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*Dissertation*

# The Contribution of Multilateral Nuclear Approaches (MNAs) to the Sustainability of Nuclear Energy

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**Abstract:** Multilateral Nuclear Approaches (MNAs) is a concept of international and/or multilateral control of nuclear material and/or nuclear fuel cycle facilities. It is a strategy for contributing to and promoting the sustainability of nuclear energy while enhancing nuclear nonproliferation, by ensuring nuclear fuel supplies and fuel cycle services, and risk control and reducing risk regarding nuclear safety. In order to establish such a MNA, the authors draw out 12 features of the MNA by analyzing various past and current MNA proposals, together with the current environment surrounding nuclear energy use. Those proposals are: (A) nuclear nonproliferation, (B) assurance of supply of nuclear material and fuel cycle services, (C) access to technologies, (D) multilateral involvement, (E) siting—choice of host state, (F) legal aspects, (G) political and public acceptance, (H) economics, (I) nuclear safety, (J) nuclear liability, (K) transportation, and (L) geopolitics. These proposals are also expected to serve as a guidepost and evaluation criteria of MNA.

**Keywords:** Multilateral Nuclear Approach; MNA; features of MNA

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## 1. Introduction

A Multilateral Nuclear Approach (MNA) is both an old and new issue which dates from the 1940s up to the present time. Very few proposals have so far been realized, whereas, most proposals in the 21st century, such as a fuel bank and a low enriched uranium (LEU) reserve, have mainly discussed

multinational supply assurance of nuclear fuel. In this article, the authors intend to focus on MNA ensuring not only nuclear fuel supplies, but also nuclear fuel services, including spent nuclear fuel (SNF) reprocessing and management (storage and disposal) by joint funding and/or ownership of nuclear fuel cycle facilities. Such a MNA is expected to contribute to sustainability of nuclear energy and nuclear nonproliferation. It could also be a solution to SNF management, which may not be effectively solvable by individual countries alone.

It is indispensable for such an extensive MNA study to find features prior to making detailed proposals. Nevertheless, few papers have dealt with such discussions.

From this viewpoint, the authors reviewed various MNA proposals from the 1940s to the present, and find the reasons which prevented their implementation. We also considered the current environment surrounding nuclear energy use, including the Fukushima nuclear accident in 2011. Based on those, features to be taken into account for the establishment of MNA are studied.

## 2. Past and Present Efforts for MNA

### *2.1. Efforts from 1940s to 1980s*

In November 1945, the U.S. President and the Prime Ministers of the U.K. and Canada made a Declaration on the Atomic Bomb. The Declaration said that no single nation could have a nuclear monopoly and proposed to set up a Commission under the United Nations in order to discuss the international control of atomic energy to the extent necessary to ensure its use only for peaceful purposes [1]. In January 1946, United Nations Atomic Energy Commission (UNAEC) was founded.

In the U.S., "A Report on the International Control of Atomic Energy" (also known as "Acheson-Lilienthal Report") was prepared for discussion in the UNAEC. Based on the above Declaration, the report proposed to establish a new international organization called the Atomic Development Authority (ADA) which owns all fissionable material and controls them under effective leasing arrangements. The ADA is expected to be in charge of all "dangerous activities" relating to raw materials, construction and the operation of production plants, and the conduct of research into explosives, while "non-dangerous activities", such as the construction and operation of power-producing piles, would be left in national hands [2].

In 1946, Bernard Baruch, the U.S. representative to the UNAEC, submitted his plan for the international control of nuclear energy (also known as the "Baruch Plan") based on the Acheson-Lilienthal Report. However, he modified the report by inserting the prohibition of the development of nuclear-weapons capability by new states and punishment for violations of such prohibition. In addition, the permanent members of the UN Security Council could not veto such penalties [3]. The Baruch Plan was intended to ensure that the U.S. would maintain its nuclear weapons monopoly, while others, including the Soviet Union, could not possess them. The plan was not accepted by the Soviet Union and as a result, the idea of international control of nuclear energy did not bear fruit in the 1940s.

An idea of international control of nuclear energy could also be found in the U.S. President Dwight D. Eisenhower's famous "Atoms for Peace" address in December 1953 [4]. He proposed to support the development of sovereign nuclear programs of other states by providing LEU through the International

Atomic Energy Agency (IAEA), although such LEU was expected to be provided by the U.S., the Soviet Union and the U.K. This IAEA role of "intermediary" was included in the IAEA Statute of 1957, although it has not been functioning as effectively as was expected. Instead, the U.S. and the Soviet Union provided nuclear reactors and their fuel to their allied nations, based on bilateral nuclear cooperation agreements.

The Treaty on the Nuclear Non-Proliferation of Nuclear Weapons (NPT) came into force in 1970. Under the Treaty, the possession of nuclear weapons is strictly limited only to five countries called "nuclear weapon states (NWS)", while other states called "non nuclear weapon states (NNWS)" are not allowed to possess them. Instead, nuclear energy use for peaceful purposes is stipulated as an inalienable right of all NPT member states. In this respect, the treaty provides all its members with equal opportunity. However, this is different from what the U.S.-led original MNA proposals had intended. As mentioned before, the Acheson-Lilienthal Report intended that "dangerous activities" would not be under the control of individual states, but rather under international control, in order to limit the number of sensitive facilities. This contradiction between the U.S.'s intentions and the NPT has been one of the obstructive factors against the establishment of MNAs.

In 1974, a nuclear explosion conducted by India revealed the fact that the NPT alone was not sufficient enough to prevent global non-proliferation, since India was not a NPT member. In order to close this NPT's loophole, U.S. President Carter led various nuclear nonproliferation initiatives, including the development of Nuclear Suppliers Group (NSG) Guidelines for nuclear export control, an enactment of the U.S. Nuclear Non-proliferation Act (NNPA) and the initiation of International Nuclear Fuel Cycle Evaluation (INFCE). The INFCE was followed by IAEA-led initiatives of International Plutonium Storage (IPS), Committee of Assurance (CAS) and International Spent Fuel Management (ISFM), in order to implement various discussions in INFCE.

Those initiatives, however, were left unfulfilled, "because parties could not agree on the non-proliferation commitments and conditions that would entitle states to participate in the multilateral activities. Moreover, differences of views prevailed between those countries or regions that did not plan to reprocess or recycle plutonium and those that favored doing so [5]." Nuclear developed states in western Europe and Japan had already engaged in the development of their own sensitive capabilities. Therefore, they tried to maintain their activities, and not let them be interfered with by such initiatives. Developing states, especially Non Allied Movement (NAM) states, argued that any requirements for the nonproliferation commitment of not engaging in sensitive nuclear activities contravene Article IV of the NPT. They also insisted that such a requirement would discriminate between the "haves" and "have-nots" of sensitive capabilities, in addition to there being an existing discrimination by the NPT between "NWS" and "NNWS". The U.S. was thus left alone and could not gain enough support for promoting its initiatives any further.

Table 1 shows a description and features of MNA proposals, their results, and reasons which prevented their further implementation, from the 1940s to the 1980s.

**Table 1.** Multilateral Nuclear Approach (MNA) Proposals from 1940s to 1980s.

| **Proposals** | **Description and *features* of proposals** | **Results and *reasons which prevented further implementation*** |
|---|---|---|
| Acheson-Lilienthal Report (1946) [2] | • Proposed international control of nuclear energy by an international organization called the "Atomic Energy Authority" (ADA)<br>• The ADA exclusively deals with all the "dangerous activities" of nuclear energy from nuclear nonproliferation perspective and ***allocates its products of nuclear fuel to states*** devoting only to "safe activities" | This concept of international control of nuclear material was succeeded by the Baruch Plan and the Eisenhower's "Atoms for Peace" address. |
| Baruch Plan (1946) [3] | 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***. |
| Eisenhower's "Atoms for Peace" Address (1953) [4] | • Proposed an international control of nuclear energy for peaceful purpose through the IAEA<br>• The Government principally involved was expected to make joint contribution 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 material and services supply. |
| Regional Nuclear Fuel Cycle Centers (RNFC) 1975–1977 [6] | • Identified the ***economic, safety, safeguards and security*** aspects of a multinational approach to nuclear fuel cycle facilities.<br>• Study group reported several possible ***nonproliferation, economic and operational*** advantages. | No follow-up action was taken, since fears of a plutonium economy had eased. |
| INFCE 1977–1980 [6] | Regarding MNA,<br>• 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.<br>• 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. | 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. |
| IPS 1978–1982 [6] | • Explored IAEA-supervised management, storage and release of plutonium in excess.<br>• ***Technical, legal and institutional aspects, including safeguards*** and plutonium buffer stocks, are discussed. | No consensus was reached as states were ***unwilling to renounce sovereign control over nuclear technology and fuel***. |
| ISFM 1979–1982 [6] | Discussed key elements about the international agreements which would need to be drawn up for an international SNF venture. They include ***technology, cost, and legal aspects*** related to spent fuel storage and transportation. | Could not proceed since ***specific storage locations could not be identified***. |
| CAS 1980–1987 [6] | Discussed measures to ensure the ***reliable supply of nuclear material, equipment and technology***, principles for international co-operation 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 states were ***unwilling to renounce sovereign control over nuclear technology and fuel***. |

### *2.2. Efforts from1990s to beginning to 2000s*

The Berlin Wall came down and the Cold War was over 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 sources of nuclear nonproliferation concerns. In order to avoid further accumulation of separated plutonium from civilian reprocessing, many proposals on SNF management have been presented since 1990. Table 2 describes some of those proposals.

**Table 2.** MNA and a Russian proposal from the 1990s to the beginning of the 2000s regarding spent nuclear fuel (SNF) management.

| **Proposals** | **Description and *features* of proposals** | **Results and *reasons which prevented further implementation*** |
|---|---|---|
| International Monitored Storage System (IMRSS) Mid-1990s [**7**] | A concept of international storage of SNF and plutonium under international supervision. SNF could be retrieved at any time for peaceful use or disposal. | No actual negotiations took place. |
| Proposal by Marshall Islands 1994–1999 [**7**] | A proposal initiated by the Marshall Islands for disposing SNF 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 [**7**] | • A proposal initiated by the U.S. Fuel and Security with Russian partner<br>• SNF storage and excess plutonium on Palmyra and Wake Island. | • Faced with ***strong opposition from the U.S. Government***<br>• Abandoned in favor of a proposal by Non-Proliferation Trust |
| Non-Proliferation Trust1998 [**7**] | • A proposal by Non-Proliferation Trust with Russian partner<br>• Long-term disposal of foreign-origin SNF in Russian territory<br>• Revenue was to be used for waste storage, clean-up of Russian nuclear sites and for Russian citizens. | • The Non-Proliferation Trust is ***against reprocessing, while Russia prefers it.***<br>• Russia initiated its own proposal including reprocessing and the proposal lost its momentum. |
| Pangea Project 1990–2000 [**7**] | 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 SNF and HLW in Western Australia | Pangea Resources abandoned the Project in 2000, due to ***opposition from the State of Western Australia and 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.*** |

**Table 2.** *Cont.*

| Proposals | Description and *features* of proposals | Results and *reasons which prevented further implementation* |
|---|---|---|
| A Russian technical storage or reprocessing facility 2001 [8] | • Russian Ministry of Atomic Energy would commercially import, temporarily store, reprocess foreign origin SNF in Russian territory and repatriate it to its generating states<br>• Background: The Russian Environment Protection Law was amended in 2001 to allow foreign-origin SNF import for technical storage and reprocessing | • The U.S. ***did not give authorization of the U.S.-origin SNF exports to Russia***, due to its opposition to<br>✓ reprocessing<br>✓ Russian support for Iran's nuclear program<br>• The U.S. controls some 80% of the world's SNF. Under the U.S. Atomic Energy Commission (AEC), ***U.S.-origin SNF can neither be sent for storage nor reprocessing to a third country without U.S. consent.*** |

However, once again, none of the above proposals have been achieved. One of the major reasons derived from the Table 2 is the existence of a disagreement between the U.S. and Russia over SNF reprocessing. The former insisted that SNF are not supposed be reprocessed for fear of proliferation and the accumulation of separated plutonium in Russia, while the latter favored SNF reprocessing as a business venture. This disagreement led the U.S.'s prevention of the Russian proposal from further evaluation by not giving necessary authorization for transfer of the U.S.-origin SNF to Russia. This fact also indicates the following important facts;

- Due to a fact that the U.S.'s ability to control more than 80% of the world's SNF, as in the case of MNA providing reprocessing and/or storage services, including U.S.-origin SNF, and transfer for such services, an authorization from the U.S. would be required, even if the U.S. itself is not be involved in the MNA.
- The U.S. must negotiate a Section 123 agreement for nuclear cooperation with MNA members in order to give such permission.

The other reason is the strong opposition from local governments and residents of potential SNF, HLW storage and/or disposal sites. The Pangea Project in particular suffered from a lack of information disclosure and transparency.

### *2.3. Efforts from 2003 to the Present*

Turning into the 21st century, since the former IAEA Director General El Baradei proposed MNA in 2003 [9], various proposals, mainly focused on the assurance of nuclear fuel and uranium enrichment service, appeared in the international arena as shown in Table 3.

**Table 3.** MNA Proposals from 2003 to the present.

| **Proposals/initiatives** | **Description and *features* of proposals** |
|---|---|
| "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") [10] | • Experts appointed by El Baradei identified options for possible MNA of the front-end and back-end of the nuclear fuel cycle for strengthening nuclear nonproliferation, without disturbing market mechanisms<br>• Identified five suggested approaches to the MNA<br>• The report presents ***7 labels as MNA assessment elements*** including the removal or banning of: ***(a) 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*** |
| Reserve of nuclear fuel [11] (renamed as American Assured Fuel Supply (AFS) [12]) | • The U.S. Department of Energy (DOE)'s proposal of creating a LEU reserve down-blended from 17.4 metric tons of HEU dismantled from the U.S.'s excess nuclear weapons.<br>• The reserve assures reliable fuel supply for ***states that forgo enrichment and reprocessing.*** |
| Russia global nuclear power infrastructure (GNPI) [13] | The Russian Federation's proposal, including a creation a system of international centers, providing uranium enrichment services, on ***a non discriminatory basis*** and ***under the control of the IAEA*** |
| U.S. Global Nuclear Energy Partnership (GNEP) [14] | • A U.S. DOE proposal including developing proliferation-resistant reprocessing technology, and advanced fast reactors, minimizing nuclear waste and establishing reliable fuel supply and SNF take-back services.<br>• 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.*** |
| Ensuring Security of Supply in the International Nuclear Fuel Cycle [15] | • The World Nuclear Association (WNA) proposal of a three-level mechanism to ensure enrichment services.<br>• The proposal originally had a ***precondition for non-supplier states to forgo domestic development of sensitive technologies and facilities, but later it abandoned such a precondition.*** |
| Concept of Multilateral Mechanism for Reliable Access to Nuclear Fuel [16] | The proposal by six enrichment services supplier States (the U.S., U.K., 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*** |
| IAEA Fuel Bank [17] | • The Nuclear Threat Initiative's proposal to create an LEU stockpile owned and managed by the IAEA that could be made available should other supply arrangements be disrupted.<br>• ***"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."*** [18]<br>• The IAEA Board of Governors approved the establishment of the bank in 2010 [19]. |

**Table 3.** *Cont.*

| Proposals/initiatives | Description and *features* of proposals |
|---|---|
| Enrichment Bonds [20] (renamed as Nuclear Fuel Assurance (NFA) [21]) | • The 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 prior consent for export assurances.<br>• ***Non-supplier states are not required to give up their rights to develop an indigenous fuel cycle by receiving alternate nuclear fuel*** |
| International Uranium Enrichment Center (IUEC) at Angarsk and its LEU Reserve [22] | • A Russian proposal to establish an International Uranium Enrichment Centre (IUEC), including a LEU reserve<br>• The IUEC would operate as a ***commercial joint stock company***. It would be a "black box" and the IUEC's participating states ***could not access Russian enrichment technologies***.<br>• ***Non-supplier states are not required to give up their rights to develop an indigenous fuel cycle by receiving nuclear fuel from the stockpile.***<br>• The LEU reserve was established in December 2010 [23] |
| Multilateral Enrichment Sanctuary Project (MESP) [24] | • A German proposal of an international enrichment centre 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.<br>• An enrichment plant would have to be constructed as a 'black box' and would therefore only be accessed and maintained by the supplier. |
| Nuclear Fuel Cycle (EU-Non-paper) [25] | • The EU non-paper proposed criteria for assessment of MNA for reliability of fuel supply.<br>• These criteria included ***a) proliferation resistance, b) assurance of supply, c) consistency with equal rights and obligations of suppliers, companies, consumer states and the IAEA and d) market neutrality.*** |
| Japan's Initiative for Mutual Assured Dependence [26] | • Proposed an internationalization of the nuclear fuel cycle facilities. All enrichment and reprocessing plants shall be internationalized and all of them, including the existing and new facilities without exception, shall take the form of ownership and control by multiple countries/companies.<br>• Such facilities are based on ***universality, transparency (verifiability) and economic viability***. |
| Nuclear Islands: International Leasing of Nuclear Fuel Cycle Sites [27] | • A proposal to enhance nuclear nonproliferation by centralization of sensitive facilities within restricted zones under long-term leasehold contracts and a newly established organization, the International Nuclear Fuel Cycle Association (INFCA).<br>• Countries and existing multilateral consortia ***would not be asked to give up their inalienable right under Article IV of the NPT,*** although all countries would voluntarily agree to exercise that right only pursuant to uniform, nondiscriminatory leasehold contracts and protocols with the INFCA and the IAEA that would ensure conformity with Articles I and II of the NPT. |

The difference between the MNA proposals in the past and those in the 21st century (except for the U.S.'s GNEP and AFS) in the latter, non-supplier states are not required to forgo their indigenous nuclear fuel cycle capabilities, including sensitive capabilities, in exchange for nuclear fuel and services supply assurance. Although the Nuclear Threat Initiative (NTI), which originally proposed establishing an IAEA bank in 2006, previously mentioned that the bank was "for nations that have

made the sovereign choice to develop their nuclear energy based on foreign sources of fuel supply services—and therefore have no indigenous enrichment facilities [28]". Such a requirement, however, was dropped from the resolution for an IAEA bank in 2010, due to sharp criticism by NAM States. Another difference is that the total amount of approximately $150 million of actual funding and pledges were made by NTI, the U.S., EU, Norway, Kuwait and United Arab Emirates (UAE) [29] for the establishment of the bank. Such contributions had actually made before the establishment of the IAEA and the INFCE in the 1950s and the 1970's respectively.

## 3. Discussion on MNA Features

By reference to the facts mentioned in previous sections and tables, and based on the seven Labels as MNA assessment elements in the "Pellaud Report", the authors have drawn out the following 12 features of the MNA in the Table 4. Those features are not always totally independent, but interdependent of each other. Among them, the most essential features of the MNA are surely (A) nuclear nonproliferation and (B) assurance of supply.

**Table 4.** 12 features of the MNA.

| | Description of Features |
|---|---|
| A | **Nuclear nonproliferation**: MNA members would need to follow the following norms;<br><In general><br>• NPT<br>✓ NPT member states' inalienable right to use nuclear energy for peaceful purposes need to be respected<br>✓ MNA members would be treated equally without making distinctions between "haves" and "have-nots" of sensitive technologies and facilities<br><Safeguards><br>• Complementary Safeguards (INFCIRC/153(Corr.))<br>• (Additional Protocol (AP, INFCIRC/540(Corr.)))<br><Nuclear security><br>• Convention on the Physical Protection of Nuclear Material (INFCIRC/274/Rev.1)<br>• International Convention for the Suppression of Acts of Nuclear Terrorism<br>• IAEA Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Rev.5) and related Nuclear Security Series documents<br><Export control><br>• Nuclear Security Group (NSG) Guidelines (INFCIRC/254/Rev.10/Part 1)<br>• UN Security Council Resolutions 1540 |
| B | **Assurance of supply**: MNA would provide both front-end and back-end nuclear fuel cycle services, including;<br>• uranium enrichment and reprocessing services<br>• SNF management services<br>• (fuel leasing) |
| C | **Access to technology**:<br>• For the purpose of protecting nuclear proliferation and proprietary information, access to sensitive technologies would be limited only to technology holders<br>• transfer of existing sensitive technologies need to be 'black-boxed' |

**Table 4.** *Cont.*

| | Description of Features |
|---|---|
| D | **Multilateral involvement**:<br>• As described in the "Pellaud Report", involvement varies with a) supply only arrangement, b) sharing ownership of facility, c) taking part in the management of the facility, d) participating in the operation of the facility, and e) joint research and development, design and construction of facilities, could be possible<br>• The involvement would also vary depend on MNA members, amount of investment (share) to facilities and technologies, *etc.*<br>• MNA members' levels of involvement needs to be agreed beforehand |
| E | **Siting—choice of host state**: Host states would;<br>• fulfill international norms on nuclear nonproliferation<br>• be politically, socially and economically stable<br>• maintain good relations with neighboring states and the international community<br>• have no territorial disputes, including conflicts on natural resources<br>• have good accessibility to international and domestic ports for transportation of nuclear materials<br>• have necessary and sufficient knowledge, expertise and experience to host and operate MNA facilities, including handling, storage and transportation of nuclear materials<br>• offer "extra-territorial" status to MNA facilities<br>• ensure safe and secure routes for transportation of nuclear material<br>• be equipped with the necessary licensed infrastructure for MNA operations<br>• have the necessary natural environment to host MNA facilities without causing harmful effects or having a negative influence by hosting such facilities |
| F | **Legal aspects**:<br>• MNA would need various agreements including;<br>✓ Agreement of the establishment of MNA<br>✓ Host state agreement<br>✓ Agreements with international organizations and other states<br>• MNA would avoid and / or solve conflicts with existing international agreements and bilateral agreements into which member states have already entered<br>✓ in particular, a nuclear cooperation agreement with the U.S. as a key factor |
| G | **Political and public acceptance**:<br>• MNA facilities would need to be well accepted by the host state and local community.<br>• Decision-making process would need to be transparent through information disclosure and information sharing<br>✓ especially in the case of SNF storage and disposal facilities<br>✓ accepting that certain information needs to be protected in the interests of nuclear security and trade secrecy |
| H | **Economics**: MNA facilities need to be<br>• commercially feasible<br>• have a greater economic advantage than state-owned facilities |

**Table 4.** *Cont.*

| | Description of Features |
|---|---|
| I | **Nuclear safety**: MNA members would need to comply with the following international nuclear safety norms;<br>• Convention on Nuclear Safety (INFCIRC/449)<br>• Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (INFCIRC/546)<br>• Convention on Early Notification of a Nuclear Accident (INFCIRC/335)<br>• Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (INFCIRC/336)<br>• Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (INFCIRC/546)<br>• IAEA Safety Standards, *etc.* |
| J | **Nuclear liability**: In particular, host states of MNA facilities are requested to;<br>• be party to a relevant international nuclear liability convention<br>• have solid national third party liability legislation |
| K | **Transportation**:<br>• MNA would need to<br>✓ ensure safety and a secure transportation route, together with geopolitical consideration.<br>✓ obtain necessary permissions from related states for transit / landing<br>• MNA members need to comply with the following international norms on transportation;<br>✓ Convention on the Physical Protection of Nuclear Material (INFCIRC/274)<br>✓ IAEA Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Rev.5) and related Nuclear Security Series documents<br>✓ Regulations for the safe transport of radioactive material (No. TS-R-1)<br>✓ Code of Practice on the International Transboundary Movement of Radioactive Waste (INFCIRC/386), *etc.* |
| L | **Geopolitics**:<br>• Careful consideration of geopolitical aspects is inevitable when formulating MNA and determining transportation routes<br>• Not to interfere political balance with the U.S., China and Russia, when formulating MNA in the Asian Region, including Kazakhstan and Mongolia as uranium producing states and south-east Asian states as non-supplier states |

### *3.1. (A) Nuclear Nonproliferation and (B) Assurance of Supply*

Most MNA proposals assure nuclear fuel and services supplies to non-supplier states, in exchange for their adherence to nuclear nonproliferation norms, including NPT and safeguards and nuclear security standards. It makes sense that the MNA originally aims to both promote sustainable nuclear energy use and enhance nuclear nonproliferation, and those two are essential features of the MNA. The former is closely related to other features of (C), access to technologies, as well as (D), multilateral involvement.

Regarding relations between (A), nuclear nonproliferation, and (B), assurance of supply, the extent to which the non-supplier states would take measures for ensuring nuclear nonproliferation is a challenging issue. Since the days of the Acheson-Lilienthal Report, the U.S. has constantly been

nervous about other states' access to sensitive nuclear capabilities, while non supplier states have been insisting that their inalienable right to the peaceful use of nuclear energy, as enshrined in Article IV of the NPT, has to be respected, and all the members should be treated equally without discrimination [30]. This gap has made the MNA's establishment difficult and the past efforts clearly indicate that a MNA requiring non-supplier states to forgo their rights to develop an indigenous fuel cycle, including sensitive capabilities, would hardly succeed. In addition, as participation in the MNA is voluntary, non-supplier states would therefore be reluctant to participate in the MNA under such a requirement.

In response, and to cope with this situation, most MNA proposals in the 21st century clearly indicate that non-supplier states' inalienable rights would not be affected by supply assurances by the MNA. In the same way, non-supplier states' ratification of the IAEA Additional Protocol (AP) is not required in most of the current MNA proposals. In reality, however, from the nuclear suppliers' approach, an export control of the NSG Guidelines (INFICRC/254/Rev.10/Part 1) principally requires non-supplier states to ratify the AP in the case of transfers of sensitive technologies and facilities. The NSG Guidelines also requires that transfers of existing sensitive technologies need to be 'black-boxed', "seek from recipients an appropriate agreement to accept sensitive enrichment equipment, and enabling technologies, or an operable enrichment facility under conditions that do not permit or enable replication of the facilities" [31]. This access to technology also depends on how far the MNA member states would be involved in the MNA.

It is understandable that due to the political nature and diplomatic aspect of nuclear nonproliferation, inconsistencies between supplier states and non-supplier states are inevitable and it may not be possible to attain perfect consistency. The real challenge is how to reach a mutually agreeable compromise between them in order to promote sustainable nuclear energy use while enhancing nuclear nonproliferation within MNA framework.

#### 3.1.1. (A) Nuclear Nonproliferation

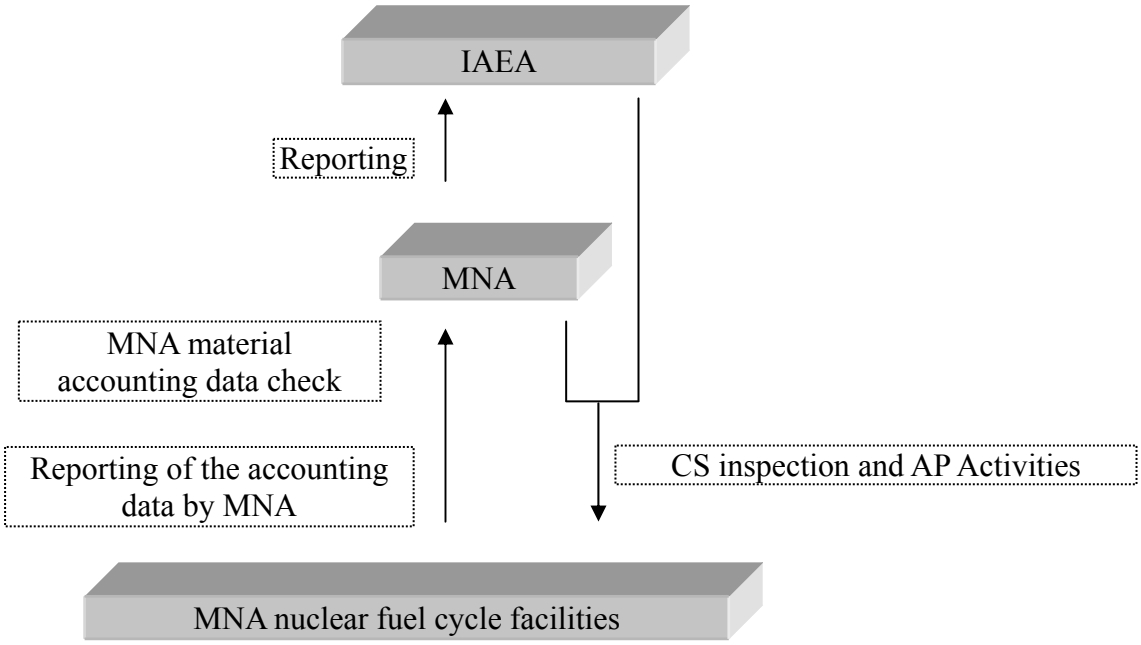
(A) Nuclear nonproliferation can be analyzed from four viewpoints: NPT, safeguards, nuclear security and export control.

NPT: As mentioned in Section 3.1, NPT members' inalienable right to use nuclear energy for peaceful purposes under Article IV of the NPT has to be respected. The real challenge is how to enhance nuclear nonproliferation while respecting this right, in a manner which NWS and NNWS as well as suppliers and non-suppliers agree on within a MNA framework.

Safeguards: Application of the IAEA comprehensive safeguards is an obligation for NNWS under NPT, although the AP is not as mentioned in Section 3.1. In addition, if the MNA has a regional safeguards system, such as EURATOM and/or a Regional System of Accounting for and Control of nuclear material (RSAC), such as ABACC (the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials), nuclear nonproliferation is expected to be enhanced. Furthermore, such a regional system possesses great potential for promoting confidence-building among MNA member states.

Figure 1 describes safeguards, inspection and material accounting aspects of the MNA.

**Figure 1.** Inspection and material accounting system of a Multilateral Nuclear Approach (MNA).




Nuclear security: The September 11 terrorist attacks and the Fukushima nuclear accident in March 2010 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, it would be desirable to set out common international and/or regional nuclear security standards, although this would not be easy since nuclear security issues are deeply involved in national security and sovereignty.

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

Export control: Nuclear nonproliferation would be strengthened if the MNA members, including host states of MNA facilities, comply with international export control norms of the NSG Guidelines (INFCIRC/254/Rev.10/Part 1) and UNSCR1540. Paragraph 6(a) of the revised Guidelines stipulates six minimum criteria which supplier states could authorize to transfer existing sensitive technologies and facilities to non-supplier states. Therefore, it is understood that if non-supplier states would satisfy such criteria, they could host MNA sensitive facilities, although sensitive technology would be transferred in a 'black-boxed' form.

#### 3.1.2. (B) Assurance of Supply of Nuclear Materials and Fuel Cycle Services

As mentioned in Table 3, an IAEA fuel bank as a supply assurance system of nuclear fuel is on the way to being established. In addition, if the MNA also includes SNF storage and disposal, or a fuel leasing system, it would make the MNA more attractive, since many states have been struggling with their own SNF management. The U.S. National Academy's "Internationalization of the Nuclear Fuel Cycle: Goals, Strategies, and Challenges" 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" [32]. However, the greatest hurdle is to find a state which is able to provide SNF management services, especially SNF storage and disposal services, to other states. In the case of commercial reactors, currently only Russia has a fuel leasing system and it has agreed to take back (to its origin, Russia) SNF from Iran.

### *3.2. (C) Siting-Choice of Host States*

Definite criteria to become a host state of MNA facilities need to be clearly established beforehand. This is especially the case with SNF storage and/or disposal sites, since discussions without identifying a specific location tends to unfruitful, such as in the case of ISFM in the Table 1. In addition, from a nuclear nonproliferation perspective, host states of sensitive facilities especially need to decide carefully, since NSF storage and disposal facilities require transparent a decision-making process coupled with growing political and public acceptance.

By reference to an IAEA fuel bank proposal and a MESP proposal in the Table 3, authors draw out various criteria to become MNA host states as in shown in Table 4, although it is not always necessary for all of them to be requisite conditions.

In addition, due to international conventions and/or domestic laws, certain states cannot host certain facilities. For example, Kazakhstan, a member of the Treaty on A Nuclear Weapon Free Zone in Central Asia, cannot "allow the disposal in its territory of radioactive waste of other States" [33]. The law in Mongolia on its Nuclear-Weapon-Free Status prescribes that any foreign state shall be prohibited to "dump or dispose nuclear weapons grade radioactive material or nuclear waste" [34]. 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 [35]. Those states, however, have enough reasons to join a MNA, if other MNA members could host such facilities and provide services to them.

### *3.3. (D) Access to Technologies and (E) Multilateral Involvement*

For the purpose of nonproliferation in 3.1.1 (A) nuclear nonproliferation, how far MNA members have access to technologies needs to be decided beforehand. In the case of the IUEC in Russia and a German MESP proposal in Table 3, access to enrichment technology is strictly limited only to a technology holder, as in the cases of the George-Besse II in France, URENCO USA and the IUEC in Angarsk, Russia.

This access to technology closely relates to another feature of (E) multilateral involvement. As described in the "Pellaud Report" (see Feature D of "Multilateral involvement" in Table 4), levels of involvement vary and also depend on MNA members, the amount of investment by MNA members, facilities, technologies, *etc.* In general, involvement varies with each MNA and as long as MNA stakeholders agree on the level of involvement and its criteria beforehand, it will not cause problems.

### *3.4. (F) Legal Aspects*

There are many legal requirements for the establishment and operation of a MNA. Such requirements all relate to other features from A to E and from G to L.

Regarding establishment of the MNA, the host states need to have the necessary regulatory bodies and legal framework in place in order to ensure international requirements for nuclear nonproliferation, nuclear safety, nuclear liability, and transportation. First, MNA member states need to enter into an agreement for establishing a MNA. The provisions of such an agreement would include purposes, missions, functions and structure of the MNA, a MNA decision-making body and its rules, areas of cooperation, prerequisites for MNA member states, rights, obligations and responsibilities of member states, supply assurances, investments, intellectual property, and titles, ownership and use of nuclear materials, access to technologies and level of involvement, jurisdiction, settlement of disputes, withdrawal from MNA, *etc.* Such an agreement would also include safeguards, nuclear security, export control, nuclear safety, and transportation aspects of the MNA. Second, MNA member states would conclude a host state agreement with a MNA host state. This agreement would be similar to the IAEA Headquarters Agreement with Austria and would include extraterritoriality, protection of the MNA, and juridical personality of the MNA, *etc.* It would also need to have licensing and permission, nuclear safety, security, emergency preparedness and nuclear liability related provisions. Thirdly, the MNA needs to conclude various agreements with international organizations and other states, in connection with safeguards, transportation and transit of nuclear materials and SNF, and nuclear liability.

As to the operation of the MNA facilities, various functions of the MNA would avoid and/or solve conflicts with existing international agreements and bilateral nuclear cooperation agreements which individual MNA member states have already concluded with other states. A nuclear cooperation agreement with the U.S. is a particularly key factor. For example, a Russian proposal on technical storage or reprocessing in 2001, as seen in Table 3, was blocked by the U.S. since it would not give prior consent for the transfer and storage of the U.S.-origin SNF to Russia. Within the MNA, such action has to be avoided for a smooth operation of the MNA. It is assumed that a MNA consisting of Japan, South Korea and Taiwan would be established in the Asian Region, since all of these states have concluded nuclear cooperation agreement with the U.S. [36] and most SNF in Japan and South Korea and all SNF in Taiwan are U.S.-origin. Therefore, transfers of such SNF to a third country for reprocessing and/or storage needs prior consent from the U.S., even if the U.S. is not a member of the MNA.

In order to obtain U.S. consent, the MNA itself needs to be equipped with robust nuclear nonproliferation characteristics, which could be equivalent to satisfying U.S. nuclear nonproliferation requirements. Alternatively, an establishment of the MNA not using the U.S.-origin materials could be possible, although this may require Russian capabilities instead.

### *3.5. (G) Political and Public Acceptance*

In the particular case of SNF storage and disposal facilities, it is necessary to gain political and public acceptance from their host states. In the Pangea Project in Table 2, the project had been conducted without adequately informing the public. Once it was exposed, it came under heavy criticism by both the Federal and state governments in Australia. Recently, protest movements in Mongolia and internationally arose following reports of "secret documentation detailing an international nuclear waste disposal site that Japan and the United States had planned to build in Mongolia" [37]. Such experience shows that in order to promote back-end MNA facilities, political

and public acceptance through information disclosure and transparent procedures are essential, although all of them are far from easy.

### *3.6. (H) Economics*

Current MNA proposals, especially on nuclear fuel supply assurance in Table 3, require economic feasibility, since the MNA is expected not to disturb the existing nuclear fuel market.

Regarding reprocessing, the economic advantages of scale and minimization of the number of reprocessing facilities are reported both in the past efforts of the RNFC and the INFCE. Economics is also an important factor for every state when choosing between SNF reprocessing and direct disposal, other than the nonproliferation aspect of reprocessing.

In the case of SNF storage and disposal, it may not be always easy to achieve commercial feasibility, since such commercial market has yet to exist. In addition, in order to calculate necessary expenses, host states, facility locations and transportation routes among MNA member states *etc.* need to be identified and well researched beforehand, taking into account geopolitical considerations.

In general, the more states to get involved in the MNA, the more investment, advantage of scale and economic efficiency can be expected.

### *3.7. (I) Nuclear Safety*

After the Fukushima nuclear accident in March 2010, the strengthening of nuclear safety measures, including implementation of additional measures against severe accidents and emergency preparedness, are recognized more than ever. Without nuclear safety, sustainability of nuclear energy cannot be achieved. Strengthening nuclear security is not a main purpose of the MNA; however, MNA facilities and their host states are required to have necessary safety measures, including nuclear third party liability.

MNA facilities would be placed under the host state's nuclear safety regulation, even if they were given extra-territorial status and jurisdiction by the host states. Therefore, MNA host states are required to follow international norms on nuclear safety as described in Table 4, and to have their own solid legal framework and regulatory bodies. They are also required to prepare adequate accident management measures and emergency preparedness for nuclear incidents.

### *3.8. (J) Nuclear Liability*

With regard to nuclear safety, the Fukushima nuclear accident also reminded the international community about improving the international legal framework for nuclear third party liability. The effects of nuclear accidents respect no borders and nuclear accidents could cause damage not only to the state in which the incident occurs, but also neighboring states. In addition, the risk of such damage may discourage foreign investment and overseas nuclear business expansion. An IAEA Action Plan on Nuclear Safety, which was an implementation of the Declaration of the IAEA Ministerial Conference on Nuclear Safety in June 2011 pointed out that "Member States work towards establishing a global nuclear liability regime that addresses the concerns of all States that might be affected by a nuclear accident with a view to providing appropriate compensation for nuclear damage" [38].

### *3.9. (K) Transportation*

Due to the limitation of numbers of nuclear facilities by MNA, frequent and long distance transportation between MNA facilities and participating states is anticipated. In order to ensure safety and secure transportation of nuclear fuel and SNF, MNA supplier states need to comply with certain regulations on transportation of nuclear material, as shown in Table 4. Furthermore, they need to obtain necessary permissions from related states for landing and/or transit landing of nuclear material and SNF. When deciding transportation routes, one of the MNA features of geopolitical consideration may also be needed.

### *3.10. (L) Geopolitics*

Geopolitics is an essential element when developing national security strategy and international relations, including nuclear energy policy. In relation with a MNA, geopolitical consideration is required when deciding host states of MNA facilities and transportation routes among MNA facilities and participating states.

Assuming that MNA would be established in the Asian Region, including Kazakhstan and Mongolia as uranium producers, Japan and South Korea as services suppliers, and Southeast Asian states as non-suppliers, the relationship with China, Russia and the U.S. is important. In Asia, "in 2009 it [Kazakhstan] became the world's leading uranium producer", [39] while Mongolia "has substantial known uranium resources and geological prospectivity for more" [40]. If those two states become members of a MNA within the Asian Region, they are expected to be major uranium suppliers. However, they are inland states sharing common borders with both China and Russia and their natural uranium needs to pass through China and/ or Russia for further utilization. In this context, such a MNA requires the maintenance of good relationships with both China and Russia for the smooth transportation of nuclear material, whether or not they are willing to be involved in the MNA.

In relation with Russia, due to the facts that (1) Russia is a neighboring state of both states and historically has close relationships with those states, (2) natural uranium from both Kazakhstan and Mongolia require enrichment, (3) Russia has a huge enrichment capacity of 24 million kg SWU/yr [41] and Kazakhstan holds a part of these interests, (4) Russia is very much interested in MNA in view of utilizing its enrichment capacity, including IUEC, and (5) Russia has already concluded nuclear cooperation agreements with Asian states, a MNA in the Asian Region needs to be based on good relations with Russia.

In terms of relations with the U.S., since Japan, South Korea and Southeast Asian states are under the security umbrella provided by the U.S. and the U.S. has already provided nuclear materials and equipment to those states, therefore, it seems that the U.S.'s involvement cannot be avoided, even thought the U.S. is not a member of such a MNA.

In general, a MNA within the Asian region requires the maintenance of a geopolitical power balance among China, Russia and the U.S.

## 4. Conclusion

The authors propose 12 features for sustainable MNA by analyzing past and current efforts for establishing MNA. The most challenging issue is how to keep balance and consistency between nonproliferation and the equal right to use nuclear energy for peaceful purposes, including development and the establishment of sensitive technologies and facilities. It has been an issue since the 1940s and the world has been struggling to solve it.

The Fukushima nuclear accident is expected to have had only a limited effect on the 'Nuclear Renaissance' and nuclear energy use would expand in the future. Under these circumstances, the importance and need for a MNA should further increase for the future of nuclear energy in a world striving against nuclear proliferation by limiting the number of sensitive facilities and avoiding accumulation of SNF through assurance of supply of nuclear fuel and services including backend of nuclear fuel cycle. It would also contribute to discourage to divert nuclear materials and misuse of the related technologies through multilateral control of the fuel cycle facilities. In this context, the 12 features set out in this study would be a useful benchmark for establishing a MNA which contributes to sustainable nuclear energy use in the future.

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