Paris Convention * [79]
- Convention on Supplementary Compensation for Nuclear Damage * (CSC) [80]

*As of May 2014, the Protocol to amend the Paris Convention and the CSC have not yet entered into force.

These conventions commonly adopt the following six liability principles [81]:

(1) Strict liability of a nuclear operator,
(2) Exclusive liability of an operator of a nuclear installation,
(3) Compensation without discrimination based on nationality, domicile or residence,
(4) Mandatory financial coverage of the operator's liability,
(5) Exclusive jurisdiction, and
(6) Limitation of liability in amount and in time.

Among these, (3) Compensation without discrimination based on nationality, domicile or residence is especially important for MNAs. MNAs are generally formed by neighboring nuclear energy states in a certain region and if these states enact different domestic laws on nuclear TPL and do not participate in the same international TPL convention, then victims of the same nuclear incident would be treated differently in accordance with their nationalities. In order to avoid this situation, the MNA member states with nuclear power (and those with a plan to have it in the future) in principle need to join the same international nuclear TPL convention. This also explains why most nuclear energy states in Western Europe jointly participate in the Paris Convention.

Regarding the three international nuclear TPL conventions mentioned above, their member states, liability amounts and lower limit of financial security amounts differ from each other as briefly summarized in Table 10.

Table 10 Brief comparison of international nuclear TPL conventions

	Protocol to Amend the Vienna Convention	Protocol to Amend the Paris Convention*	Compensation for Nuclear Damage (CSC) *
Member states	• 12 states [i], as of January 2014 • (Vienna Convention: 40 states, as of January 2014)	• Norway and Switzerland, as of June 2009 • (Paris Convention: 16 states [ii], as of June 2009)	• Argentina, Morocco, Romania and the US, as of December 2013
Liability amount	• Not less than 300 million SDRs (approx. 467 million USD, as of 7 May 2014) ✓ Transitional amount : Not less than 150 million SDRs provided that in excess of that amount and up to at least 300 million SDRs public funds shall be available	• Not less than 700 million Euros (approx. 974 million USD, as of 7 May 2014)	• The first tier: Not less than 300 million SDRs per accident ✓ Transitional amount: at least 150 million SDRs for a maximum of 10 years from the date of the opening for signature of the Convention • The second tier: An international supplementary fund prepared by contracting parties, in case the damage caused by an incident exceeds, or is likely to exceed, the amount of the first tier
Lower amount of financial security	• Not less than 5 million SDRs (approx. 7.78 million USD, as of 7 May 2014)	• Low-risk installations: 70 million Euros • Transport activities 80 million Euros	• Not less than 5 million SDRs with respect to installations and materials that pose a reduced risk of nuclear damage in the event of an incident. (However public funds must be made available to cover any claims up to 300 million SDRs.)

* As of May 2014, not yet entered into force

[i] Argentina, Belarus, Bosnia and Herzegovina, Jordan, Kazakhstan, Latvia, Montenegro, Morocco, Poland, Romania, Saudi Arabia and the United Arab Emirates;

[ii] Belgium, Denmark, Finland, France, Germany Greece, Italy, the Netherlands, Norway, Portugal, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom

Currently states in Southeast Asia, China, India and the ROK are newly introducing and rapidly expanding nuclear energy utilization, but only Russia, Kazakhstan and the Philippines are members of the Vienna Convention and most of the rest of Asian states have not yet participated in any international nuclear TPL conventions. However, after the Fukushima nuclear accident, Japan decided to join the CSC in November 2013 [82] and the ROK has already "modernized its nuclear liability legislations by introducing the major features" [83] of the Protocol to amend the Vienna Convention and the CSC. If both states jointly participate in the CSC, the CSC itself enters into force by satisfying its requirements of ratification by five states with a minimum of 400 gigawatts (GW) thermal of installed nuclear capacity.

As for the Middle East states, currently Saudi Arabia and the United Arab Emirates (UAE) of the Gulf Cooperation Council (GCC) states and Jordan are actively introducing nuclear power reactors and they have already acceded the Protocol to Amend the Vienna Convention.

5.2 Nuclear TPL Systems in MNAs

5.2.1 Nuclear TPL Systems in Existing MNAs

As a reference for exploring TPL systems in MNAs, it is worth analyzing these regimes in the existing MNAs of EURODIF and URENCO. Table 11 describes MNAs and technology holders, together with laws and international nuclear TPL conventions applied to EURODIF, URENCO and others.

Table 11 Laws and international nuclear TPL conventions applicable to MNAs

	Host state	Enrichment technology holder state(s)	Applicable law	International nuclear TPL convention
EURODIF	France	France	French law on nuclear TPL	Paris Convention
URENCO	UK, Germany, Netherlands	UK, Germany, Netherlands	UK, Germany, the Netherlands' laws on nuclear TPL	Paris Convention
Russian LEU Reserve [84]	Russia	Russia	Russian law on nuclear TPL	Vienna Convention
IAEA Fuel Bank [85]	Kazakhstan	Unknown (not Kazakhstan)	Kazakhstan's law on nuclear TPL	Vienna Convention

First of all, as described in Table 10 most Western European states including France, the UK, the Netherlands and Germany, are host states of both EURODIF and URENCO enrichment facilities and together with their neighboring states are all members of the Paris Convention. Therefore, in the case of a nuclear incident in these MNA facilities, nuclear damage in the region is in principle to be compensated in accordance with the provisions of the Paris Convention.

EURODIF was formed in 1973 by France, Belgium, Italy, Spain and Sweden as a joint stock company, but a French operator exclusively holds the enrichment technology and operates the facility. Therefore, EURODIF follows French nuclear laws and legislations including nuclear TPL, and in case of a nuclear incident, in principle the French operator is assumed to be an exclusively liable operator, while the Government of France is also assumed to take responsibilities as an installation state.

URENCO is invested in by companies from Germany, the Netherlands, and the UK, and they equally share the facilities' ownership, operation, and decision-making in URENCO, as stipulated in the Treaty of Almelo of 1970. Since each state has one enrichment facility, each facility respectively follows its host state's relevant nuclear laws and legislations including nuclear TPL, like EURODIF.

Therefore, in the event of a nuclear incident, nuclear damages are in principle compensated based on its host state legislation on nuclear TPL, which also satisfies the provisions of the Paris Convention. These EURODIF and URENCO arrangements are quite natural, since they operate their enrichment facilities based on their own enrichment technology, and consequently they should be responsible for nuclear incidents in their facilities. In addition, advantages of these arrangements are as follows:

- Even if the facilities are in the form of a MNA, they are equally treated as nation-based facilities.
- Both a liable operator and an installation state can easily be identified, despite the existence of multiple stakeholders in MNAs.
- It is unnecessary to change both host states and other MNA member states' legislations on nuclear TPL based on the existence of a MNA.

In addition, regarding frameworks of international control of nuclear material, such as a low-enriched uranium (LEU) reserve established at the International Uranium Enrichment Center in Angarsk, Russia in December 2010 [86] and an IAEA international fuel bank currently planned to be established [87] extraterritorially in Kazakhstan, in principle they follow their host states' (Russia and Kazakhstan respectively) nuclear TPL laws and the Vienna Convention. In this respect, whether or not a facility is nation-based, MNA, internationally controlled, or extraterritorial, they are all treated equally under the host states' nuclear TPL laws and regulations as well as the Vienna Convention.

On the other hand, the IAEA fuel bank has a different characteristic from the Russian LEU reserve, EURODIF and URENCO. Since Kazakhstan is neither an enricher nor an enrichment technology holder, Kazakhstan and/or its nuclear operator needs to accept and store the LEU, which has been enriched by enrichers in other states. However, in case of a nuclear incident in the bank, the Kazakhstan nuclear operator and the state of Kazakhstan, respectively, are required to bear responsibility as a liable operator and an installation state, although the bank is an IAEA-controlled bank. In the cases of EURODIF, URENCO and a Russian LEU reserve, then as mentioned above nuclear operators and their governments have enough reasons to be recognized as exclusively liable operators and installation states, since they are actually and directly engaged in enrichment activities by using their own enrichment technologies and facilities. Considering the above, in the case of an IAEA Fuel Bank, the responsibility of an installation state need to be equally shared among stakeholders by internal arrangements within the bank, instead of assigning all responsibility as an installation state to Kazakhstan [88].

5.2.2 Case Studies and Analysis of Nuclear TPL Systems in MNAs

Assuming the establishment of a MNA facility, Table 12 describes case studies of possible combinations of the MNA facility's technology holder, operator, and installation state, together with possible responsibilities of MNA member states in the case of a nuclear accident in a MNA facility based on the analysis described in previous sections.

These case studies are based on the following premises:

- All MNA member states are assumed to participate in the same international nuclear TPL convention, such as the CSC, and enact nuclear TPL laws and regulations in accordance with the convention.
- Even if the host state of a MNA facility provides the MNA facility with "extra-territorial" status, the MNA facility still needs to follow a host state's relevant nuclear laws and regulations, including nuclear TPL.
- "a", "b" are nuclear companies which belong to MNA member States A and B, respectively.
- The "MNA Company" is a joint stock company consisting of MNA member states and/or nuclear operators which belong to MNA member states;
- "c" is a nuclear technology holder company which belongs to a MNA member state, but neither States A nor B,
- "x" is a nuclear company which is not a member of the MNA Company and belongs to non-MNA member states

As for possible responsibilities of MNA member states, the key is to identify what state takes the responsibility of being "an installation state" in the event of a nuclear accident and, if necessary, how these responsibilities are shared among multiple MNA member states.

Table 12 Case studies on a nuclear TPL system in a MNA facility.

	Case Study 1	Case Study 2	Case Study 3	Case Study 4	Case Study 5
(1) A technology holder of a MNA facility	a	b	MNA company	c	x
(2) An operator of a MNA facility (= a liable operator in case of a nuclear incident in the MNA facility)	a	MNA Company	MNA Company	MNA Company	MNA Company
(3) A host state of the MNA facility	State A	State B	State B	State B	State B
(4) Responsibilities of MNA member states in case of a nuclear incident in the MNA facility	None (except State A)	None (except State B)	• In principle, as a representative of MNA member states, State B, the host state of the MNA facility, directly takes responsibility as an installation state of a MNA facility. • However, if all MNA member states agree, this responsibility can be indirectly shared among all MNA member states, through internal arrangements within the MNA, such as reimbursement paid to a host state based on pre-agreed shares and/or making deposits on such reimbursement in case of an incident.		

Case Study 1 indicates the case of a nation based nuclear facility. However, it also applies to the case of a MNA facility into which all MNA member states made investments, but that was operated by only one technology holder, such as EURODIF. In Case Study 1, it is natural that operator "a" and "State A" respectively take responsibility as the liable operator and the installation state in case of an incident, in accordance with laws on nuclear TPL of State A.

In Case Studies 2, 3, 4 and 5, the MNA Company, a joint stock company consisting of multiple MNA member states and/or nuclear operators which belong to MNA member states, operates the MNA facility. The facility is situated in State B, therefore, the MNA Company, as operator of the facility, follows the relevant nuclear laws and regulations, including nuclear TPL, of State B. In the event of a nuclear incident in the MNA facility, the MNA Company becomes the liable operator, however, as stakeholders of the Company, MNA member states and/or nuclear operators, who constitute the Company, indirectly share the responsibilities of the liable operator.

As for installation states, although other MNA member states engage in the MNA facility through the MNA Company, State B, as a host state as well as a representative of all MNA member states, needs to take direct responsibility as the installation state for the following reasons:

- The MNA Company and its facility follow the relevant nuclear laws and regulations of State B. These laws and regulations include safeguards, nuclear security, physical protection of nuclear materials and facilities, export controls, nuclear safety, emergency preparedness and nuclear TPL, etc. In addition, every authorization for the MNA facility including its design, construction and operation, is provided by the government of State B. Therefore, State B has enough reasons to become an installation state and take responsibility in the event of a nuclear incident.

- If each MNA member state is collectively or respectively considered as an "installation state", legal relations would be complex, and this complexity may prevent timely compensation for nuclear damage.

- Assuming that the above arrangement is possible and that the compensation for nuclear damage caused by the MNA Company is insufficient, all MNA member states are directly required to share their responsibilities as an "installation state". However, assuming one state cannot afford to take on a part of an installation state's responsibilities, there would be the question of which states need to substitute such responsibilities. If so, prompt compensation for nuclear damage would be prevented.

However, as for the IAEA international fuel bank mentioned in section 5.2.1, especially in Case Studies 4 and 5, it would be hard for State B to take all the responsibility as an installation state by itself, since the technology utilized in the MNA facility is not the nuclear operator's, and State B may not be able to be well informed the details of the technology, due to ensuring nuclear non-proliferation and/or protecting intellectual property of technology holders. In those Case Studies, although State B takes responsibility as an installation state in accordance with the nuclear TPL laws and regulations of State B, through internal arrangements within the MNA all MNA member states indirectly can share this responsibility of State B based on pre-agreed shares, such as reimbursement paid to a host state based on pre-agreed shares of investments and/or making deposits on these reimbursements in advance. These deposits can play the same role as a public fund in the CSC.

This sharing of responsibility as an "installation state" is also sharing nuclear safety among MNA member states. As mentioned in chapters 2 and 3, if all MNA member states' nuclear safety characteristic becomes strengthened through their adherence to international conventions and standards on nuclear safety as well as establishment of common nuclear safety standards and peer reviews, it would contribute to prevent nuclear accidents.

If neither State B nor other MNA member states are willing to take these direct and indirect responsibilities as an "installation state", then the MNA facility should not be situated in State B.

As for Case Study 3, since the MNA Company not only holds the technology but also operates its facility, it is more understandable than in Case Studies 4 and 5 that all MNA member states indirectly share responsibilities of State B as an installation state. However, from a nuclear non-proliferation viewpoint, Case Study 3 has a higher risk of proliferation of nuclear technologies than the other Case Studies have since the MNA Company consisting of various nuclear operators and their states holds the technology. Especially for the purpose of nuclear non-proliferation, MNA facilities are expected to be ENR facilities. Therefore, from a nuclear non-proliferation viewpoint, Case Study 3 is not desirable based on the risk of proliferation of ENR technologies and facilities.

Regarding Case Study 2, also from a nuclear non-proliferation viewpoint, the technology utilized in the MNA facility remains in the territory of its state. In this respect, this Case Study is a desirable situation for a MNA facility, as far as each

MNA member state does not want to have the technology and agrees to situate the facility within the territory of the technology holder. Also from this perspective, compared with Case Studies 3, 4 and 5, State B has more reasons to take responsibility as an installation state in case of a nuclear incident, since the technology holder in its state dominantly holds the technology and State B is in a better position to control this technology compared to other MNA member states.

To sum up the above Case Studies, firstly, in a MNA facility the MNA Company, as a joint stock company consisting of MNA member states and/or nuclear operators who belong to MNA member states, and the operator of the MNA facility become liable operators in case of a nuclear incident. Each member of the MNA Company indirectly bears the responsibility through investments into the facility.

Secondly, there are various combinations of technology holders, operators of the facility, and installation states, and in principle the host of a MNA facility takes on the responsibility as the installation state. However, in some cases, all MNA states can indirectly share the responsibilities through internal arrangements within the MNA, such as reimbursement paid to a host state based on pre-agreed shares and/or making deposits (a fund) on this reimbursement in the event of an incident. In other words, this is sharing nuclear safety among MNA member states. If MNA member states are unwilling to share these responsibilities, they need to find a new host state which is willing to bear the responsibility as a nuclear installation state by itself.

5.2.3 Other Considerations

Generally speaking, whether or not a nuclear facility is nation-based or in the form of a MNA, preventions of nuclear incidents take precedence over establishing nuclear TPL systems. The more nuclear incidents can be prevented, the less the nuclear TPL systems come into play. In this respect, this (E) Nuclear Third Party Liability feature closely relates to other MNA features, (C) Nuclear Safety and (F) Siting - choice of host state (installation state). As will be further discussed in chapter 6, in principle, in order to prevent nuclear incidents, a host state would need to do the following:

- To be a member of appropriate international treaties, conventions, and to follow standards and guidelines on nuclear safety, emergency preparedness and nuclear TPL etc., and to reflect them in its domestic legislation.

- To be a member of appropriate international treaties, conventions, and to follow standards and guidelines on nuclear non-proliferation, including safeguards, nuclear security, physical protection of nuclear materials and facilities, export control, etc., and to reflect them in its domestic legislation, since nuclear incidents could happen due to terrorist attacks.
- To be politically, socially and economically stable
- To maintain good relations with neighboring states and the international community
- To have no territorial disputes, including conflicts on natural resources
- To have good accessibility to international and domestic ports for transportation of nuclear materials
- To have necessary and sufficient knowledge, expertise and experience to host and operate MNA facilities, including handling, storage and transportation of nuclear materials
- To ensure safe and secure routes for transportation of nuclear material
- To be equipped with the necessary licensed infrastructure for MNA operations
- To have the necessary natural environment to host MNA facilities without causing harmful effects or having a negative influence from hosting such facilities

In addition, regarding the equal sharing of responsibility of an installation state among all MNA member states as mentioned in section 5.2.2, such sharing has the potential to contribute to strengthening MNA member states' nuclear safety characteristic as a whole, including establishing common nuclear safety standards/guidelines or possible mutual peer reviews on nuclear safety such as inspection through the IAEA and/or regional safeguards. As the Fukushima nuclear accident revealed, both liable operators and installation states need to bear a great economic burden, therefore, this sharing system would surely contribute to strengthening MNA member states' nuclear safety characteristic, as a whole. Furthermore, the sharing of responsibility also has the potential to conform to a common nuclear TPL system among MNA member states, as a common base for responsibility sharing.

5.3 Summary of Chapter 5

In this chapter, nuclear TPL systems in a MNA were discussed and identified.

The first priority is that all MNA member states with nuclear power (and those with a plan to have it in the future) need to join the same international nuclear TPL convention, in order to ensure that all victims are able to receive non-discriminatory compensation for transboundary damage caused by nuclear incidents within MNA facilities.

Second, the host state of a MNA facility, as a representative of MNA states and as an installation state, in principle takes on the responsibilities of an installation state. However, in certain situations and in agreement with all MNA member states, these responsibilities can be indirectly shared among all MNA member states through internal arrangements within the MNA, such as reimbursements paid to a host state based on pre-agreed shares and/or making deposits on these reimbursements in the event of an incident. This system is based on mutual cooperation and share of responsibilities on nuclear safety among MNA member states.

Furthermore, such a sharing system has the potential to strengthen all MNA member states' nuclear safety characteristics as well as to encourage conformity of their nuclear TPL systems.

Chapter 6 Practical Features

Chapter 6

Practical Features

Practical features include (F) Siting - choice of host state, (G) Multilateral involvement, (H) Access to technology, (I) Economics, (J) Transportation, (K) Geopolitics and (L) Political and public acceptance. In this chapter, detailed measures of these practical features which enable to satisfy one of MNA requirements of contributing MNA feasibility are discussed. As mentioned in section 2.3, characteristics and roles of MNA features of (I), (K) and (L) are slightly different from other practical features of (F), (G), (H) and (J). They are rather ones of primary deciding factors in discussing other MNA features of (F), (G), (H) and (J).

6.1 Eligibility Conditions of Host States of MNA Facilities

Regarding the (F) Siting - choice of host state feature, as described in Table 5, the Pellaud Report [89] presents the following three possible options for hosting MNA facilities;

(a) Special arrangements – legal structure limiting national jurisdiction on the site of MNA fuel cycle facility ("extra-territorial" status)
(b) States that are already technology holders, and
(c) States that are not technology holders

In the case of the IAEA Fuel Bank mentioned in Table 4, option (a) "extra-territorial" status is expected, "for the purpose of establishing the conditions necessary for the full execution of its functions" and "providing immunity to officials employed at the site" [90].

However, considering the fact that MNAs are expected to be commercially feasible and existing MNAs of both EURODIF and URENCO have not offered these benefits, there is no need to set out this "extra-territorial" status unless an international organization like the IAEA itself is actively involved in the MNA's decision making, management and operation, together with safeguards. In addition, it is worth noting that even in the case of the IAEA Fuel Bank, "The Host State of an IAEA LEU bank will have to be responsible for applying safety and physical protection measures to the LEU in the bank, in accordance with the Host State Agreement and its obligations under international law, as well as its own laws and regulations" [91]. Therefore, there seems to be few advantages to purposely arranging this "extra-territorial" status.

As for (b) and (c), if MNA facilities are ENR facilities, from the viewpoint of ensuring nuclear non-proliferation and protecting technology holders' intellectual property, in principle, host states of MNA facilities are to be ENR technology holder states (b), as the same as EURODIF and URENCO. In fact, in the case of the transfer of enrichment technology and related items, Paragraph 7 (b) (1) of the NSG Guidelines [92] suggests to "avoid, as far as practicable, the transfer of enabling design and manufacturing technology associated with" enrichment facility or equipment base on current enrichment technologies. However, option (c) is not necessarily impossible, as long as NSSs agree and follow Paragraphs 6 and 7 of the NSG Guidelines, including the transfer of enrichment equipment, technology and facility in black box. In addition, the Paragraph 6(e) of the Guidelines recommends that in the case of ENR transfers, the NSSs encourage RSs to accept MNA facility with and / or supplier's involvement, instead of a nation based facility.

As for the eligibility conditions for host states of MNA facilities, in the case of the IAEA Fuel Bank, the IAEA presented various eligibility conditions for hosting the Bank [93]. Using these conditions as a reference and in relation with other MNA features from (A) to (L), it would be appropriate for eligibility conditions of host states of MNA facilities to be as follows:

- Non-proliferation: (the same conditions as mentioned in (A)Non-proliferation feature in chapter 3)
  - ✓ To be a member of the appropriate international treaties and conventions, and to follow standards and guidelines on nuclear non-proliferation, safeguards, nuclear security, physical protection of nuclear materials and facilities, export control, etc., and to reflect them in its domestic legislation.

- Nuclear safety and nuclear third party liability (TPL): (the same conditions as mentioned previously in chapters 3 and 5)
  - ✓ To be a member of the appropriate international treaties and conventions, and to follow standards and guidelines on nuclear safety, emergency preparedness and nuclear TPL etc., and to reflect them in its domestic legislation.

• Nuclear Cooperation Agreements (NCAs):

- ✓ To conclude necessary NCAs with nuclear suppliers.

Regarding NCAs, a host state of the IAEA fuel bank is expected to conclude NCAs with nuclear supplier states. However in the case of MNAs, as mentioned in chapter 4, all MNA member states as a whole concludes NCAs with supplier states. Therefore, there is no need for each MNA member state separately concluding NCAs with NSSs.

• Technical requirements

- ✓ To have necessary and sufficient knowledge, expertise and experience to host and operate MNA facilities, including handling, storage and transportation of nuclear materials.
- ✓ To be equipped with the necessary licensed infrastructure for MNA operations. Services available including water and electricity, road, rail and transportation infrastructure.

• Environment:

- ✓ To be politically, socially and economically stable.
- ✓ To maintain good relations with neighboring states and the international community. Not to have any territorial disputes with any states, including conflicts on natural resources.
- ✓ To ensure safe and secure routes for transportation of nuclear material, including good accessibility to international and domestic ports for transportation of nuclear materials
- ✓ To have the necessary natural environment to host MNA facilities without causing harmful effects or having a negative influence by hosting such facilities, such as low probability of seismic activity and of extreme weather events such as floods, cyclones or tornados

Furthermore, due to international conventions and/or domestic laws, certain states cannot host certain facilities. For example, member states of the Treaty on A Nuclear Weapon Free Zone in Central Asia, cannot allow the disposal in their territory of radioactive waste of other states (Paragraph 2 of Article 3). Article 4.1.4 of the law in Mongolia on its Nuclear-Weapon-Free Status prescribes that any foreign state shall be prohibited from dumping or disposing of nuclear weapons grade radioactive material or nuclear waste. Furthermore, "South and North Korea shall not possess nuclear reprocessing and uranium enrichment facilities" by a Joint Declaration of South and North Korea on the Denuclearization of the Korean Peninsula in 1992. Those states, however, have enough reasons to participate in the MNA, if other MNA members could host facilities and provide them with nuclear fuel and/or services.

6.2 Multilateral Involvement and Access to Technology

As for (G) Multilateral involvement and (H) Access to technology features, the Pellaud Report presents possible options for each feature, from (a) to (i), as described in Table 5 [94]. Generally, the more deeply MNA member states are involved in the MNA and access technology, especially ENR technologies, the higher the risk of proliferation of technology becomes, as indicated in Figure 6.

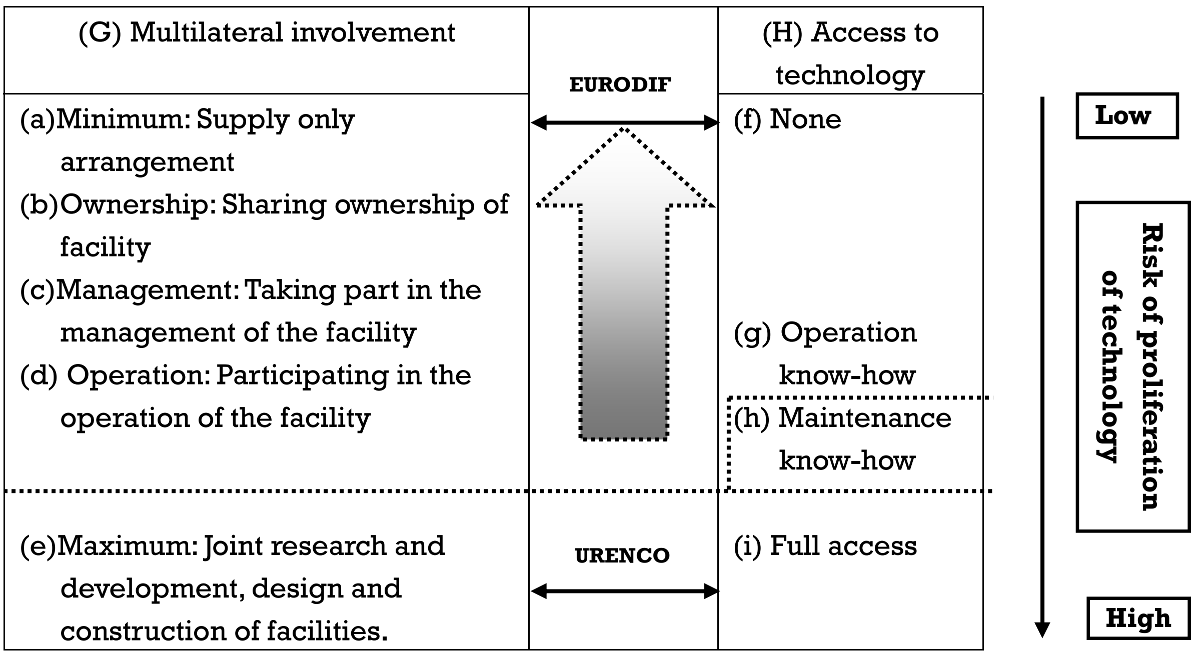


Figure 6 Options of (G) Multilateral involvement and (H) Access to technology features

Regarding combinations of options (a) to (i), (a)-(f) is a combination of EURODIF, as indicated by a horizontal arrow. EURODIF member states except France are assured supply of enriched uranium; however, they neither own the facility nor access French enrichment technology. On the other hand, (e)-(i) is a combination of

URENCO. All URENCO member states jointly engage in R&D activities with full access. In this case, compared to EURODIF, the proliferation risk of enrichment technology is high.

In similar way, various combinations, such as (b)-(f), (c)-(f), (d)-(g), (d)-(h), are theoretically possible and these combinations would depend on agreements among MNA member states or between MNA member states and technology holder(s).

However, in the case of transfers of enrichment facilities and equipment based on existing enrichment technology, as mentioned in the previous section Paragraph 7 (b) (1) of the NSG Guideline recommends to "avoid the transfer of enabling design and manufacturing technology associated with" an enrichment facility or equipment and in the case of enrichment transfers, and such transfers should be in black box so that recipients are unable to replicate the facility.

Considering the above, in principle, in the case of enrichment facilities the (e)-(i) combination is not recommended in the Guidelines. Even if technology is transferred in black box, according to the Guidelines, the maximum acceptable combination is assumed to be (d)-(g) or (d)-(h), as shown by dot-line and a big arrow on Figure 6, although it fully depends on suppliers and their technology and facility.

6.3 Economics

Regarding the (I) Economics feature, the economics of MNA facilities are generally affected by the following factors:

- Demand and supply
- Cost (raw material, services, technology, manpower, etc)
- Amount of investment by MNA member states
- Type of facility, such as enrichment plant, reprocessing plant, spent fuel storage, etc.
- Type of MNA, either transfer of existing facilities to MNAs or construction of new MNA facilities
- Facility scale
- Technology, either utilization of existing technologies or introduction of new technologies
- Host states' laws and regulations on nuclear non-proliferation (nuclear security, safeguards, export control) and nuclear safety as well as the necessary measures required by these laws and regulations

- Location of host state of MNA facilities, including their commodity prices
- Transportation, including distance, frequency, measures for transportation
- Decision making body, manager(s) and operator(s) of MNA facilities
- Others

In general, every nuclear facility including MNA facilities, are desired to attain low cost. In addition, if MNA facilities have more economic advantage than a nation based facilities, it would serve as a great incentive for states joining the MNAs, although economic is not the only factor for establishing MNAs.

Furthermore, (I) economic feature of MNAs need to be discussed in relations with (J) transportation, since compared with a nation based ENR facilities, frequent and long-distance transportation as well as mass transport between MNA ENR facilities and MNA recipient states, and / or MNA facilities and non-MNA NSSs are anticipated, due to a limited number of MNA facilities.

Regarding these (I) Economics and the (J) Transportation features, Takashima et al. made a comparison study on the cases of MNAs with transportation, whether MNAs with transportation of nuclear materials can be more economical than state-owned facilities such as reprocessing [95]. They studied several scenarios concerning alternative routes including the existing uranium transportation routes. It was found that in the base case, the MNA case is economically advantageous under all scenarios, but it loses its economic advantage when the unit cost of land transportation is very high. It was also found that the scenario involving a route via a specific port is economically advantageous under almost all transportation unit cost conditions. It suggested that geographic and geopolitical considerations would be involved in the economic discussion. Those are discussed in later chapter.

The economics of the nuclear fuel cycle, especially reprocessing cost versus spent fuel direct disposal cost, often proves to be controversial. Nevertheless, simple cost comparisons do not always reflect the various challenges associated with direct disposal. For example, except for a few states including Finland and Sweden, specific disposal locations have not yet been identified, due to difficulties in obtaining political and public acceptance due to NIMBYism. Currently only Russia is able to take back spent fuel of its own origin. In general, spent fuel of foreign origin currently has nowhere to go and must remain within reactor states. In addition, not every state has adequate geographic environment within its territory for direct disposal.

Kuno et al. stressed the importance of reprocessing in terms of proliferation risk and environmental safety in waste because a much larger amount and higher quality of plutonium will be buried as spent fuels in the direct disposal option [96]. In this context, spent fuel direct disposal by individual countries may not be the best idea. MNAs may, therefore, be able to cover the significant role of recycling. Different considerations from the economics discussed above may be needed in this concept of MNAs.

6.4 Transportation

As mentioned above, in the MNA, a number of nation-based ENR facilities are expected to be integrated into a limited number of MNA ENR facilities. Unless MNA member states are neighboring states in a certain region, generally, frequent long-distance transportation and mass transport between MNA facilities and MNA recipient states, and / or MNA facilities and non-MNA NSSs is anticipated, although it depends on the MNA member states.

Transportation routes need to be carefully selected with consideration for other practical feature of (L) Political and public acceptance, due to the necessity of obtaining authorization from relevant authorities in stopover states for transit and/or landing. In order to obtain the authorizations, MNAs need to be well accepted by their neighboring states and their local governments. In this respect, if states in the whole region share common regulations on nuclear energy, including nuclear security, nuclear safety, emergency preparedness, nuclear third party liability, etc., smooth and timely transportation would be expected.

Furthermore, MNA NSSs especially need to comply with certain regulations on transportation of nuclear material, including the following:

- Convention on the Physical Protection of Nuclear Material (INFCIRC/274)
- IAEA Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Rev.5) and related Nuclear Security Series documents
- Regulations for the safe transport of radioactive material (No. TS-R-1)
- Code of Practice on the International Transboundary Movement of Radioactive Waste (INFCIRC/386),
- Other international regulations on transportation by sea, air, rail, road, inland water, and others, if any.

6.5 Geopolitics

Geopolitics is policies and international relations, as influenced by geographical factors. From this definition, the (K) Geopolitics feature of MNAs closely relates to other MNA features of (L) Political and public acceptance, (F) Siting - choice of host state and (J) Transportation.

As mentioned in section 6.1 "Eligibility conditions of host states of MNA facilities", host states of MNA facilities require political stability, in order to assure safe and secure operation of the facilities.

From geographical and nuclear non-proliferation viewpoints, ENR activities in the neighboring states and surrounding regions of the so-called nuclear threshold states of Israel, India, Pakistan, Iran and North Korea [97] are generally unwelcomed by the international community. There are fears that such neighboring states' ENR activities would activate nuclear threshold states' nuclear activities and eventually contribute to the latter' s nuclear weapon programs, even if the former's activities are for utterly peaceful purposes with IAEA comprehensive safeguards. For example, as mentioned in chapter 4, the US has not granted its advance consent for the ROK's ENR activities, because "(Denuclearization of the DPRK) will be made even more difficult if the North Koreans can cite active fuel cycle programs in the South" [98]. The NCA between the US and the UAE includes a so-called "gold standard" provision that the UAE does not engage in ENR activities in its territory, in order "to isolate Iran's dangerous nuclear misbehavior and to forestall Middle Eastern countries themselves from pursuing nuclear arms" [99].

In the same way, political instability of a state and/or a region attributed to its geographical location severely affects its ability to host MNA facilities. Therefore, without mitigating or dispelling this political instability, these states and regions cannot host MNA facilities. Therefore, the (K) Geopolitics feature of MNAs requires the political stability of a host state and its surrounding region.

6.6 Political and Public Acceptance

Regarding acceptance by MNA member states, local communities and their residents (public acceptance), as the results of Table 3 shows, many proposals about spent fuel management were fatally dashed in the face of vehemently opposed local residents. The past MNA efforts in Table 3 also identify that transparency through information disclosure and information sharing throughout every stage of nuclear energy use is one of the important elements to obtain political and public acceptance. However, in this study, public acceptance will not be further pursued, since it is a completely different issue from nuclear non-proliferation. Therefore, after this section, a MNA feature "(L) Political and public acceptance" will be treated as "(L) Political acceptance", for convenience.

Furthermore, MNAs also need to be well accepted by international community, including non-MNA member states and international organizations such as IAEA. For example, if MNAs do not include NSSs, especially, enricher states, acceptance by those states is inevitable, in order to ensure uranium enrichment supplies. Since current uranium enrichment market is dominated by 4 big enrichers of URENCO, EURODIF (AREVA), ROSATOM and USEC, consequently the MNAs need to be well accepted their states, which are mainly NWSs.

Regarding (K) Geopolitics and (L) Political acceptance, in general, if political instability of (K) can be mitigated or dispelled by some arrangements, for example, the MNA's strong nuclear non-proliferation characteristic through measures mentioned in chapter 3 and/or involvements of world's key players in the area of nuclear non-proliferation including NSSs, NWSs and/or international organization into MNAs, the MNA can be politically accepted, although it depends on each MNA, its member states and a host state of a MNA facility. Therefore, those arrangements need to be considered on a case-by-case basis. This issue will be further discussed in case studies in chapter 7.

6.7 Summary of chapter 6

(F) Siting - choice of host state of MNA facilities

- Eligibility conditions to be host states of MNA facilities are as follows;
  - ✓ Unless an international organization is actively involved in decision-making, management and operation of the facility except safeguards, there seems to be no need to set "extra-territorial" status for MNA facilities.
  - ✓ In the case of ENR facilities, from the perspectives of ensuring nuclear non-proliferation and protecting intellectual property of technology holders, host states of the MNA ENR facilities principally need to be technology holder states.
  - ✓ The same as for a host state of the IAEA fuel bank, there are also various eligibility conditions to be host states of MNA facilities, including (A) Nuclear non-proliferation, (C) Nuclear safety and (E) Nuclear third party liability, together with technical and environmental requirements.

✓ Certain states cannot host certain nuclear fuel cycle facilities.

(G) Multilateral involvement and (H) Access to technology features

- MNA member states involvement in the MNA differ from "supply only arrangements" to "joint R&D, design, and construction of facilities", while their access to technology differs from "none" to "full access". Various combinations would be possible, and in principle, these combinations depend on the agreements among MNA member states or between MNA member states and technology holders.
- In the case of enrichment facilities, according to the NGS Guidelines, the current URENCO combination of "joint R&D, design, construction of facilities" and "full access" would not be expected. From nuclear non-proliferation and protecting intellectual property viewpoints, the maximum acceptable combination would be as follows:
  - ✓ Member states' participation into the facility: operation
  - ✓ Member states' access to technology: operation know-how or maintenance know-how

(I) Economics

- There are many factors which affect the economics of MNAs and in this respect. In general, every nuclear facility including MNA facilities, are desired to attain low cost. In addition, if MNA facilities have more economic advantage than a nation based facilities, it would serve as a great incentive for states joining the MNAs, although economic is not the only factor for establishing MNAs.
- In the case of MNA ENR facilities, due to a limited number of such MNA facilities, frequent and long-distance transportation as well as mass transport of nuclear material between MNA-ENR facilities and MNA recipient states, and / or MNA facilities and non-MNA NSSs are anticipated, compared with a nation based ENR facilities. In this respect, (I) economic feature of MNAs need to be discussed in relations with (J) transportation.
- Regarding (I) Economics and (J) Transportation, past studies using existing routes clarified that the MNA reprocessing facility has economic advantage than a nation based facility even if transportation cost is included. However, the MNA facility loses its economic advantage when the unit cost of land transportation is very high. The past studies also indicate the scenario

involving the route via a specific port is economically advantageous under almost all transportation unit cost conditions. It suggested that geographic, (K) Geopolitical and (L) Political consideration would be involved in the economic discussion.

(J) Transportation

- Transportation routes need to be carefully selected with consideration for other MNA features, especially (L) Political and public acceptance, due to the necessity of obtaining authorization from relevant authorities in stopover states for transit and/or landing. In this respect, if states in the whole region share common regulations on nuclear energy, including nuclear security, nuclear safety, emergency preparedness, nuclear third party liability, etc., it will not be difficult to get necessary authorizations.
- MNA member states need to comply with certain international convention / regulations on the transportation of nuclear material.

(K) Geopolitics and (L) Political and public acceptance

- (K) Geopolitics is politics, especially international relations, as influenced by geographical factors.
- Political instability of a state and/or a region attributed to its geographical location severely affects its ability to host MNA facilities. Therefore, without mitigating or dispelling this political instability, these states and regions cannot host MNA facilities. Therefore, the (K) Geopolitics feature of MNAs requires the political stability of a host state and its surrounding region.
- Regarding public acceptance, fuel cycle back-end facilities especially need to be well accepted by MNA member states and their public. The past MNA efforts show that transparency through information disclosure and information sharing throughout every stage of nuclear energy use is an important element to obtain public acceptance.
- Furthermore, MNAs need to be well accepted by international community, including non-MNA member states, especially NSSs of enrichment service, and international organizations such as IAEA.
- Regarding MNA features of both (K) Geopolitics and (L) Political acceptance, political instability of a state and/or a region attributed by its geographical location severely affects a state's and/or region's ability to host the MNA facilities. Without mitigating or dispelling such political instability, such

state and / or region cannot host the MNA facilities and the MNA cannot be established, due to lack of (L). These (K) and (L) features will be further elaborated within case studies in chapter 7.

Chapter 7 Applicability of MNA Features

Chapter 7
Applicability of MNA Features

7.1 Applicability of MNA Features to MNAs through Case Studies

In this chapter, in order to discuss the applicability of MNA features and detailed measures for satisfying MNA's three requirements which have been discussed in previous chapters, three case studies assuming the establishments of three different MNAs consisting of existing countries in Asian region and the Middle East are made. After looking at each state's brief nuclear activities, in accordance with twelve MNA features and their detailed measures, possibility of the MNAs' establishments are analyzed. In addition, during the analysis, challenges for establishing the MNA, if any, are identified, together with possible solutions to these challenges. In each case, it is presumed that every state in each Case Study has the desire to establish enrichment and/or reprocessing capabilities in MNA form (MNA-ENR).

7.1.1 Case Study 1

In Case Study 1, it is assumed that nuclear operators in Japan and the Republic of Korea (ROK) jointly form the "Japan-ROK MNA" and construct new ENR facilities either in Japan or the ROK, and/or transfer existing Japanese enrichment and/or reprocessing plant currently under construction to MNA facilities. In the case of a reprocessing plant in the ROK, it is assumed that pyroprocessing is to be utilized in the plant in the future, although pyroprocessing technology is currently in the experimental stage in the ROK.

Reasons for selecting these states are as follows:

- National security and dependence on the US
  - ✓ Both states have built close ties with the US for their national security. According to the US, "alliances with the R.O.K. and Japan provide deterrence and defense against the threat posed by the Democratic People's Republic of Korea (D.P.R.K) continued pursuit of nuclear weapons and ballistic missiles technology" [100].

- Nuclear energy utilization and relations with the US
  - ✓ Both states are advanced nuclear energy states and NNWSs. But due to lack of natural resources, they need to import natural uranium and uranium

enrichment service from abroad. In order to initiate their nuclear activities, both states have been provided nuclear supplies from the US under nuclear cooperation agreements (NCAs) with the US. In principle, under the NCAs with the US, both states need to be granted advance consents from the US in their engagement in ENR activities when utilizing US-origin material and in transferring the US-origin spent fuel abroad for reprocessing.

  - ✓ The current US-Japan NCA came into force in July 1988, while the current US-ROK NCA came into force in March 1973 and was amended in May 1974. Under the US-Japan NCA, the US has given Japan programmatic advance consent for Japan's reprocessing and plutonium utilization, while it has not given the ROK the same treatment. In March 2014, the current US-ROK NCA has been extended by two years [101]. Both governments had been "negotiating for a longer-term agreement, but have not been able to resolve key issues" [102]. It is reported that the ROK wants to obtain the US's programmatic advance consent especially on pyroprocessing of spent fuel and utilization of recovered plutonium in the ROK, while the US is concerned about nuclear proliferation in the Korean Peninsula, since "(Denuclearization of the DPRK) will be made even more difficult if the North Koreans can cite active fuel cycle programs in the South" [103].

- ENR facilities in the ROK and the DPRK
  - ✓ According to the "Joint Declaration of the Denuclearization of the Korean Peninsula" of 1992, both the ROK and the DPRK "shall not possess nuclear reprocessing and uranium enrichment facilities" [104].

- Relationship between Japan and the ROK on nuclear energy
  - ✓ The NCA between Japan and the ROK entered into force in January 2012. Both states share similarities mentioned above, but they are different in that Japan has both ENR capabilities, while the ROK does not.

Table 13 shows Japan's and the ROK's current status of nuclear activities as of October 2013.

Table 13 Current status of nuclear activities in Japan and the ROK

State	Current status of nuclear activities
Japan [105], [106], [107]	• Reactors: There are 50 commercial power reactors, 3 are under construction and 9 are planned, although 50 of these reactors have not been operated due to safety reviews after the Fukushima nuclear accident. • Fuel cycle facilities: There are conversion, enrichment, fuel fabrication and reprocessing facilities and waste management facilities for spent fuel away from reactors. • A commercial enrichment plant started operation in 1992, and the plant's design capacity of 1,050tSWU/y is expected to be reached in 2022. The capacity satisfies one-third of Japan's reactor fuel demands, therefore, currently most of Japan's enrichment services are imported from abroad. • The capacity of a commercial reprocessing plant is to be 800 tonU/y and it enables reprocessing of spent fuel from 40 reactors of one million kw-class. The plant is "in the stage of "Final Commissioning-Test" and planned to complete its construction in October 2014".
ROK [108]	• Reactors: Currently 23 reactors are in operation, 5 under construction and 6 are planned [109]. It has a plan to increase electric power generation from the current 20.7 GWe to 32.9 GWe by 2022. • Fuel cycle facilities: There are conversion and fuel fabrication plants; however, the ROK does not possess ENR facilities. Pyroprocessing, a technology for spent fuel processing, is now in experimental stages and its prototype facility is expected to start operation in 2028 [110]. Currently the US and the ROK have been engaging in Joint Nuclear Fuel Studies, in order to evaluate non-proliferation, technical and economic feasibility of pyroprocessing for 10 years since 2011 [111].
• Safeguards: Japan and the ROK are NPT members and they concluded a comprehensive safeguards agreement with the IAEA and ratified the AP. After obtaining the Broader Conclusion, the IAEA integrated safeguards have already been implemented in Japan and the ROK. • Nuclear security: Both states are members of the Convention on the Physical Protection of Nuclear Material and they have ratified its amendment.	

- Nuclear export control: Both states are members of the NSG and submit their national report to the 1540 Committee.
- Nuclear safety: Both states are members of the following conventions on nuclear safety.
  - ✓ Convention on Nuclear Safety (INFCIRC/449)
  - ✓ Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (INFCIRC/546)
  - ✓ Convention on Early Notification of a Nuclear Accident (INFCIRC/335)
  - ✓ Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (INFCIRC/336)

The following is analysis of this MNA by twelve MNA features with their conditions as described in previous chapters.

7.1.1.1 Analysis of Case Study 1

(1) (A) Nuclear non-proliferation

As mentioned in Table 13 above, both Japan and the ROK are NPT members and concluded international treaties/conventions on nuclear non-proliferation, including safeguards, nuclear security and export control. As mentioned in chapter 3, if regional safeguards and RSAC are implemented, they would strengthen nuclear non-proliferation characteristic of the MNA.

(2) (B) Assurance of supply (of nuclear fuel and nuclear fuel cycle services)

Regarding the supply of ENR services, neither state can offer these services due to the ROK's absence of such capabilities and Japan's current capacities are only for domestic purposes. In this case, the participation of other states with such capacities into the MNA and/or ensuring supplies from other states through concluding NCAs is necessary. Alternatively, completions and enlargements of Japan's existing enrichment and expected reprocessing capacities will contribute to supplies assurance. In addition, if the ROK would like to use its future pyroprocessing plant as a MNA facility, it needs to commercialize pyroprocessing technology. Furthermore, from a nuclear non-proliferation perspective, it is desirable for the MNA to assure a fuel-leasing service supply. Currently, however, neither state can offer these services, due to their incapability of accepting other state's spent fuel.

(3) (C) Nuclear safety

As mentioned in table 13 above, both Japan and the ROK concluded international conventions on nuclear safety. As mentioned in chapter 3, if common nuclear safety standards and peer review systems are implemented, they would strengthen nuclear safety characteristic of MNA facilities.

(4) (D) Nuclear cooperation agreements (NCAs), (F) Siting - choice of host state of MNA facilities, (G) Multilateral involvement, (H) Access to technology, (K) Geopolitics and (L) Political acceptance

For (F) Siting - choice of host state of the Japan-ROK MNA-ENR facilities, the following three options can be considered.

- ✓ Option 1: Establishment of new MNA-ENR facilities in Japan utilizing its current ENR technologies,
- ✓ Option 2: Transferring Japan's existing ENR facilities to MNA facilities, and
- ✓ Option 3: Establish new MNA-ENR facilities in ROK, including utilization of the ROK's pyroprocessing technology, although this is a future option.

As already mentioned, if the US-origin material is expected to be utilized within Japan-ROK MNA-ENR facilities, the US's programmatic advance consent is necessary for a stable and smooth supply of nuclear fuel and nuclear fuel cycle services.

In the case of Options 1 and 2, considering the fact that Japan already has engaged in ENR activities including reprocessing by obtaining US programmatic advance consent, and transparency of the facilities are additionally enhanced by the MNA's multilateral characteristic, obtaining this consent is not expected to be difficult, on the condition that separated plutonium would be efficiently utilized as MOX fuel, similarly to how it is being utilized in France, Belgium and Germany, in case of reprocessing.

On the other hand, in Option 3, as mentioned in chapter 6, the host state of the MNA facility needs to be politically stable and to maintain good relations with neighboring states (requirements of (F) Siting – choice of host state and (K) Geopolitics features). Considering the fact that "no final settlement (of the Korean War) was ever reached" [112] and Joint Declaration of the Denuclearization of the Korean Peninsula, the ROK cannot satisfy these conditions and it cannot host the MNA-ENR facilities. This is also a political challenge to establish the MNA.

Another challenge is that the US has not given its programmatic advance consent to the ROK's reprocessing.

Fred McGoldrick and Robert Einhorn analyzed the US's reasons for not giving its programmatic advance consent to the ROK as follows: [113], [114], [115]

- ✓ Not to jeopardize the satisfactory resolution of the DPRK's nuclear issue, including a nuclear-weapon-free Korean Peninsula,
- ✓ Acceptance of the ROK pursuit of pyroprocessing may raise regional and global non-proliferation concerns,
- ✓ Preventing the spread of sensitive nuclear facilities is the US's long-standing policy and it is challenging to find a rationale for making an exception for the ROK,
- ✓ The US made exceptions for Japan, EURATOM and India for granting programmatic advance consents for their reprocessing, since they had already built and operated reprocessing facilities.
- ✓ On the other hand, the ROK's pyroprocessing technology has been still in experimental stage and currently the Joint Nuclear Fuel Studies have been engaged by the US and the ROK.

All the above reasons, except the last one, are highly political in nature and beyond the ROK's control. On the other hand, as a potential that the ROK's pyroprocessing could be allowed by the US, McGoldrick presented the establishment of a US-ROK "joint venture or multinational entity with IAEA involvement in the policy-making or management of the plant", as one possible option, because such an arrangement has the following advantages [116]:

- The US can maintain its position of opposing the spread of sensitive facilities,
- The US or multinational involvement could establish additional barriers through transparency, to the diversion of nuclear materials to non-peaceful purposes and thus serve as an important complement to international safeguards and physical protection,
- The presence of a multinational staff would place participants under a greater degree of scrutiny by partners and may also constitute an additional obstacle against a breakout by the ROK, and
- It offers a less discriminatory approach than a regime that allows a few states to continue their national programs while strongly discouraging most states from acquiring such technologies.

Considering the above advantages and in order to satisfy the MNA features of (K) Geopolitics and (L) Political acceptance, it would be more desirable to establish a US-Japan-ROK MNA with IAEA involvement, together with regional safeguards and the RSAC. Due to the US's and the IAEA involvements, the Japan-ROK MNA has becomes more transparent and has more international characteristic, compared with solo Japan-ROK MNA. Furthermore, with the US's participation, the MNA's role as confidence-and security-building measure is to be strengthened.

As for the (H) Access to technology feature, Japanese reprocessing technology and the ROK's pyroprocessing are different; therefore, one cannot have access to the other's technology, for the sake of non-proliferation and protection of the technology holder's intellectual property.

(5) (E) Nuclear third party liability (TPL)

Currently neither state are members of any international nuclear TPL conventions; however, as mentioned in chapter 5, for the purposes of ensuring adequate and prompt compensation as well as of maintaining equal and non-discriminate compensation among MNA member states for transboundary damage in case of a nuclear accident in the MNA facility, MNA members of neighboring states in principle must participate in the same international nuclear TPL convention. After the Fukushima nuclear accident, Japan decided to join the Convention on Supplementary Compensation for Nuclear Damage (CSC) in November 2013 [117], while the ROK has already "modernized its nuclear liability legislations by introducing the major features" [118] of the Protocol to amend the Vienna Convention on Civil Liability for Nuclear Damage in 1977 and the CSC. In addition, if both states jointly participate in the CSC, the CSC itself will enter into force due to satisfying its requirements.

In addition, as mentioned in chapter 5, sharing the responsibilities of an installation state would be possible, as long as both states agree.

(6) (I) Economics

As mentioned in chapter 6, MNA facilities are expected to have more economic advantage than nation-based facilities. An existing Japanese enrichment plant aims to offer uranium enrichment production cost of approximately 100 US dollars /kgSWU [119] and considering from this fact, improvement of economic efficiency would be required, in case the plant is to be utilized as a MNA facility.

As to utilization of Japan's reprocessing plant as a MNA facility in the future, the past study found out that the MNA facility is more economically advantageous than a nation based reprocessing facility, including transportation and if Kazakhstan is to be included in the MNA. This will be further elaborated in Case Study 2.

Regarding economics of the ROK's pyroprocessing, economic feasibility of pyroprocessing has been evaluated under the Joint Nuclear Fuel Studies.

(7) (J) Transportation

Transportation by sea is expected between Japan's nuclear facilities and those of the ROK's. There should be no big problems for sea transportation, since this transportation does not cross any states.

7.1.1.2 Summary of Analysis of Case Study 1

Table 14 summarizes the analysis of Case Study 1.

Table 14 Summary of Case Study 1

Features	A	B	C	D,F,G,H,K,L	E	I	J
Result of the analysis	✓	X	✓	Δ	X	X	✓

✓: Satisfied, Δ: Partly satisfied, X: Not satisfied

The biggest challenges to establish this Japan-ROK MNA relates to (K) Geopolitics and (L) Political acceptance.

As far as the US-origin material is to be utilized in MNA facilities in Japan and / or the ROK, the US's programmatic advance consents is necessary under the US-Japan and the US-ROK NCAs.

The establishment of a new MNA pyroprocessing facility in the ROK would not be easy, due to current situation of political instability of the Korean Peninsula and the lack of the US's advance consent. In addition, MNA facilities in Japan would also need the US's programmatic advance consent, as long as US-origin material is utilized in these facilities. In these cases, possible solutions to these challenges are the MNA including the US with IAEA involvement and Japan-ROK regional safeguards and the RSAC, together with the US and the IAEA. Those solutions could enhance the transparency of Japan-ROK nuclear activities through US's and the IAEA's direct involvements of MNA activities, and increase international characteristic of the MNAs. Furthermore, with the US's participation, the MNA's role as confidence-and security-building measure is to be strengthened.

For establishing the MNA, the following additional arrangements are necessary;

- (B) Assure supply of enriched uranium and ENR services: In order to assure the supply of enriched uranium and ENR services, the following options need to be considered:

  - ✓ Participation of other states with ENR capacities into the MNA
  - ✓ Ensuring ENR supplies from other states through NCAs
  - ✓ Enlargement of Japan's existing ENR capacities
  - ✓ Commercialization of the ROK's pyroprocessing technology

- (E) Nuclear third party liability: both states need to participate in the CSC. As for (I) Economic, in the case that existing Japanese enrichment plants are to be used as the MNA facility, economic efficiency is required.

By implementing above measures on MNA features, this MNA can be established by satisfying twelve MNA features.

7.1.2 Case Study 2

In Case Study 2, assume that nuclear operators in Russia, Kazakhstan, Vietnam, Japan and the ROK jointly form a MNA and construct new MNA facilities and / or transfer existing facilities to MNA facilities. In this study, it is also assumed that the US-origin nuclear material is not be utilized within this MNA.

Reasons for selecting these members are as follows;

- Kazakhstan and Russia: As mentioned in Table 15, the former is rich in natural uranium resources, while the latter has large uranium enrichment capacity. In addition, it is in principle possible for Russia to take-back spent fuel that it originated.
- Japan and the ROK: Both states have reactor technologies. Japan has ENR technologies and facilities.
- Vietnam: an example of an emerging nuclear energy state which has already planned to introduce nuclear reactors.
- With participation of Kazakhstan, Russia, Japan and the ROK in the MNA, every nuclear fuel cycle service is expected to be ensured.

Table 15 summaries Russia, Kazakhstan and Vietnam's current status of civil nuclear activities as of March 2014. Nuclear activities of Japan and the ROK are already mentioned in Table 13.

Table 15 Current status of nuclear activities in Russia, Kazakhstan and Vietnam

State	Current status of civilian nuclear activities
Russia [120]	• Reactors: There are 33 operating reactors (17 VVERs, 13 RBMK light water reactors, 4 small graphite moderated BWR and one BN-600 fast breeder reactor) totaling 24,164 MWe. • Fuel cycle facilities: Russia has every facility of the nuclear fuel cycle. ✓ Enrichment: There are four enrichment plants and total capacity is 24,300tSWU/y, the largest enrichment capacity in the world. ✓ Reprocessing: RT-1 Plant (Chelyabinski-65, 400 t/yr) reprocesses spent fuel from VVER-440, BN-600 and naval reactors. RT-2 Plant (700 t/yr. capacity) is expected to start its operation around 2024 for both VVER-1000 and RBMK fuel, and BN fuel.

	✓ Spent fuel take-back: the Russian laws were changed in 2001 allowing bringing spent fuel to Russia, for technological storage and/or reprocessing, but not for final disposal. However, according to ROSATOM, this spent fuel needs to be Russian-origin, not foreign-origin [121].
Kazakhstan [122]	• Uranium resources: Kazakhstan has 12% of the world's uranium resources and produced about 22,500 tons in 2013. In 2009, it became the world's leading uranium producer with almost 38% of the world production in 2013. • Reactors: The BN-350 fast reactor was closed down in 1999. Two Russian VBER-300s are planned to start their operations in 2016 and 2017 respectively. • Fuel cycle facilities: ✓ Enrichment: Kazakhstan itself does not have enrichment facilities; however, it has shares of the Uranium Enrichment Centre (UEC) and International Uranium Enrichment Center (IUEC) in Russia. ✓ Fuel fabrication: Kazakhstan has a major plant making nuclear fuel pellets and it aims to supply one third of the world fuel fabrication market by 2030, including fuel for French-designed reactors and for Westinghouse reactors.
Vietnam [123]	• There are currently no commercial reactors, but in June 2010, the Vietnam government announced that it would introduce 14 reactors at 8 locations by 2030. In 2010, Vietnam agreed with Russia and Japan to build 2,000 MWe of nuclear capacity (2 units each) respectively. • Vietnam is taken in this option study as a typical potential country to introduce nuclear energy.
• Safeguards: All states concluded the comprehensive safeguards agreement with the IAEA and ratified the Additional Protocol (AP). • Nuclear security and export control: Vietnam is a member of neither the Nuclear Terrorism Convention nor the NSG. • Nuclear safety: All states have already ratified international conventions on nuclear safety, including INFCIRC/449, 546, 335 and 336	

The following is analysis of this MNA by twelve MNA features with their conditions as described in previous chapters.

7.1.2.1 Analysis of Case Study 2

(1) (A) Nuclear non-proliferation

In general, Russia, Kazakhstan, Vietnam, Japan and the ROK are all members of primary non-proliferation, including safeguards, nuclear security and export control related international treaties/conventions.

(2) (B) Assurance of supply of (of nuclear material and nuclear fuel cycle services)

As mentioned in chapter 3, from a nuclear non-proliferation perspective, the MNA needs to assure fuel-leasing service supply. In contrast with Case Study 1, the assurance of nuclear fuel cycle services supplies including fuel-leasing within this MNA will not be impossible with the following combinations:

- Natural uranium: Kazakhstan
- Uranium conversion and enrichment: Russia (and Kazakhstan, since it has a stake of Russian's Uranium Enrichment Center)
- Fuel fabrication: Kazakhstan, Russia, Japan and the ROK
- Reprocessing: Russia and Japan with completion and enlargement of their facilities, if necessary.
- Fuel take-back services: Russia (Russian-origin is necessary)

In addition, the above supply assurance can be achieved without US involvement.

Currently, Russia is actively for exporting nuclear reactors to emerging nuclear energy states. "Russia's policy for building nuclear power plants in non-nuclear weapons states is to deliver on a turnkey basis, including supply of all fuel and repatriation of used fuel for the life of the plant. The fuel is to be reprocessed in Russia and the separated wastes returned to the client country eventually" [124]. However, in order to be assured fuel-leasing service supply, it is required to utilize Russian-origin fuel. This means that front-end supply will heavily depend on Russia.

(3) (C)Nuclear safety

Russia, Kazakhstan, Vietnam, Japan and the ROK are all members of primary nuclear safety related international conventions.

(4) (D) Nuclear cooperation agreements (NCA)

These five states have concluded NCAs with each other and with NSSs, as shown in Table 8. In this MNA, with completion of Russia and Japan's reprocessing facilities, a certain level of capacity is ensured, therefore, there would be no need to be provided such services outside the MNA under NCAs with non MNA member states.

In addition, in this case study, neither US-origin materials nor ENR activities in MNA facilities are expected, therefore, in principle, there is no need to be granted programmatic advance consent from the US. If the US-origin material is expected to be reprocessed in MNA reprocessing plant, US consent is necessary.

(5) (E) Nuclear third party liability (TPL)

Table 16 [125] shows brief overview of the nuclear liability systems of Russia, Kazakhstan, Vietnam, Japan and the ROK, as of February 2011.

Table 16 Nuclear liability systems in Russia, Kazakhstan, Vietnam, Japan and the ROK

	Membership of international convention on nuclear	Domestic nuclear liability law	Operator's liability			Amount of financial security		Compensation / support by the Government: Available (A) /not available (N)
			Limited (L)/ Unlimited (U)	Amount of limit of liability	(Approximately mil. US dollars, as of 10 April 2014)	local currency	(Approximately mil. US dollars, as of 10 April 2014)	
Russia	Yes	Yes	L	US$5 mil.	5	US $5 mil.	5	A
Kazakhstan	Yes	Yes	L	Not specified in the law				
Vietnam	No	Yes	L	150 mil. SDRs	232	150 mil. SDRs	232	Not specified in the law
Japan	No	Yes	U	-	-	120 billion Japanese yen	1,176	A
Republic of Korea	No	Yes	L	300 mil. SDRs	464	5 billion Korean Won	47.8	A

Among these states, only Russia and Kazakhstan are members of the Vienna Convention on Civil Liability for Nuclear Damage in 1977 and Kazakhstan also acceded the Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage (Revised Vienna Convention). However, the nuclear liability system is quite variable depending on the state, especially on amounts of liability and financial security. Except Russia and Kazakhstan, and Japan and the ROK, these states are located in different parts of the region; therefore, generally speaking, it is unlikely that a nuclear accident at a nuclear facility in either Russia or Kazakhstan would cause serious damage to either Japan or the ROK, and Vietnam, or vice versa. In this case, it is not necessary that every MNA member state participates in the same international nuclear TPL convention, except Russia-Kazakhstan and Japan-ROK which either share borders or are geologically close to each other. In this case, if responsibilities of an installation state in case of a nuclear accident are agreed to be shared among all MNA member states, the sharing needs to be agreed upon ahead of time.

In addition, as mentioned in chapter 5, sharing of responsibilities of an installation state would be possible, as long as both states agree.

Furthermore, as mentioned in Case Study 1, Japan and the ROK need to participate in the same international nuclear TPL convention, for adequate and equitable compensation among victims suffered from transboundary damage by a nuclear accident in either state.

(6) (F) Siting - choice of host state

Different from case study 1, the ROK's role in this MNA is fuel fabrication. Since the ROK already has fuel fabrication plants in its territory, from nuclear non-proliferation viewpoint, there is no problem to hosting a MNA-fuel fabrication plant or to transfer its existing plants to the MNA.

(7) (G) Multilateral involvement, (H) Access to technology and (I) Economics

Since there are already existing and/or under construction nuclear fuel cycle facilities in this MNA, utilization of such facilities has an economic advantage over establishing new facilities. In this case, non-ENR technology holder states cannot access such technologies, from the viewpoints of nuclear non-proliferation and protection of intellectual property.

(8) (I) Economics, (J)Transportation and (K)Geopolitics

Comparisons of (1) economics of a nation based and a MNA reprocessing plant and (2) economics of possible spent fuel transportation routes between Japan and Kazakhstan have already been studied in "A Study on the Establishment of an International Nuclear Fuel Cycle System for Asia" by the Nuclear Nonproliferation Study Committee, Graduate School of Engineering, University of Tokyo [126]. In the study, the following four scenarios described below and Figure 7 [127] were examined for the case transferring spent fuels from Japan to Kazakhstan where spent fuel storage is expected in the study;

A: The route via Saint Petersburg Port (via the Suez Canal)

B: The route via Saint Petersburg Port (Arctic Sea route)

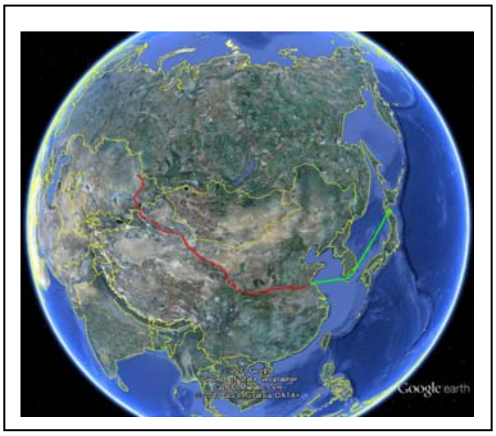
C-1: The route via Vostchny (Russia) Port

C-2: The route via Lianyungang (China) Port

A. The route via Saint Petersburg Port via the Suez Canal

B. The route via Saint Petersburg Port via Arctic Sea

C-1. The route via Vostchny Port



C-2. The route via Lianyungang Port

Figure 7 Transportation routes of each scenario

The results of the study, found the following issues:

- The MNA is more economically advantageous than a nation based facility under all scenarios, but it loses its economic advantage when the unit cost of land transportation is very high.

- The scenario involving the route via Lianyungang Port is economically advantageous under almost all transportation unit cost conditions, although the scenario does not use an existing route.

According to the Study, above C-2 route route "has no system to track the position of freight trains in real-time and there is a need to transfer goods at border stations due to railway tacks being different in Kazakhstan and China". However, compared with the C-1 route, the C-2 route "had more stable winter weather and lower freight costs, so it is currently handling increasing amounts of freight as a primary rail transport route between Europe and Asia. If this route is further investigated and the problem of having to transfer freight a border stations between Kazakhstan and China solved and facilities for transferring nuclear fuel established in Lianyungang port in China, then hits could be a good choice for a transport route from Kazakhstan for the international nuclear fuel cycle" [128].

The study indicates the importance of China in nuclear material transportation. Geographically, China is located between the NSSs' block of Russia-Kazakhstan to RSs' block of Japan and the ROK in the above route. In addition, it is also located between NSSs' block of Russia-Kazakhstan and another RSs' block in the Southeast Asian region where many states are very much interested in newly introducing nuclear reactors. Therefore, China would be a logistics hub of transportation of nuclear material not only from west to east, but also from north to south. In this respect, even if China is not a MNA member, the MNA needs to maintain a good relationship with China.

Regarding transportation via Russia, in order to satisfy the rapid energy demand in the Asian region, Russia currently focuses on energy and infrastructure developments in Eastern Siberia and the Far East [129]. Along with these initiatives, necessary routes for nuclear energy supplies are expected to be developed in the near future.

(9) (K)Geopolitics and (L)Political acceptance

In Case Study 2, assuming that Japan and the ROK do not utilize US-origin material within the MNA and they fully depend on their fuel supply from Russia. In this respect, from the viewpoints of ensuring energy security of Japan, the ROK and Vietnam, how to ensure reliable fuel supply on Russia would be a challenging political issue. In January 2009, Russia cut off gas pipelines to Europe via Ukraine, due to failures of negotiations on gas prices with Ukraine, which was pro-EU government [130]. Therefore, even if any political conflicts between Russia and other states, including the US and European states occur, Japan, the ROK and Vietnam need to avoid being embroiled in those conflicts for their energy security, although Japan and the ROK maintain close relationship with the US, including their national security.

One possible solution for them would be to ensure alternatives of uranium enrichment service resources, including transportation routes, the same as that every nuclear utility in every state has already taken as preventive measures. However, other uranium enrichers are only URENCO, AREVA and the USEC and in this respect, both Japan and the ROK have no other choice but still depend on enrichment uranium supply from Europe and the US.

7.1.2.2 Summary of Analysis of Case Study 2

Table 17 summarizes the analysis of Case Study 2.

Table 17 Summary of Case Study 2

Features	A	B	C	D	E	F	G,H, I	I,J,K	K,L
Result of the analysis	✓	Δ	✓	✓	Δ	✓	✓	✓	X

✓: Satisfied, Δ: Partly satisfied, X: Not satisfied

The great advantage of this Russia-Kazakhstan-Vietnam-Japan-ROK MNA is that assurance of nuclear fuel cycle services supplies, including fuel-leasing will not be impossible, although Russian and Japan's reprocessing plants needs completion and enlargement. In addition, this supply assurance can be achieved without the US involvement.

On the other hand, the biggest challenge to establish this MNA relates to (K) Geopolitics and (L) Political acceptance, the same as for Case Study 1. Even if not the US-origin material but only Russian-origin material is to be utilized in the MNA, in order to ensure stable and smooth supplies of nuclear fuel and services within the MNA, the MNA needs to avoid being embroiled in any conflicts between Russia and other states including the US. One of possible solutions for Japan and the ROK would be to ensure alternatives of uranium enrichment service resources and transportation routes, not fully depending on supplies from one state.

In addition, from a geographical viewpoint, even if China is not a MNA member, the MNA needs to maintain good relationship with China, since China has the potential to become a logistic hub of nuclear transport between NSSs and RSs.

One of possible solutions for Japan and the ROK would be to ensure alternatives of uranium enrichment service resources and transportation routes, not fully depending on supplies from one state. Since world's enricher states except Russia are the US and European states, therefore, in this respect, Japan and the ROK still need to depend on enrichment uranium supply from Europe and the US.

To establish the MNA, the following additional arrangements are necessary:

- (B) Assurance of supply: Completion and enlargement of Japan's and Russian's reprocessing plants are necessary.
- (E) Nuclear third party liability: The same as Case Study 1, Japan and the ROK need to participate in the CSC.

By implementing above measures on MNA features, this MNA can be established by satisfying twelve MNA features.

7.1.3 Case Study 3

In Case Study 3, assume that the nuclear operators in six states in the Cooperation Council for the Arab States of the Gulf (GCC), namely the United Arab Emirates (UAE), the Kingdom of Bahrain (Bahrain), the Kingdom of Saudi Arabia (Saudi Arabia), the Sultanate of Oman (Oman), Qatar and Kuwait form a MNA. Reasons for selecting these members are:

- Currently there are no commercial power reactors in the GCC states. However, the UAE and Saudi Arabia have ambitious plans to newly install nuclear capacities by the early 2020s [131]. On the other hand, the introduction of nuclear capacities in a politically unstable region close to the threshold states of Israel, Syria and Iran raise nuclear proliferation concerns. In this regard, instead of establishing nation-based ENR facilities in those states separately, the MNA can be one measure for nuclear non-proliferation, as follows:

- As a practical matter, there has been momentum to establish a MNA, in addition to the nuclear weapon free zone, as follows;
  - ✓ In December 2005, the GCC announced its initiative to declare the Golf region as a Nuclear Weapons Free Zone (Golf NWFZ) for the first time [132], as the first step in establishing the Middle East Nuclear Weapons Free Zone (MENWFZ) in the future.

  - ✓ In December 2006, the GCC states announced their joint decision to establish a nuclear research program and the GCC Secretariat and some GCC member states respectively asked for the IAEA's support for their projects.

  - ✓ In October 2007, the GCC presented its initiative to establish an international uranium enrichment consortium in a neutral state outside the region through participation by interested states in the Middle East. However, the initiative was rejected by Iran insisting to continue its own enrichment activities, even with the establishment of such a consortium [133].

The biggest difference between this GCC-MNA and the other two MNAs in Case Studies 1 and 2 is that the GCC states are located in the center of the Middle East, one of the most politically unstable areas in the world. Nicole Stracke mentions that "The past decades have shown that if one state in the Gulf region aims to achieve military superiority, other regional states will react decisively and try to restore the balance of power", and "in case the non-proliferation regime falls short in preventing certain regional states from developing their nuclear military capability", "It is most likely that majority of the GCC states will seriously consider joining the nuclear arms race as means of self-defense and as a necessary measures to protect their independence and security" [134]. Alternatively, if one state in the GCC or another state in the Middle East obtains a nuclear weapon, it may lead to a nuclear arms race. Therefore, nuclear non-proliferation needs to be especially enhanced in the region.

In addition, the GCC itself is a framework for 6-state's national security against Iran. In this respect, in case the GCC-MNA nuclear facilities within GCC territory encourage Iran's nuclear activities and grow its proliferation concerns, purposes of establishing GCC itself would be inhibited. Therefore, (F) a host state of GCC-MNA-ENR facilities need to be carefully considered from (K) Geopolitical and (L) Political acceptance perspectives.

Table 18 shows summaries of the UAE's, Saudi Arabia's, and Kuwait's current status of nuclear energy utilization plans. The UAE and Saudi Arabia are aggressive about introducing nuclear energy to the GCC states.

Table 18 Nuclear energy plans in UAE, Saudi Arabia and Kuwait

State	Nuclear activities (plans)
UAE [135]	In December 2009, the UAE accepted a bid by the Korea Electric Power Corporation (KEPCO)-led consortium to construct four APR-1400 reactors, total 5.6 GWe, by 2020 at Barakah. Construction of the first unit started in 2012 and the second one started in May 2013.
Saudi Arabia [136]	Has a plan to construct 16 nuclear reactors over the next 20 years. The first reactor will be on line in 2020.
Kuwait [137]	Its original nuclear energy plan was to build four 1,000 megawatt NPP reactors by 2022, but it was reported to abandon this plan due to the Fukushima nuclear accident.

Among the other states in the Middle East that are not GCC states, Jordan also has an ambitious nuclear plan. Jordan concluded a NCA with the ROK in 2009 for the construction of a 5MW research reactor. Its fuel of 19% low enriched uranium will be supplied by AREVA. It has plans to construct a 1,000MWe nuclear power unit to be operating by 2021. In October 2013, the Jordan Atomic Energy Commission announced that ROSATOM's reactor export subsidiary AtomStroyExport (ASE) would be the supplier of two AES-92 nuclear reactors [138].

The following is analysis of this MNA by twelve MNA features with their conditions as described in previous chapters.

7.1.3.1 Analysis of Case Study 3

(1) (A) Nuclear non-proliferation and (C) Nuclear safety

Table 19 shows the GCC states' status of participations in international nuclear non-proliferation and nuclear safety related treaties, conventions and guidelines.

Table 19 Current status of GCC states on participation in international nuclear non-proliferation and nuclear safety related treaties, conventions and guidelines

		Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	United Arab Emirates
Nuclear non-proliferation	Treaty of Non-proliferation of Nuclear Weapons (NPT)	✓	✓	✓	✓	✓	✓
	Complementary safeguards (INFCIRC/153(Corr.))	✓	✓	✓	✓	✓	✓
	Modified Small Quantities Protocol (SQP) (X: Original SQP)	In force	amended	✓	In force	✓	✓
	Additional Protocol (AP, INFCIRC/540 (Corr.))	✓	✓	X	X	X	✓
	Convention on the Physical Protection of Nuclear Material (CPPNM, INFCIRC/274/Rev.1)	✓	✓	✓	✓	✓	✓
	Amendment to the CPPNM (not into force)	✓	X	X	X	✓	✓
	International Convention for the Suppression of Acts of Nuclear Terrorism	✓	✓	X	✓	✓	✓
	Nuclear Security Group (NSG) Guidelines (INFCIRC/254/Rev.12/Part 1)	---	---	---	---	---	---
Nuclear safety	Convention on Nuclear Safety (INFCIRC/449)	✓	✓	✓	X	✓	✓
	Convention on Early Notification of a Nuclear Accident (INFCIRC/335)	✓	✓	✓	✓	✓	✓
	Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (INFCIRC/336)	X	✓	✓	✓	✓	✓

	Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (INFCIRC/546)	X	X	✓	X	✓	✓

✓: Members, X: Non members

Even if there are no nuclear facilities or activities, from the viewpoint of ensuring nuclear non-proliferation and the fact that their neighboring states of Iraq and Iran had promoted clandestine nuclear activities under IAEA comprehensive safeguards, it is necessary for MNA member states to adopt the AP. Alternatively, the GCC states would be able to establish a regional safeguards system which is equivalent to the AP, such as the regional safeguards by ABACC.

As for this regional safeguards, Sara Z. Kutchesfahani proposes the establishment of "A Middle East Regional Safeguards Organization" [139]. According to the proposal, this organization would have the following benefits:

- Development of confidence and trust building,
- The Middle Eastern states' involvement in the nuclear non-proliferation regime, such as ratification of AP, and
- Development of further cooperation with others, including economic, technical, and energy provision, as already proved by the ABACC.

Therefore, if this a regional safeguards operation, together with the RSAC is established and introduced within the MNA, the MNA will itself also contribute to trust, confidence-and-security building and nuclear cooperation.

In addition, considering the fact that the ABACC supports the verification activities of the Agency for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (OPANAL), an inter-governmental agency created by the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (Treaty of Tlatelolco), the establishment of this regional safeguards organization has potential not only for the MNA, but also for the future establishment of the Golf NWFZ and MENWFZ.

However, from a realistic viewpoint, the establishment of such an organization may not be easy, since there is a long history of political, territorial, religious, racial and tribal conflicts and deep-rooted hatred in the Middle East, which are not expected to vanish in a short period of time. In this respect, due to the fact that the GCC has already been organized, the first step would be to create "A GCC Regional

Safeguards Organization". If this Organization works properly, then it will be time to move to establish "A Middle East Regional Safeguards Organization" [140].

Regarding the (C) Nuclear safety feature, some states have not yet ratified nuclear safety related international conventions. Since vulnerability of nuclear facilities from a nuclear safety perspective also become vulnerabilities from a nuclear non-proliferation perspective, before forming the MNA, potential member states need to therefore ratify international nuclear safety conventions and enact the necessary domestic laws on nuclear safety.

(2) (B) Assurance of supply (of nuclear fuel and nuclear fuel cycle services)

Since none of the GCC states currently have nuclear capacities, the participation of other states with ENR capacities plus fuel-leasing capacities, if possible, into the MNA or ensuring such supplies through NCAs with other states is necessary.

On the other hand, the UAE is an exception. Its nuclear fuel and enrichment fuel service supplies are ensured by the US, in return for its commitment of forgoing domestic ENR capabilities under the US-UAE NCA and under the contract with the ROK for building four APR-1400 reactors.

(3) (D) Nuclear Cooperation Agreements (NCAs)

In order to establish a MNA, first, the GCC member states, as a whole, needs to conclude NCAs with non-MNA member NSSs, for ensuring supply assurance, since they have no enrichment capability. Table 20 shows the current status of the GCC states' conclusions of NCAs or Memorandums of Understanding/Cooperation with NSSs. Regarding the GCC states' international cooperation, in 2008, Bahrain and Saudi Arabia concluded Memorandum of Understandings (MOUs) with the US containing their commitments of refrain from ENR activities, although these MOUs are not legally binding. The UAE signed a NCA with the US in 2009 and under the agreement, the UAE is legally bound to forego its domestic uranium enrichment and reprocessing capabilities (this commitment is called the "gold standard" by the US side). Although the US hopes to include the "gold standard" with NCAs with Saudi Arabia and Jordan, they have neither agreed to nor concluded NCAs with the US [141]. Saudi Arabia and Jordan take the same position.

Table 20 Current status of GCC states on conclusions of NCAs with NSSs

	US	Russia	France	UK	Japan	ROK	Canada	Australia	China
Bahrain	MOC		✓						
Kuwait	MOC	MOU	✓		MOC	MOU			
Oman		✓							
Qatar		✓							
Saudi Arabia	MOU, △	△	✓	△	△	✓			✓
UAE	✓	✓	✓	MOU	✓	✓	✓	✓	

✓: Agreement, △: Under negotiation for further cooperation

As mentioned, the US has concluded a NCA only with the UAE, while Russia and France have already concluded NCAs with most of the GCC states. In this respect, different from Case Study 1 of the Japan-ROK MNA, the nuclear activities of the GCC states, except the UAE, are not necessarily affected by the US. In addition, together with the fact that Russia and France do not require the "gold standard" in their NCAs and that Russia is able to take back spent fuel of its origin, the same as in Case Study 2, a MNA without the US can be established if Russia agrees either to participate in this MNA or to ensure uranium enrichment supply under NCAs with the GCC.

In the case of MNA-GCC, each GCC member states do not necessarily have to conclude NCAs with NSSs separately, since GCC states as a whole as a MNA, conclude NCAs with NSSs.

(4) (E)Nuclear liability

Among the GCC states, the UAE and Saudi Arabia acceded the Revised Vienna Convention. The Revised Vienna Convention applies to its non-contracting states; however, if non-contracting states have a nuclear installation in their territory and do not afford equivalent reciprocal benefits, an installation state may exclude the application of the convention to these non-contracting states (Article 3 of the Revised Vienna Convention). Therefore, at this moment, nuclear damage in Bahrain, Kuwait, Oman and Qatar caused by a nuclear accident in UAE and Saudi Arabia would be compensated, since the former four states currently have no nuclear installation in their territories. However, when the former states launch to hold nuclear installation, they also need to participate in the Revised Vienna Convention, in order to be ensured adequate and equitable compensation for transboundary damage.

(5) (F) Siting - choice of host state, (G)Multilateral involvement, (H) Access to technology, (J) Transportation, (K)Geopolitics and (L) Political acceptance

As for features of (F) and (K), first of all, as mentioned in chapter 6, the host state of a MNA facility needs to be politically stable. From this perspective, the GCC, together with Jordan, cannot host the MNA facility due to its geographical location near Israel, Syria and Iran, so-called nuclear threshold states. In addition, Dubai in the UAE is said to be one of the hubs of A.Q. Khan's nuclear black market [142].

In addition, the GCC itself is a framework of 6-state' national security against Iran, therefore, existence of MNA ENR facilities in the region should not become a threat to their national security.

Regarding (F) Siting - choice of host state, the GCC's 2007 initiative of establishing an enrichment consortium, none of the GCC states, including the UAE, have the intention to host a MNA enrichment facility within their region, considering the political instability in the region and activating Iran's nuclear energy program.

Therefore, a MNA enrichment facility outside the region would be a rational idea. This is one solution to avoid political challenges for establishing the MNA. In addition, considering the fact that GCC states need to be supplied nuclear fuel by NSSs, involvements of NSSs in the MNA contribute efficient function of the MNA. Considering the fact that current major enricher states are NWSs, therefore, involvements of NSSs and/or NWSs is necessary and together with the regional safeguards mentioned above, the MNA's nuclear activities would become more transparent compared with the solo GCC-MNA.

On the other hand, there are already uranium enrichment market and enrichment companies outside the region. In this respect, there would be economic rationale for the GCC state as a whole to take a stake in several existing enrichment companies and receive assured enriched uranium supply, in return. This would be another formation of the MNA, as far as the enrichment companies and their states agree.

Other than GCC states, Jordan, with its natural uranium resources, presented its potential to be a regional center as a "hub for nuclear fuel" within a regional context under the IAEA, as a potential option in the future when this establishment achieves economic rationality [143]. Unlike the UAE, Jordan has not concluded a NCA with the US including the "gold standard", and in this respect, there are no reasons for it to be denied its future option of establishing a MNA enrichment facility under IAEA auspices in its territory, due to the following facts:

- Article 4 of the NPT ensures peaceful use of nuclear energy,
- Jordan has adhered to international nuclear non-proliferation and nuclear safety norms, including the IAEA AP,
- The NSG Guidelines do not necessarily deny the possibility of transfer of ENR technologies, if the recipient state satisfies certain conditions,
- On top of everything, Iran continues its uranium enrichment activities on the pretext of "peaceful use of nuclear energy".

However, as mentioned above, from a realistic political viewpoint it is a question of whether or not existing enrichment technology holders will actually transfer their technologies to Jordan. Regarding transfers of ENR-related items to RSs, as mentioned in chapter 6, Paragraphs 6 and 7 of the NSG Guidelines prescribe special conditions. Paragraph 6(b) of the Guidelines stipulates that NSSs "take into account at their national discretion, any relevant factors as may be applicable". This so-called "subjective criteria" of NSSs for transferring their ENR-related items to RSs. Considering the fact that most enrichment technology holders are NWSs actively engaging in EU3 +3 activities to solve Iran's nuclear issues and that Jordan is a neighboring state of the Palestinian authority, Israel, Syria and Iraq, where high political tension and turmoil remain, it is unlikely that current enrichment technology holders will transfer their enrichment facilities and technologies to Jordan, by "take into account at their national discretion, any relevant factors as may be applicable". This is also a political challenge to establishing the MNA.

On the other hand, in the long-term, in the event that the GCC Safeguards Organization and/or the Middle East Safeguards Organization are established and then the GCC-NWFZ and/or MENWFZ are pursued, a MNA enrichment plant in Jordan has the potential to be established, without facing any political challenges.

(6) (I) Economics

Currently there are no commercial power reactors in the GCC states; therefore, under the current circumstances, establishments of ENR facilities, even in the form of a MNA, do not have economic rationality. In this respect, this MNA is only a potential option for the future.

On the other hand, according a projection on uranium enrichment service demand until 2035 [144], even in high growth scenario, existing and currently-projected uranium enrichment capacities are enough to satisfy world demand by 2035. Therefore, in the case of establishing a new MNA enrichment plant, the plant needs to face severe price competition with other enrichers.

7.1.3.2 Summary of Analysis of Case Study 3

Table 21 summarizes the analysis of Case Study 3.

Table 21 Summary of Case Study 3

features	A	B	C	D	E	F, G, H, J, K, L	I
Result of the analysis	Δ	X	Δ	Δ	Δ	X	X

✓: Satisfied, Δ: Partly satisfied, X: Not satisfied

First of all, since there are currently no commercial power reactors in GCC states; there is no economic rationale to have ENR facilities. In this respect, this MNA is totally a potential option in the future option.

Assuming the GCC states have economic rationale, the biggest challenge to establishing this MNA relates to (K) Geopolitics and (L) Political acceptance, the same as with Case Studies 1 and 2. Due to the GCC's geographical locations which are very close to the nuclear threshold states of Israel, Syria and Iran, the GCC states cannot satisfy the conditions to become a host state of MNA facility of "political stability" and "good relation with neighboring states", as mentioned in chapter 6, as conditions of (F) Siting – choice of host state.

Possible solutions to this political challenge would be to establish the MNA facility outside the region with the involvement of NSSs and/or NWSs in the MNA and the regional safeguards and the RSAC. Such solutions would make the GCC's activities transparent as well as promote confidence-and-security building among its member states. In addition, an expert indicates that the GCC safeguard organization has the potential to become the Middle East safeguards organization in the future, as well as to create the GCC-NWFZ and/or MENWFZ in the future.

Alternatively, there are already uranium enrichment market and enrichment companies outside the region. In this respect, there would be economic rationale for the GCC state as a whole to take a stake in several existing enrichment companies and receive assured enriched uranium supply, in return. This would be another formation of the MNA, as far as the enrichment companies and their states agree.

For establishing the MNA, the following additional arrangements are necessary.

- (A) Nuclear non-proliferation and (C) Nuclear safety: Some states need to ratify the IAEA Additional Protocol (AP) and participate in international conventions on nuclear safety. Alternatively, the GCC states would be able to establish a regional safeguards system which is equivalent to the AP, such as the regional safeguards by ABACC.

- (B) Assurance of supply (of nuclear fuel and nuclear fuel cycle services): in order to ensure them, the following arrangements are necessary.
  - Participation of other states with ENR capacities into the MNA and / or
  - Ensuring ENR supplies from other states through the conclusion of NCAs
- (D) Nuclear cooperation agreements: Some GCC states need to conclude NCAs with NSSs.
- (E) Nuclear third party liability: GCC states with nuclear power plants need to participate in the Revised Vienna Convention, as UAE and Saudi Arabia have already acceded it.
- (I) Economics: As mentioned, currently, there is no economic rationality for GCC states to establish ENR facilities, since there are no power reactors. According to a current projection on enriched uranium by 2035, a new MNA-ENR facility needs to face intense enriched uranium price competition.

By implementing above measures on each MNA feature, this MNA can be established by satisfying twelve MNA features.

7.2 Summary of Chapter 7

In this chapter, in order to discuss applicability of twelve MNA features and their detailed measures satisfying MNA's purposes discussed in previous chapters, three case studies assuming the establishments of three different MNAs consisting of existing countries in the Asian region and the Middle East were made.

By satisfying twelve MNA features and their detailed measures for MNA's requirements, MNAs are able to be established, although there are various challenges especially on (K) Geopolitics and (L) Political acceptance. Those challenges and possible solutions are as follows;

- Case Study 1: Japan-ROK MNA
  - ✓ Challenges: As far as the US-origin material is to be utilized in the MNA,

programmatic advance consents from the US are necessary. From perspectives of MNA features of (K) and (L), the MNA-pyroprocessing facility in ROK would not be easy, due to the political instability of the Korean Peninsula and the lack of the US's advance consent.

- ✓ Possible solutions: The MNA includes the US with IAEA involvement and the regional safeguards and the RSAC. Those solutions could enhance the transparency of Japan-ROK nuclear activities through US's and the IAEA's direct involvements of MNA activities, and increase international characteristic of the MNA. Furthermore, with the US's participation, the MNA's role as confidence-and-security building measure is to be strengthened.

- Case Study 2: Kazakhstan-Russia-Vietnam-Japan-ROK MNA
  - ✓ An establishment of the MNA would be favorable for every member state, since supplies of every nuclear fuel cycle service within the MNA can be possible by utilizing each member states' capabilities. However, there are political challenges.
  - ✓ Challenges: From perspectives of MNA features of (K) and (L), the MNA needs to avoid being embroiled in any conflicts between Russia and other states, including the US, in order to ensure a stable and smooth supply of nuclear fuel and services from Russia. Regarding transportation of nuclear material, a challenge is the necessity to maintain good relations with China, since China has the potential to become a logistic hub of nuclear transport between NSSs and RSs.
  - ✓ Possible solutions: One possible solution would be to ensure alternatives of uranium enrichment service resources, including transportation routes, not fully depending on supplies from one state. Since world's enricher states except Russia are the US and European states, therefore, in this respect, Japan and the ROK still need to depend on enrichment uranium supply from Europe and the US.

- Case Study 3: GCC (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the UAE) MNA
  - ✓ Currently there are no commercial power reactors in the GCC states; therefore, establishments of ENR facilities, even in the form of a MNA, do not have economic rationality and this MNA is only a potential option for the

future.

- ✓ Challenges: Regarding MNA features of (K) and (L), due to the GCC states' geographical location in the middle of the politically unstable Middle East, between the Israel-Syria bloc and Iran-Iraq bloc, realistically it is difficult for GCC states to host MNA-ENR facilities. Since the GCC itself is a 6-state's national security framework against Iran, GCC-MNA's nuclear activities should neither grow Iran's proliferation concerns nor threat GCC states' own national security.
- ✓ Possible solutions: Establish the MNA facility outside the region with the involvement of NSSs / NWSs in the MNA, together with regional safeguards and the RSAC. Such arrangements make the GCC's activities transparent as well as promoting confidence-and-security building among its member states. In addition, the GCC safeguard organization is expected to become the Middle East safeguards organization in the future, as well as to create the GCC-NWFZ and/or MENWFZ.
- ✓ Alternatively, considering the fact that there is already a uranium enrichment market and enrichment companies outside the region, there would be economic rationale for the GCC states as a whole to take a stake in several existing enrichment companies and receive an assured enriched uranium supply, as opposed to establishing a new MNA-ENR facility. This would be another formation of the MNA.

In all case studies, political instability of member states and/or the region, supplier states' disapproves of sensitive activities within MNAs and political conflicts between NSSs and other states are all challenges to establish MNAs. All these challenges relate to MNA features of (K) and (L). There are no simple measures to overcome such challenges, however, as already clarified as detailed measures of each MNA feature, additional case-by-case measures including direct involvements of an international organization, NSSs and/or NWSs in the frameworks as well as application of regional safeguards and RSAC among member states may contribute to mitigate the political challenges.

In this respect, it can be said that every MNA in case studies are able to be established through application and implementation of twelve MNA features and detailed measures on each MNA features discussed in this study.

Chapter 8 Conclusion

Chapter 8
Conclusion

The MNAs is one of measures promoting peaceful use of nuclear energy while ensuring nuclear non-proliferation. It also contributes to confidence-and-security building among member states. However, only a few MNAs have been successfully established so far, due to a lack of sufficient, in-depth and systematic studies on MNA fundamentals, including the necessary and sufficient features of MNAs.

Based on this fact, in order to establish functional and feasible MNAs, this study aimed to identify necessary and sufficient features of MNAs (MNA features) and clarify their detailed measures, which enable to satisfy MNA's three requirements of (i) accomplishing MNA's essential purposes, (ii) ensuring MNA's smooth functions and (iii) contributing MNA's practical feasibility.

As discussed in chapter 2, through analysis of past efforts and studies for establishing MNAs, following twelve features from (A) to (L) were identified as MNA features.

(A) Nuclear non-proliferation,
(B) Assurance of supply,
(C) Nuclear safety,
(D) Nuclear cooperation agreements (NCAs),
(E) Nuclear third party liability (TPL),
(F) Siting - choice of host state,
(G) Multilateral involvement,
(H) Access to technology,
(I) Economics,
(J) Transportation,
(K) Geopolitics, and
(L) Political and public acceptance

Those twelve features were categorized according to MNAs' three requirements mentioned above, as (i)"essential features", (ii)"functional features" and (iii) "practical features", in accordance with MNA's requirements. MNA features (A) to (C) are essential features, while features (D) and (E) are functional features. MNA features from (G) to (H) are functional features.

As discussed in chapters 3, 4, 5 and 6, detailed measures of the twelve MNA features which satisfy MNA's three requirements were clarified. Those clarifications were mainly based on analysis of existing MNAs and legal systems on nuclear energy and nuclear non-proliferation, since both the peaceful use of nuclear energy and nuclear non-proliferation have already been established in and are carefully regulated by international, regional and national legal systems.

In order to discuss the applicability of twelve MNA features and their detailed measures identified and clarified in chapters 3, 4 5 and 6, three case studies assuming the establishments of three different MNAs consisting of following existing states in Asian region and the Middle East were made in chapter 7. If a number of states desiring to form a MNA jointly satisfy the above twelve MNA features from (A) to (L) and their detailed measures, then the MNA may theoretically be able to be established.

- Case Study 1: A MNA consisting of Japan and the ROK
- Case Study 2: A MNA consisting of Russia, Kazakhstan, Vietnam, Japan and the ROK
- Case Study 3: A MNA consisting of the GCC member states of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the UAE

In all case studies, it was found out that political instability of member states and / or region, NSSs' disapproves of ENR activities within MNAs, and political conflicts between NSSs and other states are all political challenges to establish MNAs. All these challenges relate to MNA features of (K) Geopolitics and (L) Political acceptance. These 2 features realistically cannot easily be fulfilled. Since nuclear non-proliferation highly depends on the realities of international politics on security, establishments on MNAs and MNA's function are also affected by them, where nuclear weapon states (NWSs) especially have been played key roles.

However, establishments of MNAs are not necessarily impossible. There are no simple measures to overcome such challenges, however, as already clarified as detailed measures of each MNA feature, additional case-by-case measures, including direct involvements of an international organization, NSSs and / or NWSs in the framework as well as application of regional safeguards and RSAC among MNA member states, may contribute to mitigate the political challenges. In this respect, it can be said that every MNA in case studies are able to be established through application and implementation of twelve MNA features and detailed measures on each MNA features discussed in this study.

By the study, MNA features were identified and their detailed measures which satisfy three MNA requirements of accomplishing MNA's purposes, ensuring MNA's functions and contributing MNA's feasibility, are clarified. Case studies showed that by application and implementation of twelve MNA features and their detailed measures, MNAs in case studies are able to be established.

It is expected that these features and measures would be effectively utilized when establishing MNAs in the future.

Future Works

As became clear in case studies, among twelve MNA features, (K) Geopolitics and (L) Political acceptance are keys to establish MNAs. Therefore, in order to establish much more functional and feasible MNAs, much further and deeper discussion on these (K) and (L) features, including international politics, international relations, regional and national security of MNA member states, need to be made.

In such discussion, especially relations with the US and Russia, which have exerted a powerful influence both on world nuclear non-proliferation regime and nuclear energy utilization, also need to be considered. In addition, how to maintain a good relationship with China is also important, since it is geologically located between Russia-Kazakhstan of the main supplier block and South East Asian States of the recipients block, as well as Japan and the ROK. China would be one of key states with a view toward transportation, whether or not it becomes a MNA member state.

In this regard, from a global perspective, although both a rapid expansion of nuclear energy utilization and concerns over nuclear proliferation coexist in the Asian region, currently there are no MNAs in Asian region. An application of this study to this specific region, where a MNA is expected to be established, contributes to pursuing the efficient and effective utilization of nuclear energy as well as the enhancement of nuclear non-proliferation. More so than EURODIF and URENCO in Europe, states in the Asian region have an evident diversity and complexity politically, economically, historically, ethnically and culturally, and therefore, it seems by no means easy to establish a MNA in the region. However, to put it another way, that explains exactly why a MNA is necessary to be pursued in the region, as a confidence-and-security building measure among Asian states.

In the future, further studies will be performed on MNAs, focusing more on (K) Geopolitics and (L) Political acceptance features, and Asian region, including how to maintain a good relationship and political balance with the US, Russia and China.

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