UNITED NATIONS

UNITED NATIONS INSTITUTE FOR DISARMAMENT RESEARCH

Multilateralization of the Nuclear Fuel Cycle
The Need to Build Trust

Yury Yudin

UNIDIR/2010/1

Multilateralization of the Nuclear Fuel Cycle

The Need to Build Trust

Yury Yudin

UNIDIR
United Nations Institute for Disarmament Research
Geneva, Switzerland

UNITED NATIONS

New York and Geneva, 2010

About the cover

Plutonium store at Sellafield, United Kingdom. Sellafield is the United Kingdom's centre for the reprocessing of spent nuclear fuel from Britain's nuclear power stations and overseas customers.

British Nuclear Fuels plc photo, courtesy of the International Atomic Energy Agency.

NOTE

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

*
* *

The views expressed in this publication are the sole responsibility of the individual author. They do not necessarily reflect the views or opinions of the United Nations, UNIDIR, its staff members or sponsors.

UNIDIR/2010/1

UNITED NATIONS PUBLICATIONS
Sales No. GV.E.10.0.1
ISBN 978-92-9045-197-6

The United Nations Institute for Disarmament Research (UNIDIR)—an autonomous institute within the United Nations—conducts research on disarmament and security. UNIDIR is based in Geneva, Switzerland, the centre for bilateral and multilateral disarmament and non-proliferation negotiations, and home of the Conference on Disarmament. The Institute explores current issues pertaining to the variety of existing and future armaments, as well as global diplomacy and local tensions and conflicts. Working with researchers, diplomats, government officials, NGOs and other institutions since 1980, UNIDIR acts as a bridge between the research community and governments. UNIDIR's activities are funded by contributions from governments and donor foundations. The Institute's web site can be found at:

www.unidir.org

CONTENTS

ACKNOWLEDGEMENTS

Special thanks to Alexander Glaser and Lawrence Scheinman who provided useful comments on earlier drafts of the manuscript.

The author would like to thank his UNIDIR colleagues for their support and advice. Special thanks to Theresa Hitchens and Kerstin Vignard for their practical, administrative and managerial advice. Special thanks to Jason Powers, who provided excellent editorial assistance, and to Anita Blétry for production assistance.

Special thanks to Peter Tzeng, who conducted the background research for this project and provided excellent assistance at the early stage of drafting the manuscript.

Special thanks to the Governments of Austria, the Russian Federation, Sweden and the United Kingdom for funding the UNIDIR project Multilateral Approaches to the Nuclear Fuel Cycle.

ABOUT THE AUTHOR

Yury Yudin is a Senior Researcher at UNIDIR and manager of the Multilateral Approaches to the Nuclear Fuel Cycle project. Previously, he was Director of a Russian NGO, the Analytical Centre for Non-proliferation, and Senior Researcher at RFNC–VNIIEF, the Russian Federal Nuclear Centre—All-Russian Research Institute of Experimental Physics. He graduated from the Moscow Engineering Physics Institute as a nuclear physicist and holds a PhD in nuclear engineering. He has special expertise in nuclear engineering, nuclear non-proliferation and nuclear disarmament.

SUMMARY

After several decades of virtual stagnation, nuclear power is attracting renewed interest. In 2008, International Atomic Energy Agency (IAEA) Director General Mohamed ElBaradei announced that some 50 states have expressed interest in nuclear power. Energy supply is a critical economic, national security, and environmental issue for our planet and nuclear energy could be a vital part of the energy mix providing energy in quantities needed to decrease our dependence on fossil fuels.

Expanding global access to nuclear power, nevertheless, has the potential to lead to the spread of dual-use nuclear technologies—uranium enrichment and spent fuel reprocessing. The dilemma then is quite evident: how can the international community encourage the peaceful use of nuclear energy while curbing the spread of nuclear weapons? Left uncontrolled, the dissemination of fuel cycle technologies could notably exacerbate the risk of proliferation of nuclear weapons and nuclear weapon capabilities.

These fears have prompted renewed interest in the multilateralization of the nuclear fuel cycle. Around a dozen proposals have been put forward by states, nuclear industry and international organizations. These proposals range from creating "last resort" fuel banks, to establishing a new multinational enrichment plant, to eventually removing all new and existing enrichment and reprocessing facilities from purely national control.

However, the proposals for multilateralization of the nuclear fuel cycle have come under considerable criticism from some non-supplier states. The main fears and concerns expressed by these states are that:

- multilateral fuel cycle arrangements infringe the inalienable right of non-nuclear-weapon states under Article IV of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) to pursue peaceful nuclear power;
- they deny access to advanced technologies under the guise of non-proliferation;
- they are an attempt to create a supplier cartel to control the market; and

- the proposed multilateral fuel supply mechanisms are unreliable.

These concerns came to a head in June 2009, when several states that sit on the IAEA Board of Governors blocked ElBaradei's request to move forward with two fuel bank proposals. This decision of the IAEA Board clearly demonstrated how extremely sensitive issues related to the nuclear fuel cycle are for many non-supplier states.

The majority of NPT states parties recognize the risks of proliferation of sensitive nuclear technologies and the diversion or misuse of nuclear materials. Multilateral fuel cycle arrangements may offer a way to ensure that the benefits of nuclear energy are available to all states, while strengthening the nuclear non-proliferation regime.

There is now broad agreement among states that the issue of forgoing the development, construction or operation of fuel cycle facilities is not a necessary criterion for a multilateral mechanism. Instead such mechanisms should offer to states sufficient incentives (political, economic, etc.) not to acquire proliferation-sensitive technology by ensuring the benefits of nuclear energy without possession of the technology itself. In the long run the differences between states that possess this technology and states that do not might be balanced out to a great extent by the eventual "denationalization" of sensitive fuel cycle facilities.

In addition to "guarantee in-depth" arrangements designed to back-up the existing nuclear market, a mechanism that could provide any state that wishes to use this option with some vested interest and form of participation in the major elements of fuel cycle services would be desirable. Such broad participation may satisfy the economic and political interests of many non-supplier states while simultaneously guarding against a "cartel" of nuclear suppliers.

Any real progress toward a multilateral approach to the nuclear fuel cycle can be achieved only in the context of mutual understanding that an international non-discriminatory nuclear fuel cycle control regime has the potential to benefit the whole of humankind by curbing the proliferation of technologies that could be used for nuclear weapons while at the same time allowing full access for all states to "the benefits of peaceful applications of nuclear technology" in accordance with the NPT's preamble.

Obviously, the success of multilateral approaches to the nuclear fuel cycle first of all depends on their political acceptability to all parties. The central problem hampering further progress toward a multilateral approach to the nuclear fuel cycle is distrust among states. There are no technical or legal questions that cannot be resolved in due course—the problem of building trust is a political problem that needs to be tackled using political means. To be successful, multilateral fuel cycle arrangements will inevitably require a broad political consensus on how the international community can limit access to these technologies, while protecting the right of states to develop nuclear energy for peaceful purposes. The priorities and concerns of the non-suppliers should be well understood and taken into consideration.

CHAPTER 1

INTRODUCTION

From the outset of the nuclear age, the challenge has been to facilitate the peaceful use of nuclear energy while inhibiting the proliferation of nuclear weapons. But, as Robert Oppenheimer once observed, "the close technical parallelism and interrelation of the peaceful and the military [i.e., weapons] applications of atomic energy" make countering nuclear proliferation an especially difficult task. At the heart of the problem is a large overlap between civilian and military (meaning for weapons use) applications of nuclear energy, which both depend essentially on the same key ingredient: fissile materials.[1] These materials can undergo fission to release significant amounts of energy, which can be harnessed to generate electricity or be used to produce tremendous explosive force.

Common fissile materials include uranium-233, uranium-235 and plutonium-239. Uranium-235 is the only fissile nuclide that occurs naturally while all others, like uranium-233 and plutonium-239, are man-made—they have been present on Earth for only a little longer than the last 60 years.

The uranium-235 isotope accounts for only 0.71% of natural uranium. Special technologies are used to increase the abundance of this fissile isotope in the material, or "enrich" uranium. Enriched uranium is a critical component for both nuclear power generation and nuclear weaponry. The most prevalent commercial power reactors—light water reactors—use uranium enriched to 3–5% uranium-235. The fissile uranium in nuclear weapons, known as weapon-grade uranium, usually contains 90% or more of uranium-235.[2]

Essentially, the challenge to countering nuclear proliferation stems from the fact that there is no technological barrier between the production of low-enriched uranium (LEU) for nuclear reactors and high-enriched uranium (HEU) for weapons. Weapon-grade material can be produced using the

same enrichment equipment that otherwise is used to produce LEU for power generation.

Unlike uranium, plutonium does not occur naturally. However, the uranium-238 isotope, which accounts for 99.2% of natural uranium and comprises most of the fuel mass in a nuclear reactor, is converted into heavier isotopes through nuclear reactions. This is how plutonium-239 and other isotopes of plutonium are formed in the process of nuclear-reactor operation. After irradiated nuclear fuel has been discharged from a nuclear reactor, reprocessing technologies are used for the chemical separation of plutonium and uranium from the radioactive fission products and transuranic isotopes. Separated plutonium can be used to fabricate fuel for different types of nuclear power reactors. However, it is also a key fissile component in nuclear weapons, favoured for most advanced nuclear weapon designs. Weapon-grade plutonium—that is, the plutonium most suitable for the use in nuclear weapons—generally contains more than 93% plutonium-239.[3] But in fact, the International Atomic Energy Agency (IAEA) classifies almost any isotopic composition of plutonium as direct-use material that "can be used for the manufacture of nuclear explosive devices without transmutation or further enrichment".[4] As with uranium enrichment, there is no technological barrier between separating plutonium for peaceful purposes or for military purposes.

In 2005, an IAEA Expert Group on Multilateral Approaches to the Nuclear Fuel Cycle published a report identifying certain parts of the nuclear fuel cycle as proliferation sensitive, namely "the production of new fuel, the processing of weapon-usable material, and the disposal of spent fuel".[5]

Proliferation risks derive directly from the "dual-use" nature of certain nuclear fuel cycle technologies—first of all, uranium enrichment and spent fuel reprocessing. These are required for nuclear power generation, but at the same time they can provide states, and even non-state actors, with materials that are directly usable in a nuclear weapon or a nuclear explosive device. Any non-nuclear-weapon state with such technological capabilities would still be in full compliance with the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), but would just be a "screwdriver turn" away from acquiring nuclear weapons (see Annex C).

The risks associated with fuel cycle technologies have been well recognized since the dawn of the nuclear age. The first effort to resolve the dilemma

of the military and peaceful uses of nuclear energy was made in 1946 by the US government, with the *Report on the International Control of Atomic Energy* (commonly known as the Acheson–Lilienthal Report).

The Acheson–Lilienthal report was the first effort to propose a policy on the international control of atomic energy. But, the report's recommendation to establish an international authority over the most dangerous aspects of the nuclear fuel cycle was not feasible given the international climate at the time. Instead, the international community eventually adopted the very approach—occasional inspection—criticized by the report's authors who believed that "a system of inspection superimposed on *an otherwise uncontrolled exploitation of atomic energy by national governments* will not be an adequate safeguard".

Since then, the world has more than once turned to the idea of the multilateral[6] management of the nuclear fuel cycle, specifically denationalizing certain fuel cycle activities posing proliferation risks. Throughout the 1970s a number of proposals for regional, multinational and international arrangements were put forward with the intention to reinforce the NPT objective of curbing nuclear proliferation while preserving the right of all states to exploit nuclear energy for peaceful purposes. But none of these proposals and initiatives led anywhere for a number of political and economic reasons, including Cold War tensions and a slow-down in nuclear power development toward the end of the decade.

The dilemma that Oppenheimer identified long ago is becoming more difficult to resolve because of the spread of nuclear knowledge and technology. Today the world faces the prospect of a nuclear revival or "renaissance"—a significant expansion in the use of nuclear energy worldwide. The driving force behind this process stems from various political, economic, and environmental benefits that nuclear energy potentially can provide.

In 2008, IAEA Director General Mohamed ElBaradei announced that some 50 states have expressed interest in the introduction of nuclear power into their energy mix. This may result in the spread of dual-use nuclear fuel cycle technologies—uranium enrichment and spent fuel reprocessing. Left uncontrolled, this dissemination could notably exacerbate the risk of nuclear weapons proliferation. So the key questions are these: how

should the international community address the growing security and proliferation risks from the nuclear fuel cycle, while protecting the right of states to develop the peaceful use of nuclear energy? How should the international community cope with the most recent non-proliferation concerns—foremost, revelations about clandestine nuclear activities in some NPT states parties and the emergence of new sources of supply of sensitive nuclear technologies?

In an attempt to find answers to these difficult questions, attention has recently refocused on ways to manage the proliferation-sensitive steps of the nuclear fuel cycle. In 2003 the Director General of the IAEA proposed a fresh look at multilateral approaches that could serve to strengthen the NPT regime while not impeding the development of nuclear energy for states wishing to choose that option. Later he proposed a three-stage process for developing a new multilateral mechanism:

> The *first* step would be to establish a system for assuring supply of fuel for nuclear power reactors—and, if necessary, supply of the actual reactors. The *second* step would be to have all new enrichment and reprocessing activities in future put exclusively under multilateral control. And the *third* step would be to convert all existing enrichment and reprocessing facilities from national to multilateral operations.[7]

Recently the subjects of assurances of supply of nuclear fuel and international fuel cycle centres have received considerable attention. A number of proposals for the multilateralization of the nuclear fuel cycle have been put forward by governments, nuclear industry and international organizations. These proposals cover a broad spectrum, from providing assurances of supply of fuel to those not operating fuel cycle facilities, to the conversion of an existing national enrichment facility to a multinational one, to the establishment of a new multinational enrichment plant, to eventually removing all new and existing enrichment and reprocessing facilities from purely national control.[8] Table 1 provides a brief description of the existing proposals.

However, almost all proposals for multilateral approaches to the nuclear fuel cycle have come from current or potential nuclear suppliers. Considerably less attention has been given to the concerns and needs of the non-suppliers. As a result, many non-supplier states have remained either indifferent or have voiced fears that the proposed arrangements could somehow deprive them of their right to develop peaceful uses of

nuclear technology; for example, at the June 2009 meeting of the IAEA Board of Governors, three fuel assurance proposals were discussed but received no support from many non-supplier states.

Table 1. The existing proposals

Proposal	Principal targets
US Reserve of Nuclear Fuel	A nationally controlled reserve of LEU, produced from HEU declared excess to national security needs, as a backup to an international assurance supply mechanism
Russian Global Nuclear Power Infrastructure	A system of international centres providing fuel cycle services on a non-discriminatory basis and under IAEA control
US Global Nuclear Energy Partnership	The full spectrum of front-end and back-end services provided by a limited number of supplier states using new proliferation-resistant technologies
WNA Ensuring Security of Supply Proposal	Collective guarantees of supply of uranium enrichment services provided by nuclear industry and supported by governments
Six-Country Concept	Assurances of supply of uranium enrichment services provided by supplier states and supported by the IAEA
Japanese Standby Arrangements Proposal	Assurances of supply of all front-end fuel cycle services
NTI/IAEA Fuel Bank	An LEU stockpile owned and managed by the IAEA as a last resort of member states
UK Nuclear Fuel Assurance Proposal	Assurances of supply of uranium enrichment services provided by supplier governments through guaranteed export licenses
Russian International Uranium Enrichment Centre	Multinational uranium plant under IAEA safeguards with no access to enrichment technology by stakeholders. Supplemented by an IAEA-controlled LEU reserve
German Multilateral Enrichment Sanctuary Project	An IAEA-controlled international uranium enrichment plant in an extraterritorial area with no access to technology by stakeholders

Proposal	Principal targets
Austrian Proposal on Multilateralization of the Nuclear Fuel Cycle	A multilateral framework of supervision of all stages of the nuclear fuel cycle "from the cradle to the grave"
EU Nuclear Fuel Cycle Proposal	A list of criteria to evaluate multilateral fuel cycle arrangements
GCC Multinational Nuclear Consortium proposal	An international uranium enrichment consortium for the Middle East which could be based in a neutral country outside the region

Clearly understanding the concerns of non-supplier states is important for the future of a multilateral approach to the nuclear fuel cycle. In March 2009 the United Nations Institute for Disarmament Research (UNIDIR) hosted a seminar entitled "Multilateral Approaches to the Nuclear Fuel Cycle" in Geneva. There Ambassador Leslie M. Gumbi, Permanent Representative of South Africa to the United Nations and International Organizations in Vienna, made a comprehensive presentation of views of non-supplier states on the multilateral control of the nuclear fuel cycle (see Appendix A). In June 2009, at a meeting of the IAEA Board of Governors, the Group of 77 (G-77) made a statement of its apprehensions regarding some proposed fuel assurance mechanisms (see Appendix B).

This study paper seeks to examine the concerns of non-supplier states on the multilateralization of proliferation-sensitive steps of the nuclear fuel cycle, and to frame how multilateral mechanisms could be structured in a truly multilateral and non-discriminatory manner.

The central problem hampering the further progress of a multilateral approach to the nuclear fuel cycle lies in distrust between supplier and non-supplier states. An open dialogue among states will go a long way toward establishing a basis of trust and confidence for further action. This study paper is conceived first of all as food for thought and a contribution to such dialogue. The discussion here is rather general in many respects because it is often impossible to give more detail, as ideas and proposals for a multilateral approach to the nuclear fuel cycle have not yet sufficiently matured. Nevertheless, the author hopes that this will not detract from the main purpose of the paper.

CHAPTER 2

CORE CONCERNS OF NON-SUPPLIER STATES

ANY MULTILATERAL MECHANISM MUST BE NON-DISCRIMINATORY, TRANSPARENT AND INCLUSIVE

Today the fundamental obstacle to the multilateralization of the nuclear fuel cycle is the lack of trust between supplier and non-supplier states. The latter are afraid that the former may try to expand the status quo of the NPT (that is, the "two-tier" division between Nuclear Weapon States and Non-Nuclear-Weapon States) under the disguise of non-proliferation (this suspicion can be traced, at least in part, to President Bush's 2004 proposal, discussed below). Non-supplier states would most likely resist the establishment of a new regime of "haves" and "have-nots" in terms of the peaceful use of nuclear energy. Thus it is imperative that the creation of a new multilateral framework be as transparent and inclusive as practically possible in order to avoid the perception that multilateral mechanisms are aimed at a status quo that some regard as unfair.

This status quo has arisen from the legal obligations of the 1970 NPT, which rest on three fundamental issues, or "pillars":

- Pillar 1: **non-proliferation**. Each nuclear-weapon state party undertakes not to transfer "nuclear weapons or other nuclear explosive devices" or control over them and "not in any way to assist, encourage, or induce" a non-nuclear-weapon state party to acquire nuclear weapons (Article I). Non-nuclear-weapon states parties agree not to receive, manufacture or acquire nuclear weapons or to "seek or receive any assistance in the manufacture of nuclear weapons or other nuclear explosive devices" (Article II). Non-nuclear-weapon states parties also agree to accept safeguards by the IAEA to verify that they are not diverting "nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices" (Article III);
- Pillar 2: **peaceful use of nuclear energy**. The NPT guarantees "the inalienable right of all the Parties to the Treaty to develop research,

production and use of nuclear energy for peaceful purposes without discrimination", in conformity with their non-proliferation obligations (Article IV.1). As a result, all states parties are obliged "to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy" (Article IV.2); and

- Pillar 3: **disarmament**. "Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament" (Article VI).

The NPT endeavours primarily to halt horizontal nuclear proliferation, that is, the spread of nuclear weapons to states that had not previously possessed them, by limiting the Nuclear-Weapon States to those states that had manufactured and detonated a nuclear explosive device prior to 1 January 1967, these being France, the People's Republic of China, the Soviet Union (obligations and rights now assumed by Russia), the United Kingdom and the United States. At the heart of the NPT is a central bargain between the Nuclear-Weapon States (NWS) and the Non-Nuclear-Weapon States (NNWS)—the NNWS agree to forgo nuclear weapons and, in exchange, are given an "inalienable right" to exploit nuclear energy for peaceful purposes, subject to the safeguards system of the IAEA, while the NWS commit themselves to nuclear disarmament.

The NPT is nearly universal: 188 states are party to the treaty. Only three states have not signed it (India, Israel and Pakistan), while the Democratic People's Republic of Korea announced its withdrawal from the NPT in 2003, although the validity of the withdrawal is debated.

Negotiated in the 1960s, the NPT is not a perfect treaty (if any perfect international treaty could ever be concluded), and today a number of its premises seem less than optimal. For example, the treaty has an inherently discriminatory nature in terms of legitimizing, at least temporarily, the arsenals of the five NWS and setting different rights and obligations for the NWS and the NNWS, which often has led to disagreements between them in the interpretation of the key provisions of the treaty.

Nevertheless, perfect or not, the NPT is the cornerstone of the international non-proliferation regime and it is as important today as it was when first agreed almost 40 years ago. Any new non-proliferation framework, which

could include additional multilateral and cooperative measures, should be built on the NPT with maximum inclusiveness and transparency. Attempts to reinterpret the treaty's premises, in particular the right to develop the peaceful uses of nuclear energy, have met with resistance from many states because the Article IV clause—"the inalienable right" to use nuclear energy for peaceful purposes—served as the keystone of the original NPT deal. Such attempts at reinterpretation could ultimately have a negative impact on the non-proliferation regime.

THE RIGHT OF STATES TO USE NUCLEAR ENERGY FOR PEACEFUL PURPOSES MUST BE RESPECTED

Some early proposals for multilateral approaches to the nuclear fuel cycle (the 2004 Bush proposal, the Global Nuclear Energy Partnership, the Six-Country Concept, and the World Nuclear Association proposal) had preconditions for non-supplier states to forgo domestic development of sensitive fuel-cycle technologies—thus meeting with criticism from non-supplier states—and later either abandoned these preconditions or were suspended.

In February 2004, in a speech at the National Defense Institute, US President George W. Bush proposed a plan that effectively would have denied uranium enrichment and spent fuel reprocessing technologies to states not already in possession of them:

> The world must create a safe, orderly system to field civilian nuclear plants without adding to the danger of weapons proliferation. The world's leading nuclear exporters should ensure that states have reliable access at reasonable cost to fuel for civilian reactors, so long as those states renounce enrichment and reprocessing. Enrichment and reprocessing are not necessary for nations seeking to harness nuclear energy for peaceful purposes.
>
> …
>
> [T]he Nuclear Suppliers Group should refuse to sell enrichment and reprocessing equipment and technologies to any state that does not already possess full-scale, functioning enrichment and reprocessing plants.[9]

This proposal essentially required a reinterpretation of Article IV of the NPT because its intent was to restrict the right of states parties to participate in "the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy".

The US administration ran into a strong opposition to this proposal both from the members of the Nuclear Suppliers Group (NSG)[10] and from non-supplier states.[11] At the 2005 NPT Review Conference, several states voiced their opposition to such a proposal. The Non-Aligned Movement (NAM) submitted a working paper to the conference that stated:

> The Group of Non-Aligned States Parties to the Treaty continues to note with concern that undue restrictions on exports to developing countries of material, equipment and technology for peaceful purposes persist. In this regard, the Group believes that any undue restrictions or limitations on peaceful uses of nuclear energy, incompatible with the provisions of the Treaty, should be removed. The Group emphasizes that proliferation concerns are best addressed through multilaterally negotiated, universal, comprehensive and non-discriminatory agreements. The Group further emphasizes that non-proliferation control arrangements should be transparent and open to participation by all States and should ensure that they do not impose restrictions on access to material, equipment and technology for peaceful purposes required by developing countries for continued development.[12]

Similarly to the Bush proposal, the US Global Nuclear Energy Partnership (GNEP) proposal[13] at first sought to create two categories of states: one for states with full nuclear fuel cycles ("fuel cycle states" according to the initial GNEP language) and one for states utilizing nuclear energy but not having enrichment and reprocessing facilities ("reactor states"). The World Nuclear Association proposal and the Six-Country Concept also at one point included a requirement for states to "forego" the development of, or the building and operation of, sensitive fuel cycle facilities.

These proposals effectively tried to introduce additional discrimination into the non-proliferation regime, beyond that already present in the distinction between the NPT Nuclear-Weapon States and Non-Nuclear-Weapon States. Like the Bush proposal, they were met with strong disapproval from many states. These proposals can be blamed, at least partially, for giving rise to the common misconception that any multilateral mechanism

necessarily implies the deprivation of the Article IV right of NNWS to peaceful nuclear technology.

This is not true. The majority of proposals for the multilateralization of the nuclear fuel cycle do not require states to forgo any of their rights under Article IV of the NPT and do not foreclose the possibility of states to have their own fuel cycle facilities. Currently the Six-Country Concept is the only proposal that explicitly contains such a requirement after the World Nuclear Association stated during the International Nuclear Fuel Supply Conference in London in March 2009 that it had decided to remove the requirement from their proposal.[14] There is general agreement among states that a multilateral approach for the nuclear fuel cycle should not require states to forgo their rights because any such proposals will most likely be doomed to failure. As the IAEA Director General recently said, "It should be clear by now that any mechanism that smacks of inequality or dependency will never get off the ground".[15]

ANY MULTILATERAL MECHANISM MUST INVOLVE THE IAEA, AND MUST BE IN ACCORDANCE WITH THE IAEA STATUTE

To facilitate the implementation of Article IV of the NPT, the IAEA Statute provides for assuring access for all states to nuclear fuel and reactor technology. In particular, Article III.A.2 of the statute authorizes the Agency to:

> make provision, in accordance with this Statute, for materials, services, equipment, and facilities to meet the needs of research on, and development and practical application of, atomic energy for peaceful purposes, including the production of electric power, with due consideration for the needs of the under-developed areas of the world.

Almost all of the proposals put forward to assure the supply of fuel for nuclear power reactors call for the active participation of the IAEA, anticipating that this would give non-suppliers greater confidence. These proposed mechanisms envisage the IAEA as a guarantor of uninterrupted and predictable access to nuclear fuel in a non-discriminatory and equitable manner based exclusively on compliance with predetermined non-proliferation criteria.

The IAEA Statute provides the Agency the authority to carry out the activities foreseen in these proposals:

> Under Article III of the Statute, the Agency is authorized to acquire materials, services and equipment, and establish its own facilities and plants, in order to facilitate the practical application of nuclear energy for peaceful purposes. The legal authority for the receipt, custody and supply of nuclear material [or to act as an intermediary for the purpose of securing the performance of fuel cycle services or the supply of nuclear material] is to be found, in particular, in Articles IX and XI of the Statute. In addition, Article X of the Statute refers to the possibility of Member States making available to the Agency services, equipment and facilities which may be of assistance in fulfilling its objectives and functions.[16]

Different roles for the IAEA can be envisaged. For example, in the case of an LEU bank under the auspices of the IAEA, as proposed by the Nuclear Threat Initiative (NTI), the material in the bank would be under the control and formal possession of the Agency, which would have to safeguard it against various hazards and apply its own safety standards and measures. Customer states might find an LEU bank owned and controlled by the IAEA more attractive than just commitments made by supplier-state governments. "The supply of LEU from the bank to a Member State would be based on pre-determined eligibility criteria and a pre-determined process".[17] Moreover, "having the right to receive LEU from the guaranteed supply mechanism would not require giving up the right to establish or further develop a national fuel cycle or have any impact on it. The additional options for assurance of supply would be over and above the rights that exist at present".[18]

Alternatively, the IAEA could fulfil the role of a guarantor of supply without being the owner of an LEU reserve. On 25 January 2006, President of the Russian Federation Vladimir Putin promoted the initiative to create "a global infrastructure that will give all interested countries equal access to nuclear energy, while stressing reliable compliance with the requirements of the non-proliferation regime".[19] As part of the initiative, the Russian Federation later proposed the creation of a guaranteed reserve of LEU in Angarsk. Russia agreed to cover all the costs associated with the establishment of the LEU reserve, its storage and maintenance, the application of IAEA safeguards, and ensuring safety and security.[20] Following a request from the IAEA Director General to withdraw material

from the reserve, Russia would deliver the required amount of LEU to the IAEA with all the necessary export licenses and authorizations required under Russian law. Upon receipt of the material, "the IAEA would acquire ownership of the LEU and immediately transfer the ownership of the LEU to the requesting Member State".[21] In this case the IAEA would not own an LEU reserve, which would lift the burden of operation and maintenance. The Agency simply would control and assure the supply of material from the reserve to a "non-nuclear-weapon State member of the IAEA experiencing a disruption in the supply of LEU for nuclear power plants not related to technical or commercial considerations".[22] Similar to the NTI-proposed IAEA fuel bank, under the Russian proposal "having the right to receive LEU from the guaranteed reserve would not require giving up the right to establish or further develop a national fuel cycle".[23]

The German Multilateral Enrichment Sanctuary Project (MESP) envisions a completely new multinational enrichment facility under IAEA supervision established on an extraterritorial site. The host state would have to transfer functional immunities to the IAEA to such an extent that the operation of the enrichment plant would be protected from any potential interference by the host state or any other state. The IAEA "would be responsible for licensing, inspection, enforcement, and import and export controls in the MES [Multilateral Enrichment Sanctuary]",[24] although some of these tasks could be delegated to the host state or other state authorities. The IAEA would also ensure that activities in the MES complied with the applicable IAEA standards for safety, security and safeguards. The IAEA Board of Governors would be responsible for defining the criteria by which decisions would be made on the release of LEU. "As a further assurance for the supply of nuclear fuel, the Enrichment Company could establish and maintain a buffer stock or a physical reserve of nuclear fuel available to the Director General of the IAEA on conditions established by the Board of Governors".[25]

The Six-Country Concept envisions a number of roles for the IAEA: it would (1) trigger the proposed supply backup mechanism if a commercial supply relationship is interrupted; (2) assess whether a non-supplier state is eligible to participate; (3) seek to facilitate new arrangements with one or more alternative suppliers of uranium enrichment services; and (4) hold rights regarding the use of last-resort nationally owned reserves of LEU.

The UK Nuclear Fuel Assurance mechanism would involve an agreement between supplier state(s), the non-supplier state and the IAEA, in which the supplier state(s) would guarantee that, subject to compliance with the non-proliferation commitments to be assessed by the IAEA, national enrichment providers would not be prevented from supplying enrichment services to the non-supplier state. This mechanism aims to give further assurance of supply with a "prior consent to export" arrangement. The IAEA would serve as "honest broker" between supplier and non-supplier states providing further assurance that governments of supplier states would not revoke export licenses for commercial contracts for reasons other than credible non-proliferation risks.

Japan's IAEA Standby Arrangements System calls for the IAEA to be a depository organization for information regarding each participating state's supply capacity of front-end fuel cycle services (uranium supply, uranium conversion, uranium enrichment and fuel fabrication). The IAEA would administer this information in a database and would facilitate uninterrupted supply to non-supplier states. Should disruption of normal commercial mechanisms occur, the IAEA would then act as a "match maker" between states to arrange provision of the required services or materials.

Austria proposed a two-stage mechanism aimed at the creation of a new multilateral framework for nuclear energy—a so-called Nuclear Fuel Bank—that over time would achieve full multilateralization of fuel cycle facilities worldwide. In the first stage, an IAEA information system would be created that would contain comprehensive information on each state's capabilities, activities and transfers at each stage of the fuel cycle. The second stage would seek full multilateralization of the nuclear fuel cycle. At this stage the IAEA "would be granted the mandate to act as a mandatory virtual broker in all transactions related to the nuclear fuel cycle".[26]

The envisaged role of the IAEA in assuring access for all states to nuclear fuel varies from an intermediary facilitating back-up supply arrangements if a commercial supply contract is interrupted, to an owner and manager of an LEU reserve, to a broker in all fuel cycle transactions. Logically, multilateral fuel cycle mechanisms should ensure that the IAEA will be in the position—as envisaged in its Statute—to assure access to nuclear material and services to all its member states.

The establishment of multilateral fuel cycle arrangements is likely to be implemented gradually and through various complementary instruments. The role and involvement of the IAEA is likely to differ according to the specific instrument and phase of multilateralization. Of course, the Agency should not be overburdened to the point that current missions would be hindered. Further discussions and careful calculations are necessary to allow the Agency to fulfil its statutory mission while avoiding overextension and transformation into a huge international bureaucracy.

ANY MULTILATERAL MECHANISM MUST NOT ADD TO STATES' EXISTING LEGAL OBLIGATIONS

As mentioned above, there is now broad agreement among states that a multilateral approach to the nuclear fuel cycle must not impose additional legal obligations requiring states to forgo their rights under the NPT.

At the same time, the existing proposals for multilateral fuel cycle mechanisms stipulate certain non-proliferation conditions for those states wishing to make use of these arrangements. These conditions are necessary—it would be counterproductive to supply nuclear material to a state that might divert it to manufacture nuclear weapons. However, the substance of these conditions is debated. Should they reproduce those codified in the NPT? Or should they be used to expand non-proliferation efforts by making stronger demands on states? If stronger demands were imposed, any additional requirements might run the risk of alienating states that found them unfair and discriminatory. In this case a broad political agreement between states would be needed to avoid the risk of such alienation.

The Six-Country Concept and the UK Nuclear Fuel Assurance proposal require a state to have a comprehensive safeguards agreement (CSA) and Additional Protocol (AP) in force to be eligible to take advantage of proposed supply backup mechanisms. Currently, only a CSA is required by the NPT; an AP is still not obligatory. The AP is an important legal instrument that provides further authority for the IAEA to monitor for undeclared nuclear materials and activities. Many states support the universalization of the protocol, but it still remains voluntary today. Some states—for example, Argentina, Brazil, Egypt and Syria—have refused to sign the AP for various national reasons. Until the international community agrees to

make the protocol mandatory, it would be reasonable not to require it as a criterion for participation in multilateral fuel cycle arrangements. First, it could set the bar for participation too high. Second, it would exacerbate the political tensions around the issue of multilateralization.

On the other hand, an additional obligation for the NPT NWS—a direct requirement to put nuclear materials and facilities involved in a multilateral mechanism under IAEA safeguards—would certainly be positive as a means to expand the application of IAEA safeguards in these states.

All in all, most proposals in their current state do not impose additional obligations on states wishing to make use of the multilateral mechanisms. In general, these proposals include language that entails the compliance of non-supplier states with the accepted non-proliferation norms, like requiring them to be "in full compliance with international safeguards" or "in full compliance with their non-proliferation obligations". As the overwhelming majority of non-supplier states are NPT states parties, they should undertake comprehensive safeguards agreements with the IAEA in fulfilment of their obligations under the treaty. In this case, to be in full compliance with their non-proliferation obligations means that these states should not have outstanding issues with the IAEA. The Agency has to verify and assure their compliance with safeguards agreements.

The application of multilateral mechanisms to non-NPT states and states not in good standing with the IAEA is a more difficult issue. A more inclusive approach may appear as if the international community is rewarding these states for "bad" behaviour. But a more restrictive approach may overlook key opportunities to engage with those states that are not well integrated into the international non-proliferation framework.

ANY MULTILATERAL MECHANISM MUST BE VOLUNTARY

Article IV of the NPT specifies that all states parties to the treaty have the right "to develop research, production and use of nuclear energy for peaceful purposes". As the 2005 IAEA Expert Group Report confirms, "a new binding international norm stipulating that sensitive fuel cycle activities are to be conducted exclusively in the context of multilateral mechanisms and no longer as a national undertaking would amount to a change in the scope of Article IV of the NPT".[27] Therefore, in compliance with the treaty,

"[p]articipation in any multilateral nuclear fuel supply arrangements should be on a voluntary basis".

Given this voluntary nature of participation, states would avail themselves of multilateral fuel cycle arrangements according to the economic and political incentives and disincentives offered by these arrangements. That is why it is important to have a variety of proposals on the table providing different options and opportunities. Voluntary participation gives states the power to express where their interests lie by joining the multilateral arrangements that suit their own preferences. To be attractive, multilateral fuel cycle mechanisms should be based on fairness and cost effectiveness and be applied in a political framework acceptable to the majority of states.

The tabled proposals for multilateralization of the nuclear fuel cycle do not obligate states to participate. The majority of these proposals do not require states to forgo any of their rights (as discussed above). Instead, given the widespread agreement that participation in multilateral fuel cycle arrangements should be voluntary, they rely on a set of incentives to convince states to rely on the global nuclear fuel market instead of developing indigenous capabilities. Different incentives may be needed for different states. For example, some states with developed nuclear power may not be very interested in fuel assurances as the world nuclear market works well and these states have never had problems with fuel supplies. But these states already have problems with storage and disposal of spent nuclear fuel, thus they would be more interested in comprehensive multilateral arrangements including both front-end and back-end services.

The three proposed fuel banks (by Russia, the United States and NTI), for example, are all supplemental resources of LEU for states to use if they wish to do so. Similarly, the IAEA Standby Arrangements System and the UK Nuclear Fuel Assurance mechanism create back-up mechanisms for the existing market that states have the choice to join. The WNA proposal and the Six-Country Concept give states an option to make use of "in-depth" assurances of supply. The Russian IUEC allows states to buy stakes in the existing enrichment facility to have guaranteed enriched uranium product or a share in the profits. And the MESP gives states the additional power to participate in ownership and operation of a multilateral enrichment facility in an extraterritorial environment. All of the currently active proposals basically provide a choice with incentives for states.

At the same time, as the 2005 IAEA Expert Group Report notes, it is not impossible to imagine a new binding international norm that would stipulate that all sensitive nuclear fuel cycle activities worldwide should be restricted exclusively to multilateral mechanisms. Such a norm would effectively denationalize certain nuclear fuel cycle activities by requiring that future facilities be multilaterally owned and operated while existing facilities be converted to multilateral ownership and operation as well.

International regimes are complex, dynamic institutions that evolve over time, along with their norms, rules and decision-making procedures, to satisfy actors' expectations in a given area of international relations. As IAEA Director General Mohamed ElBaradei aptly pointed out: "The [NPT] has served us well for 35 years. But unless we regard it as part of a living, dynamic regime capable of evolving to match changing realities, it will fade into irrelevance and leave us vulnerable and unprotected".[28]

Nevertheless, a shift toward such a binding international norm would likely face considerable resistance, requiring a consensus of all states parties to the NPT on a new "bargain" in a broader negotiating frame. In 1981 Lawrence Scheinman observed that "multinationalism, or any other institutional approach cannot substitute for consensus; it can only reflect and reinforce that consensus".[29] Such consensus can be achieved only on a conceptually new level of mutual confidence and international cooperation.

Therefore participation in any multilateral fuel cycle arrangement should for now remain voluntary according to the "inalienable right" guaranteed by Article IV of the NPT, unless a consensus of states parties to the treaty agrees to a fundamental change of the current regime, which seems unlikely given the current international political environment.

ANY MULTILATERAL MECHANISM MUST BE OF OBVIOUS UTILITY TO STATES

There are different reasons that may underlie a national decision to acquire domestic uranium enrichment or plutonium extraction facilities. If this decision is driven by the desire to develop nuclear weapons or to create a "hedge" or "virtual" nuclear weapon programme, then a multilateral approach to the nuclear fuel cycle would likely help expose

those intentions but not dissuade the state from taking such action. Nevertheless there are a number of other reasons why a state may want to start developing domestic fuel cycle technologies, which potentially could be addressed by multilateral arrangements. These reasons include:

- desire to ensure security of fuel supply and reduce external dependence on foreign suppliers;
- low confidence in existing suppliers;
- commercial interest in selling materials and services on the market; and
- national prestige (or "nuclear nationalism").

If, for perceived economic reasons, a state embarks on the development of domestic fuel cycle technologies, especially uranium enrichment, it would inevitably be several decades behind the current state-of-the-art centrifuge technology. This gap is not going to be closed any time soon. So this state most likely would not be able to compete in the international market with established suppliers of uranium enrichment services because its domestically produced enriched uranium would most likely be more expensive.

But for domestic fuel supply, a small-sized enrichment programme utilizing less advanced technology may be sufficient. Fuel costs constitute only a few percent of the cost of electricity produced by nuclear power plants, which is dominated by the costs of construction, operation and decommissioning. It has been noted that "economics alone are not a significant basis for foregoing an indigenous enrichment capability when it simultaneously offers a measure of energy security".[30]

Given the huge capital costs and long expected lifetimes of nuclear power plants, it is understandable that their operators want to secure reliable long-term access to fuel at reasonable cost. Investments in these capital-intensive projects, whose costs could easily turn out to be a few billion dollars per typical electricity-generating reactor—a light water reactor (LWR) with a generating capacity of about 1GWe—and whose time horizons for financing payback are too distant, are risky enough even without prospective problems with fuel supply.

Multilateral mechanisms thus need to provide not just economic benefits but also energy security to non-supplier states. Some supplementary fuel

assurance mechanisms, such as an international fuel bank, could offer such security and should be pursued, but may only modestly reduce incentives to establish national enrichment capabilities as they still may be considered insufficient by some non-supplier states. Thus, a mechanism is required to respond to the "entitlement" motivation of non-supplier states or "a mechanism that gives any nation that wants it at least some form of vested interest in one or more major elements of fuel-cycle services".[31] Participation in ownership, management and operation of fully internationalized fuel cycle facilities may ensure the desired degree of involvement, economic benefit and energy security for the majority of non-supplier states.

Some argue that it is often cheaper to purchase enrichment services on the market than to develop and build domestic facilities. In order to provide objective criteria as background for policy decisions in emerging nuclear-energy states, comparative case/cost studies are needed to evaluate the advantages and disadvantages of participating in multilateral mechanisms against those of developing indigenous technology. A comparison of this sort may serve to illustrate the financial implications of current uranium enrichment programmes against the alternative of multilateral mechanisms.

Currently nuclear reactor operators buy fuel on the international nuclear market. In its 2005 report, the International Expert Group on Multilateral Approaches to the Nuclear Fuel Cycle, established by the Director General of the IAEA, commended the existing market mechanisms. The report states that "a healthy market exists at the front end of the fuel cycle", and "the legitimate objective of assurances of supply can be fulfilled to a large extent by the market".[32]

At the front end, the nuclear fuel cycle market consists of four major steps, each of them actually having its own separate market:

- **mining and milling**; the final product is uranium concentrate (U_3O_8), called "yellow cake";
- **refining, conversion, and reconversion**; the final products are natural uranium hexafluoride (UF_6) gas as the feed material for enrichment and uranium dioxide (UO_2) for fuel fabrication;
- **enrichment**; the final product is UF_6 gas enriched in uranium-235; and

- **fuel fabrication**; the final product is nuclear fuel assemblies to load into power reactors.

Today, production and demand at the front end of the nuclear fuel cycle are in balance although the supply is supplemented by secondary sources, such as down-blending of weapon-grade uranium, or stockpiled uranium held by utility companies. Nevertheless, in 2007 the IAEA estimated that:

> [N]ew discoveries and re-evaluations of known conventional uranium resources will be adequate to supply nuclear energy needs for at least 100 years at present consumption level. Growing demand and higher prices have spurred greater investment in exploration and led to larger identified conventional uranium resources over the past two years.[33]

Of these four steps, the uranium enrichment process is the most "sensitive" (that is, of the most proliferation concern) because it can produce HEU. The conversion process does not produce direct-use nuclear materials but it is a necessary technological step as it feeds uranium hexafluoride, the main uranium compound suitable for enrichment, into the enrichment process. Mining and milling of uranium ore as well as fabrication technology for LEU oxide fuel used by the majority of nuclear power reactors are not generally of proliferation concern.

In establishing a well-functioning system to fuel civilian nuclear reactors, three possible scenarios are conceivable: (1) leaving everything to the existing market; (2) creating some supplemental mechanisms to strengthen the market; and (3) "denationalizing" sensitive parts of the nuclear fuel cycle. All these scenarios can potentially provide power reactor operators with reliable access to fuel at reasonable cost. The difference may lie in the extent to which these scenarios may or may not increase the risk of nuclear proliferation.

First, some advocate that we should leave everything to the existing market. They reason that if everyone is satisfied with the existing nuclear market mechanisms, there is no reason to change them. The capacities of front-end nuclear service providers are sufficient to satisfy present demand, if not exceed it. Thus world capacities for uranium enrichment and fuel fabrication are likely to be in excess of projected increases in demand in the medium term. Moreover, the long lead time for nuclear reactor construction would provide enough time for the existing suppliers to accommodate growing demand. However, some states consider

the current market system, which is controlled by a limited number of commercial suppliers and their governments, to be unfair. They also fear that normal supplies could be interrupted for reasons having nothing to do with non-proliferation or the market itself. These feelings, as well as the desire to be on equal terms with other states, may govern their decision to acquire domestic technologies for enrichment and reprocessing for a number of reasons: to insure the security of supply, to realize their commercial interests in the manufacturing and sale of nuclear materials and services, or to prove their technological capability. Even if a large-scale nuclear revival does not occur, we can expect further diffusion of nuclear technologies and materials if the present system of nationally controlled enrichment and reprocessing facilities continues to prevail. Thus, the first scenario may actually exacerbate nuclear proliferation.

The second scenario envisages the creation of certain supplemental instruments, or "guarantees-in-depth", for the existing market that would be triggered only in the event of a disruption of normal commercial supplies for reasons not related to non-proliferation, commercial or technical considerations. Among the proposals to date, several can be considered as supplemental mechanisms: the Russian LEU reserve in Angarsk, the NTI-proposed IAEA fuel bank, the US reserve of nuclear fuel, the Six-Party concept, the World Nuclear Association proposal, the UK Nuclear Fuel Assurance proposal (formerly known as the "enrichment bonds") and the Japanese Standby Arrangements System proposal. These mechanisms, if properly arranged, could be an important supplement to the existing market in creating additional incentives for states to avail themselves to the international market and not to pursue domestic nuclear fuel cycle technologies. But those incentives may be rather modest since the commercial market already provides reliable supplies of LEU and nuclear fuel while the proposed supplemental mechanisms would not appease the resentment of some states against the existing "two-tier" system. Guarantees provided by these multilateral arrangements might not be entirely convincing to some states, especially those that do not have strong political ties with at least one supplier state.

The third scenario is capable of offering a way to separate national prestige from nuclear technology by ultimately "denationalizing" sensitive nuclear fuel cycle activities and converting the existing system of nuclear technology haves and have-nots into a truly multilateral fuel cycle arrangement of equal rights and obligations. As the Director General of the IAEA proposed,

all future enrichment and reprocessing activities would be multilaterally owned and operated, and existing enrichment and reprocessing facilities would over time be converted from national to multilateral operations. This "denationalized" fuel cycle could benefit all states:

- large multinational fuel cycle facilities could be more cost effective and provide economies of scale that smaller national facilities could not;
- multilateral fuel cycle mechanisms could respond to the goals of non-supplier states in terms of their participation in ownership, management, operation, decision-making, profit-sharing, and so on;
- these facilities could guarantee non-discriminatory access to nuclear fuel services at reasonable price thus providing energy security;
- multinational facilities would serve as confidence-building measures, helping to reduce suspicions among participating states about others' nuclear intentions;
- multilateralism would obviate the need for nationally owned and operated facilities making justification of national enrichment or reprocessing programmes difficult;
- without nationally controlled and operated uranium enrichment and spent fuel reprocessing facilities, no fissile materials for military purposes could be produced by any state; and
- there would be no states with nationally-controlled "threshold" capabilities, which would be important in a world moving toward nuclear disarmament.

Thus, multilateralization could offer a gateway to assured nuclear fuel cycle services for any state without a negative impact on the international non-proliferation regime. The internationalization of fuel cycle facilities would be particularly relevant in the context of nuclear disarmament. National enrichment and reprocessing capabilities scattered among dozens of states around the globe would be highly destabilizing because these states would retain a significant threshold capability. In this case multilateral ownership and operation of plants in a framework where all partners have equal status could significantly contribute to the strengthening of international security.

What multilateral arrangements should seek is to propose to states an attractive alternative to building their own plants and facing the trouble and expense of developing their own fuel cycle technologies by offering political and economic incentives to those that decide to participate in

these arrangements. Multilateral fuel cycle mechanisms should ensure that the benefits of nuclear energy are made available to all states, while strengthening the nuclear non-proliferation regime and reducing incentives to build new nuclear fuel cycle facilities in states that do not already have them.

MULTILATERAL ARRANGEMENTS SHOULD NOT FORM A MONOPOLY OF SUPPLIERS

Some customer states have voiced fears that a "cartel" of suppliers might be formed under the guise of non-proliferation and multilateralization. The Minister of Minerals and Energy of the Republic of South Africa, Buyelwa Sonjica, summed up the views of these states:

> [T]here is a need to guard against actions, which would merely serve to exacerbate existing inequalities, including through the creation of another kind of cartel that would exclude full participation, particularly by States in full compliance with their safeguards obligations. …
>
> Although prevailing proliferation concerns may prompt us to consider alternative arrangements on supply mechanisms, these may under no circumstances impose unwarranted restrictions and controls over the legitimate peaceful use of nuclear energy. … If we agree to such conditions, we may well be contributing to undermining the very bargains on which the NPT was founded and further disturb the delicate balance of rights and obligations under this instrument.[34]

Both the Bush proposal and GNEP sought to "ensure that states have reliable access at reasonable cost to fuel for civilian reactors" while trying at the same time to limit the number of suppliers. However, these two approaches are contradictory to some extent. If the objective is to ensure that non-supplier states have reliable access to low-cost fuel for their civilian nuclear reactors, then multiple sources of supply would be advisable. The proposed restriction on the number of suppliers would raise suspicions that commercial and political motives could be involved and that the existing suppliers would benefit from this policy.

Some non-supplier states suspect that by limiting new competition the existing suppliers could form a monopoly dictating prices for fuel cycle materials and services. The more recent proposals for the

multilateralization, like the World Nuclear Association proposal and the Six-Country Concept, which required the non-supplier states not to pursue sensitive fuel cycle activities as a condition for participation in the proposed fuel supply backup mechanisms, further deepened those suspicions.

If more states would use nuclear energy in the future, this could potentially drive dissemination of sensitive fuel cycle technologies, first of all uranium enrichment because newcomers would be more concerned with fuel supply for their nuclear reactors.

The uranium enrichment market is today shared by only a handful of companies. Currently, there are 12 states with military or civil enrichment capabilities: Brazil, China, France, Germany, India, Iran, Japan, the Netherlands, Pakistan, the Russian Federation, the United Kingdom and the United States. Yet only four LEU supplier firms dominate the international market with approximately 97% market share: EURODIF, URENCO, Tekhsnabexport, and the United States Enrichment Corporation (USEC). Two of these suppliers (EURODIF and URENCO) are multinational European consortia, while two are national corporations (Tekhsnabexport and USEC).

- EURODIF, a subsidiary of the French corporation AREVA, is a joint stock company owned by France, Belgium, Spain, Italy and Iran. It operates a gaseous diffusion plant in France. Although EURODIF is a multinational joint venture, France owns the majority of shares, French national legislation governs its operations, and the gaseous diffusion enrichment technology is restricted to France. The old gaseous diffusion equipment will soon be replaced by a new "black box"[35] centrifuge plant. This gas centrifuge technology will be provided by the Enrichment Technology Company (ETC), a joint venture equally owned by URENCO and AREVA. AREVA also plans to expand into the United States with a new black box centrifuge plant in Idaho.

- URENCO is a multinational corporation with centrifuge enrichment operations in Germany, the Netherlands and the United Kingdom. It is finishing construction of a new black box centrifuge plant in New Mexico through its US subsidiary Louisiana Enrichment Corporation. Unlike EURODIF, URENCO is based on an international agreement that gives all three states involved equal status of participation in the consortium.

- Tekhsnabexport, a subsidiary of Russia's state-owned Rosatom Corporation, operates multiple centrifuge enrichment facilities in Russia. Rosatom accounts for almost one half of global enrichment capacity and uses excess capacity to down-blend HEU pursuant to the US–Russian Megatons to Megawatts agreement.

- USEC is a private US corporation that operates the only active uranium enrichment facility in the United States—a gaseous diffusion plant in Kentucky. Like EURODIF, USEC aims to replace the outdated diffusion technology with a centrifuge plant in Ohio, using technology developed by the US Department of Energy.

Box 1. Black-boxing of enrichments technologies

Black-box approaches are technically feasible and generally considered viable by the suppliers, who already rely on them to protect proprietary information in plants located in other countries. However, it is unclear if the available technology providers would be willing to supply black-box technology to partners with whom they do not already have strong business and political relations given that "a certain fraction of their intellectual property could be at risk of being compromised and given that they would effectively help establish a potential competitor".[36] Commitments of supplier state governments may be needed to secure the supply of black-box technology.

But this approach is certainly practical: several black-box uranium enrichment facilities are currently in different stages of development and construction. The Russian IUEC in Angarsk follows the black-box structure so that no access to Russian enrichment technology or classified information will be granted to the other participants. The IUEC stockholders would sit on the centre's board of directors, play roles in the administration of the business, and either have guaranteed enriched uranium product or a share in the profits. They would not, however, have access to technology. Russia has also supplied black-box centrifuge plants to China.

Two uranium enrichment facilities that will feature black-box technology are now under construction in the United States. The first facility in Lea County, New Mexico, will be the first centrifuge plant in the United States. It is being constructed by Louisiana Energy Services, a wholly owned subsidiary of URENCO, the European supplier of uranium enrichment services. The second facility in Idaho Falls, Idaho, is under construction by the French company AREVA. AREVA is also currently constructing a new gas centrifuge enrichment facility in France, Georges Besse II. The Enrichment Technology Company (a joint venture between Areva and URENCO) is providing the black-box centrifuge technology for all of these facilities.

In addition to these four current suppliers, the US conglomerate General Electric and the Japanese multinational corporation Hitachi have agreed to pool their nuclear units and enter the global enrichment services market with a new laser enrichment plant in North Carolina. Brazil, China and Japan also host national enrichment facilities, but they currently only supply their respective domestic nuclear energy markets. With time though, these companies could potentially join the existing suppliers competing in the global market of uranium enrichment services.

However, as some non-supplier states may point out, these eight suppliers would only be representing a rather limited group of states—nine countries, most of which are political allies. A solution, it seems, is to have a larger (and more diverse) group of states owning and operating enrichment plants. There are, however, possible problems with such an approach. First, today there is no need for new enrichment capacity as the demand for enrichment services over the next two decades, even under high-growth scenarios for nuclear energy, can be covered by enrichment plants that exist today and those that are currently being constructed or planned. Moreover, expanding the capacity of existing enrichment plants is economically more efficient than establishing new facilities. Second, the further spread of centrifuge enrichment technology would undermine the confidence in non-proliferation as gas centrifuge facilities are difficult to detect and verify and they can easily be converted from peaceful to military use. Third, even if a few new suppliers enter the enrichment market, it still will be controlled by a limited, even though larger, group of states.

Advocates believe that the denationalization of sensitive parts of the nuclear fuel cycle like enrichment could help find a way out of the situation when the market is controlled by a few states because it would remove sensitive facilities from the jurisdiction of individual states and put them under multinational or international jurisdiction. Moreover, such multilateralization would be non-discriminatory if any state, meeting agreed non-proliferation criteria, would have the right to participate in ownership and management of an enrichment company and if no single state would be allowed to hold a majority of shares. Multilateral approaches to the nuclear fuel cycle do indeed encourage the involvement of more states in the supply side of the industry with only one qualification—sensitive technology is to be “black boxed”, that is the technology supplier would provide, install and maintain assembled enrichment equipment ensuring

that sensitive technology remains secret. Such an approach could help curb the proliferation of technology that could be used for nuclear weapons while at the same time allowing full access for all states to "the benefits of peaceful applications of nuclear technology" in accordance with the NPT's preamble.

CHAPTER 3

DESIRABLE QUALITIES OF MULTILATERAL FUEL CYCLE ARRANGEMENTS

ELIGIBILITY CRITERIA MUST BE CLEARLY DEFINED AND AGREED ON

Concerns have been expressed by non-supplier states that some of the existing proposals for multilateral approaches to the nuclear fuel cycle do not explicitly include NPT membership and a comprehensive safeguards agreement with the IAEA as requirements for participation in fuel assurance mechanisms.

The IAEA is endowed with the authority to establish, administer and apply safeguards to verify that safeguarded nuclear material and activities are not used for military purposes. Today, the IAEA safeguards system remains the only mechanism expected to provide assurance to the international community that nuclear fuel-making facilities (enrichment, reprocessing, and fuel processing plants utilizing nuclear materials directly useable to make nuclear weapons or other nuclear explosive devices) operate for solely peaceful purposes, by providing timely warning of diversions of nuclear materials from these facilities.

The system has undergone substantial changes since its inception. Beginning with INFCIRC/26 in 1961, the IAEA established its safeguard procedures as applicable to research, test and power reactors with less than 100MW thermal output, and to the fissionable material used and produced in these reactors.[37] The IAEA eventually abandoned the 100MW limit in 1964, and approved in INFCIRC/66/Rev.2 of 1968 the expansion of the system's application to all "principal nuclear facilities" rather than solely nuclear reactors. However, throughout the 1960s, all safeguards agreements were voluntary arrangements initiated by a state or group of states with respect to specific nuclear facilities or materials. The limitations of this system—in that only *declared* facilities and materials were under safeguards—became evident around the turn of the decade. In 1969, the

Treaty for the Prohibition of Nuclear Weapons in Latin America (better known as the Treaty of Tlatelolco) required each participating state to provide a guarantee that it did not host any nuclear activity prohibited under the treaty.

The following year, the NPT obligated all non-nuclear-weapon states parties to not manufacture or acquire nuclear weapons. Article III.1 of the NPT requires all non-nuclear-weapon states parties of the treaty:

> to accept safeguards, as set forth in an agreement to be negotiated and concluded with the International Atomic Energy Agency in accordance with the Statute of the International Atomic Energy Agency and the Agency's safeguards system, for the exclusive purpose of verification of the fulfilment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices. Procedures for the safeguards required by this Article shall be followed with respect to source or special fissionable material whether it is being produced, processed or used in any principal nuclear facility or is outside any such facility. The safeguards required by this Article shall be applied on all source or special fissionable material in all peaceful nuclear activities within the territory of such State, under its jurisdiction, or carried out under its control anywhere.

As a result, in 1972 the IAEA approved INFCIRC/153(Corr.), a model "comprehensive safeguards agreement" that enacted safeguards on all of a state's source or special fissionable material in all peaceful nuclear activities within its territory, as required by the NPT. This "traditional" safeguards mechanism relies on three verification activities: nuclear material accountancy, containment and surveillance measures, and on-site inspection. Although these newer agreements are comprehensive, they are not complete in the sense that the safeguards are only applied to *declared* nuclear facilities and materials. Prompted by the discovery of clandestine nuclear weapon-related activities in Iraq and the Democratic People's Republic of Korea in the early 1990s, the IAEA Board of Governors approved the Model Additional Protocol (INFCIRC/540) in May 1997, allowing safeguards inspectors to ensure that the state in question is not engaging in *undeclared* nuclear activity. However, under the NPT, states are not obliged to make Additional Protocol agreements with the IAEA, so today those agreements remain voluntary.

As of 15 December 2009, 22 non-nuclear-weapon states parties of the NPT have not yet enforced a comprehensive safeguards agreement with the IAEA pursuant to the NPT. However, five of these 22 states have already submitted comprehensive safeguards agreements to the Board of Governors and have received the Board's approval, and nine of these agreements have already been signed (though are not yet in force). Moreover, none of the eight states that have not yet submitted comprehensive safeguards agreements to the Board of Governors for its consideration currently host a nuclear programme or have the intention of doing so in the near future.[38]

Almost all of the existing proposals contain language that entails compliance with accepted non-proliferation norms:

- the World Nuclear Association requires customer states to be "in full compliance with international safeguards";[39]
- the NTI-proposed IAEA fuel bank guarantees reliable access to a nuclear fuel reserve for states that are "in full compliance with their nonproliferation obligations";[40]
- Japan's Standby Arrangements System requires compliance with "the IAEA safeguards agreements by that State";[41]
- the GNPI, proposed by Russia, stresses "reliable compliance with the requirements of the non-proliferation regime" through a system of international centres providing nuclear fuel cycle services "under the control of the IAEA";[42]
- the Russian IUEC is open for all interested states "meeting the established non-proliferation requirements";[43]
- the US GNEP proposal sets "improving nuclear safeguards"[44] as an indispensible element of its strategy; and
- Austria's multilateralization proposal actually encourages international transparency "going beyond current IAEA safeguards obligations".[45]

Moreover, some proposals, like the NTI-proposed fuel bank and Germany's MESP, delegate to the IAEA Board of Governors the right to draw up a binding catalogue of criteria, adherence to which would guarantee availability of nuclear material.

However, few multilateral proposals today explicitly include NPT membership or comprehensive safeguards as requirements for participation. Only the Six-Country Concept and the UK Nuclear Fuel

Assurance proposal require a state to have a comprehensive safeguards agreement and an Additional Protocol in force to be eligible to take advantage of proposed supply backup mechanisms.

As an acceptable multilateral approach to the nuclear fuel cycle seeks to strengthen the NPT regime while not impeding the development of nuclear energy for states wishing to choose that option, NPT membership could be considered as a requirement for participation in the multilateral mechanisms. In this case an explicit requirement for a state participant to have a comprehensive safeguards agreement with the IAEA would be unnecessary as an NNWS is obliged to enforce such an agreement with the IAEA while a NWS is not required to have it. On the other hand, a direct requirement to put nuclear materials and facilities involved in a multilateral mechanism under IAEA safeguards would be positive as a means to expand the application of IAEA safeguards in the NWS. This could place additional work load on the IAEA—already strained both in budget and personnel—but would serve to mitigate the distinction between the two categories of states under the NPT and to build additional confidence and trust.

However, costs may arise from an NPT membership requirement as well. Without involvement of non-NPT states, the goal of the eventual denationalization of the nuclear fuel cycle worldwide becomes unattainable. Whether and how multilateral fuel cycle mechanisms could be available for non-NPT states is an essential issue that has yet to be thoroughly discussed. In its report, the International Expert Group on Multilateral Approaches to the Nuclear Fuel Cycle considered possible participation of non-NPT states in multilateral approaches mainly in the context of conversion of existing fuel cycles facilities from national to multilateral operations. Other modalities of this participation should be investigated as well.

There is also another way to look at the omission of NPT membership and comprehensive safeguards agreement in the tabled proposals. This could really just be a matter of proposal development—as the proposals come to fruition, discussion would make the finalized versions more specific.

Multilateral approaches to the nuclear fuel cycle are works in progress that could require modification before implementation. With the IAEA at the centre of many of these proposals, it is very likely that stipulations and conditions of participation will be constructed to further the non-

proliferation regime, regardless of whether requirements of NPT membership or a comprehensive safeguards agreement are imposed. What is necessary at this point in time is, first, further discussion in an internationally transparent and inclusive forum over such requirements and, second, scrupulous consideration of inclusion of these requirements in the implementation of each multilateral proposal.

ANY MULTILATERAL MECHANISM MUST NOT ALLOW FOR POLITICAL MANIPULATION

A number of proposals have been tabled by states, nuclear industry and international organizations to assure states reliable access to nuclear fuel at reasonable cost, while furthering non-proliferation goals of containing the spread of sensitive fuel cycle technologies. However, some non-supplier states have expressed certain suspicions of these proposals. They fear that supplier states may be trying to embed a two-tier system of "haves" and "have-nots" of nuclear technology under the guise of non-proliferation to promote their national interests, be they economic or political. This fear essentially stems from a lack of trust, or a misunderstanding between supplier states and non-supplier states. If this trust barrier can be overcome (which is fundamentally a political task), then an agreement could more easily be reached on proposed multilateral nuclear fuel supply arrangements.

Many of the proposed multilateral fuel cycle arrangements are envisaged as "guarantees-in-depth" or supplement instruments that would be triggered only in the event of a disruption of normal commercial supplies. Most proposals discriminate among three types of disruptions in fuel supply: political disruptions, commercial disruptions and non-proliferation disruptions. They highlight that politically motivated disruptions (for example, a state forbids its enrichment companies from supplying LEU to another state for political reasons not related to non-proliferation) are the ones that should be protected against with proposed back-up mechanisms. Commercial disruptions (for example, an enrichment company does not supply LEU because of technical or financial problems) are natural, and should not normally require intervention as the market should correct itself. Non-proliferation disruptions (for example, after the IAEA reports non-compliance of a state with its NPT obligations) are entirely acceptable under the NPT.

History tells us that political disruptions are quite rare; in fact, only a few political disruptions of nuclear fuel supply have ever occurred—and they occurred over thirty years ago. Furthermore neither involved sanctions from an entire coalition of supplier states, but rather from individual governments or companies.

The first instance of a political disruption occurred in response to the Indian nuclear test in May 1974. The US administration temporarily postponed deliveries of nuclear materials to all states, including those that had nothing to do with the Indian nuclear weapons programme. However, this reaction was short-term and normal supplies of nuclear fuel were soon restored.

The second instance revolved around the relationship between EURODIF and Iran. In 1974, Iran loaned US$ 1 billion to support the construction of the EURODIF diffusion enrichment plant in France. In 1977, Iran agreed to pay another US$ 180 million to obtain a 10% share in the ownership of the company, entitling it to 10% of the uranium enriched by EURODIF. However, with the revolution in 1979, Iran withdrew from its agreement, demanding a repayment of its US$ 1 billion loan. A dispute ensued between EURODIF and Iran, which was settled in 1991 and Iran was reimbursed US$ 1.6 billion for its 1974 loan plus interest. However, Iran still demands the delivery of its share of enriched uranium under the original contract. But EURODIF—a multinational joint venture governed solely by French national legislation—refused to deliver LEU to Iran maintaining that the enriched uranium deliveries contract had expired in 1990. Iran, which still held an indirect share in EURODIF,[46] views this refusal as politically motivated.

Knowledge of these episodes, along with the continued reference to "political disruptions" in many multilateral proposals for a reliable supply of nuclear fuel, makes a similar situation appear feasible in the future. However, it should be emphasized that such scenarios have occurred rarely and they have never been an agreed decision of all supplier states. The reference to political disruptions is used only to underscore that the proposed multilateral arrangements are just supplement instruments that should be used as a last resort in the event of a politically motivated disruption of normal commercial supplies.

Both supplier and non-supplier states agree that the current nuclear fuel market has worked reasonably well, has satisfied the demand for fuel services subject to government approval for exports and has been able to cope with occasional disruptions of supply in the past. The proposed extra-market measures—fuel banks, multi-tiered "guarantee-in-depth" mechanisms or guaranteed export licenses—would serve as extra assurances of supply in the existing market, nothing less, nothing more.

To address the concerns of non-supplier states, it would be reasonable to clarify the issue of "unforeseen politically motivated disruptions" in nuclear fuel supply. The multilateral back-up mechanisms could provide an assured uninterrupted access to fuel in the case of political disruptions, but they could also serve a stronger purpose: hypothetically they could serve as a guarantor of uninterrupted supply of nuclear materials in the case of any disruption not related to non-proliferation, perhaps even if the disruption is commercial in nature, thus giving additional time for the market to readjust itself and restore normal supplies. This broader role of the proposed back-up mechanisms should be discussed by the international community.

MULTILATERAL MECHANISMS SHOULD NOT ESTABLISH A NEW EXPORT CONTROL REGIME

Article III.2 of the NPT imposes the conditions of supply of nuclear items:

> Each State Party to the Treaty undertakes not to provide: (a) source or special fissionable material, or (b) equipment or material especially designed or prepared for the processing, use or production of special fissionable material, to any non-nuclear-weapon State for peaceful purposes, unless the source or special fissionable material shall be subject to the safeguards required by this Article.

In 1971, the Zangger Committee was formed by a group of interested states to specify exactly what material and equipment are relevant under that clause. Three years later, the committee drafted a "trigger list" of applicable items that was published in IAEA document INFCIRC/209. The NPT states parties agree that any transfer of any of the listed materials to an NNWS for peaceful purposes would "trigger" three conditions of supply: a non-explosive use assurance, an IAEA safeguards requirement on the transferred materials, and a retransfer provision to apply the same conditions if the materials are to be exported by the importing country.

Today, 37 states participate in the regular revision of this trigger list, which embraces nuclear materials, including plutonium and HEU, as well as nuclear facilities. The Zangger Committee considers itself to be an informal organization, specifying that its export controls are not legally binding on the states involved. Rather, each state makes unilateral declarations to each other and to the IAEA to abide by such controls. The restrictions on export of sensitive nuclear materials and technologies are enforced by states through their national export control laws.

In May 1974, the Indian nuclear test revealed the ease with which nuclear materials and equipment allegedly acquired for peaceful purposes could be diverted to military use. Spurred by the revelations of this test and by the desire to include non-NPT supplier states in export control discussions, the United States proposed the formation of a more formalized export control regime called the Nuclear Suppliers Group (NSG). In the NSG Guidelines, published in IAEA document INFCIRC/254, the 45 supplier state members of the NSG define a more comprehensive trigger list of items that, when transferred to an NNWS for peaceful purposes, trigger the requirement of IAEA safeguards not just on the delivered items, but on all nuclear-related materials in the receiving state—so called comprehensive safeguards. The NSG trigger list is more restrictive than the Zangger Committee's list: the former includes dual-use technologies and all technologies used for the development, production and use of the items in the latter, thus going beyond Article III.2. The NSG Guidelines also include extra export conditions: physical protection measures, particular caution in the transfer of sensitive facilities, and a strengthening of the retransfer provisions of the Zangger Committee.

These two export control regimes have not seen much dispute because their primary requirement lies in the application of IAEA safeguards, which is an obligation already imposed on all NNWS by the NPT. Nevertheless, a number of NPT states belonging to the Non-Aligned Movement (NAM) have criticized nuclear export controls,[47] citing the inalienable right to the peaceful use of nuclear energy and the discriminatory nature of export controls. Many non-supplier states share the worry that a new export control regime may emerge from multilateral fuel cycle mechanisms that would impinge on their Article IV rights and restrict their capacity to utilize nuclear power peacefully. It is fair to say that a few early initiatives of some supplier states—like the 2004 Bush proposal or the GNEP—have only fuelled those worries.

MULTILATERAL MECHANISMS MUST NOT PLACE UNDUE BURDEN ON IAEA MEMBER STATES

The tabled multilateral proposals do not impose any involuntary financial burdens directly on individual states. However, the execution of some of the proposals may place costs on the IAEA, and thus indirectly on the IAEA member states that both regularly and voluntarily support the Agency. Therefore it is essential to ensure that these costs are not too great—especially given that the IAEA is chronically underfunded.[48]

Most existing multilateral proposals take financial responsibility for the project and do not seek financial assistance from the IAEA. The NTI-proposed fuel bank, for example, has already secured voluntary financial pledges from various states, surpassing the target US$ 150 million and thereby relieving the IAEA of any financial burden related to the establishment of the fuel bank. At the Third Preparatory Committee for the 2010 NPT Review Conference, the Russian Federation emphasized that "there would be no financial burden on IAEA or its member States"[49] as one of the key features of its proposed guaranteed LEU reserve in Angarsk. The cost of the LEU supplied from the reserve would be incurred by the receiving states, while the Russian Federation would cover all remaining costs. Similarly, Germany's MESP explicitly states that the enrichment plants "would not be subsidized by the IAEA but rather financed on a commercial basis or by the Member States on their own responsibility".[50]

Nevertheless, some of the proposals may suggest the creation of extra responsibilities for the IAEA that would, perhaps indirectly, impose some financial burden on the Agency—usually in terms of financing personnel, management, or specific activities. The MESP, for example, creates a range of roles for the IAEA that could necessitate financial resources. The proposal only guarantees that the participating states would cover the costs of the enrichment plant(s). The IAEA could still be responsible for making "agreements" with all parties desiring to participate in the enrichment project on the IAEA-administered territory. The IAEA may also have to shoulder costs incurred from maintaining "administrative and sovereign rights"[51] in the extraterritorial area, or from its supervisory role of the enrichment plant. Moreover, it remains unclear what financial implications for the IAEA could be involved in making arrangements "to ensure that no comparative advantages arise from the fact that the plant(s) were sited in an area not under national jurisdiction".[52]

Japan's IAEA Standby Arrangements System proposal could also require the IAEA to commit certain resources. First, the proposal calls for the IAEA to collect, store, analyze and report on information regarding each participating state's supply capacity, requiring at the very least a team of technical personnel. The IAEA would also have to conclude bilateral "standby arrangements" with each participating state. And in the case where a state is affected by a disruption of supply, the IAEA would have to play an "intermediary role" by helping the state find an appropriate supplier of nuclear fuel. Although this proposed system seems organized, transparent and efficient, the personnel, management and logistical costs could potentially be substantial.

It is not certain that these or any other multilateral proposal will be a major financial burden on the IAEA, but the possibility exists. And this issue undoubtedly has to be addressed. Today the IAEA is facing significant financial challenges due to increasing nuclear verification costs, which currently comprise more than one third of the entire IAEA budget, for three primary reasons:

- many nuclear facilities are approaching the end of their life cycles and thus require safeguards for decommissioning and deactivation;
- the demand for nuclear power worldwide is expected to rise, and would engender the construction of more nuclear facilities requiring safeguards; and
- the Additional Protocol entails additional financial burdens on the IAEA, broadening the safeguards mission and requiring the IAEA to determine if a state has any undeclared nuclear materials or activities.

The IAEA has opted to face their financial constraints in two ways. First, it has begun to implement "integrated safeguards", where the Agency aims to minimize costs by tailoring unique combinations of safeguards measures to the needs of each state. Second, the IAEA is promoting the "safeguards by design" approach for new nuclear facilities, potentially making the execution of safeguards easier (and more cost-efficient) to conduct. The Director General has clearly stated that "the safeguards system has at all times to be technically sound and not compromised by financial constraint; it has to be driven primarily by effectiveness".[53] Multilateral approaches to the nuclear fuel cycle could contribute to this cost-reducing effort in two ways.

First, they can potentially reduce the number of facilities needing safeguards. If many states decide to collaborate on a single multilateral facility instead of constructing national facilities, the IAEA would effectively have to safeguard only one facility rather than many facilities spread out around the world. Moreover, focusing efforts on one facility rather than many can make safeguarding more comprehensive and complete.

Second, new multilateral facilities could be designed in a safeguards-friendly manner. This could potentially make nuclear material accounting more convenient and less costly for IAEA inspectors.

Acknowledging that many multilateral proposals are still in the process of development, it is unclear what financial and administrative challenges some of them might bring to the IAEA and the international community. But certainly those challenges would not be insurmountable and the potential benefits that multilateralization of the nuclear fuel cycle could bring would substantially outweigh those additional burdens. For the first few multilateral projects, additional funding could be provided to the IAEA in the form of voluntary contributions of money by member states. The IAEA regulations say that "such contribution can readily be incorporated into a project, programme, or activity which the Director General has already been given authority to execute by the competent organ or organs of the Agency".[54] As participation of the IAEA in a multilateral fuel cycle arrangement should be discussed and approved by the Board of Governors, such an approval will provide the Director General with authority to spend the funds. Eventually, if the benefits of multilateralization were to become concrete and the number of multilateral projects to grow, member states could consider including those expenses into the regular IAEA budget.

The IAEA has always functioned under significant budget constraints, despite the importance of its obligation to implement safeguards in accordance with the NPT. Most of its funding comes from annual dues paid by member states, forming an annual regular budget of approximately €300 million. Yet considering the significant responsibility that the IAEA holds in maintaining global nuclear peace and security, the budget is rather slim.

Yet even beyond the regular annual budget, the IAEA needs extrabudgetary contributions if it is to truly fulfil its mission. In addition to paying annual dues, states have the option to make voluntary contributions to the

Agency—most of which go toward the Technical Cooperation Fund. Yet the IAEA may only accept these voluntary contributions if one of the two following conditions are met:

- the voluntary contribution is "offered without limitation as to use".[55] Such a contribution would "be placed in a general fund which may be used as the Board of Governors, with the approval of the General Conference, may determine";[56] or
- the voluntary contribution "can readily be incorporated into a project, programme or activity which the Director General has already been given authority to execute by the competent organ or organs of the Agency".[57]

Financial pledges toward proposed multilateral fuel cycle mechanisms could not be accepted under the first condition, as their specification for the mechanisms in question would impose a limitation on their use.

These financial pledges also could not be accepted under the second condition because none of the proposed mechanisms are under the authority of the Director General to execute. Currently, the NTI-proposed fuel bank, Russian LEU reserve in Angarsk and Germany's MESP are under discussion by the Board of Governors, but none of them have been approved so far. The first two proposals were tabled during the June 2009 meeting of the IAEA Board of Governors but some member states refused to discuss them.[58]

As mentioned above, some proposals for an assured supply of nuclear fuel have already made funding plans, and do not necessitate the IAEA to seek financial pledges from member states toward those proposed mechanisms. Yet, it is important to carefully consider possible implicit costs that may not have been taken into consideration by the proposals and to craft these proposals in such a way that allows reducing undue financial burden on IAEA member states.

THE UTILITY OF MULTILATERAL APPROACHES TO DEALING WITH THE BACK-END SHOULD BE ACKNOWLEDGED

Currently some non-supplier states may not be interested in fuel assurances as the world nuclear market works well and these states have never had

real problems with fuel supplies. However, these proposed mechanisms might be made more attractive if they address not only front-end but also back-end issues. States with developed nuclear power already have problems with storage and disposal of spent nuclear fuel; newcomers will have the same problems in the future, even if right now they are more concerned with fuel supply.

The management of spent nuclear fuel remains one of the greatest challenges of nuclear power. Satisfactory arrangements (in terms of economics, environment, non-proliferation, etc.) for the back-end of the nuclear fuel cycle are necessary to make nuclear energy a sustainable process in the long run. There are also non-proliferation concerns associated with management of spent nuclear fuel, especially considering the fact that almost all nuclear-weapon-possessing states, with the exception of Pakistan, used plutonium extracted from irradiated nuclear fuel to manufacture their first nuclear weapons.

Spent nuclear fuel contains uranium, plutonium, minor actinides and fission products. The fuel continues to undergo nuclear decay even after discharge from the reactor, generating enormous amounts of heat and radioactivity. Safe management of spent fuel thus requires both cooling (for heat) and shielding (for radioactivity). When discharged, fuel is typically cooled in water pools at the reactor site for a few years. After that, the fuel must be either disposed of in a "safe place", as its levels of radioactivity will be dangerous for tens of thousands of years, or reprocessed to extract plutonium and uranium for further use. Over 10,000 metric tons of heavy metals are unloaded from power reactors every year, and less than a third is reprocessed.[59]

As stated in the IAEA Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, "the ultimate responsibility for ensuring the safety of spent fuel and radioactive waste management rests within the state".[60] The convention, which is the first legal instrument to directly address these issues on a global scale, seeks "to achieve and maintain a high level of safety worldwide in spent fuel and radioactive waste management".[61] Currently, there are two principal national policy options for the management of spent nuclear fuel:

Reprocessing. Some states have chosen to reprocess the spent nuclear fuel, thereby closing the fuel cycle. Reprocessing typically separates

spent fuel into three components: uranium (96%), plutonium (1%), and minor actinides and fission products (3%). The uranium may be recycled for enrichment, or may be fabricated into mixed oxide (MOX) fuel with plutonium to serve as an alternative fuel for nuclear reactors, especially fast neutron reactors. The actinides and fission products make up high-level wastes (HLW), which are not currently recycled and thus must be disposed of. Reprocessing may provide two advantages: it reduces the volume of HLW for final disposal, and it increases the generative capacity of nuclear fuel. However, depending on the market climate, reprocessing may be economically unfavourable, given that natural uranium is comparatively cheap. Reprocessing also poses proliferation risks because separated plutonium can be used in nuclear weapons. Currently only France and the United Kingdom sell reprocessing services on the international market. India, Japan, and the Russian Federation own and operate reprocessing facilities for spent fuel from their own power reactors. China is finishing the construction of a pilot reprocessing facility. The United States stopped reprocessing completely in 1977, although it was reconsidered with GNEP. It is important to note that choosing the reprocessing route does not eliminate the need for long-term nuclear waste repositories because the HLW by-product from reprocessing still needs to be disposed of.

Direct disposal. Other states have chosen to directly dispose of the spent fuel from nuclear reactors. Scientists generally agree that the only safe and economically viable method of disposal is in a geologic repository. However, no such repository for spent fuel currently exists, as they are quite difficult and costly to establish and are generally politically unpopular since local communities are not enthusiastic about having such repositories nearby. For example, the United States in particular has faced significant political obstacles to its proposed Yucca Mountain repository in Nevada. The US Congress selected the location in 1987 and reaffirmed the choice in 2002, approving the development of a repository at Yucca Mountain for the disposal of HLW and spent nuclear fuel. The project has been widely opposed in Nevada as many inhabitants feel it is unfair that their state was chosen as the only potential site for a repository.[62] The project has been strongly opposed by environmentalists nationwide, who argue that it presents numerous environmental and safety risks.[63] Some influential members of the US Congress have also been staunch opponents of the Yucca Mountain project.[64] Finally, on 3 June 2009, US Secretary of Energy Steven Chu announced that the 2010 budget would effectively "terminate the Yucca Mountain program [and] explore alternatives for nuclear waste

disposal",[65] despite the fact that about US$ 8 billion has been spent on the project since its inception.[66]

Finland and Sweden have been more successful in establishing geologic repositories. In Finland, the nuclear power companies have the responsibility to arrange disposal of their nuclear waste (the government is only responsible after the waste's approved disposal). Posiva, a joint company formed by the two largest Finnish nuclear power utilities to take care of spent fuel disposal, has already made regular progress on its first geologic repository, and expects it to begin operation in 2020.[67] Meanwhile, the Swedish Nuclear Fuel and Waste Management Company (also owned by nuclear power plant operators) selected its repository site in June 2009, and it expects operations to begin in 2023.[68] Canada, France, Japan, Switzerland and the United Kingdom also have considered the development of geologic repositories that might start accepting spent fuel in a matter of decades.

Most states have not publicly endorsed one option or the other. Instead they await further scientific advances and technological breakthroughs to determine the optimal choice. In this "wait and see" policy, spent nuclear fuel cooled in water pools for 10 to 20 years is then usually sent to interim dry cask or vault storage. However, the reprocessing and repository projects have generally taken longer than initially expected and as a result interim storage facilities are slowly becoming longer-term storage facilities, presenting an eventual challenge to storage capacity. Many sites have adapted to this problem by increasing storage densities to accommodate more spent fuel. But since space is limited, ultimately material in interim storage will need to be reprocessed or transferred to a geologic repository. Another problem with using these surface facilities for longer-term storage, as some experts note, is that they may provide a greater danger to society (e.g. environmental safety, terrorist attacks, theft, etc.) than geologic repositories.

The feasibility of a state's nuclear programme greatly depends on its plans to manage spent fuel. States that do not currently host nuclear programmes may not be especially concerned with these issues now but they inevitably will have them in the future. Regardless of whether we see a nuclear revival in the next decades, the issue of spent fuel management will become of substantial concern in a relatively short time. Existing reprocessing technologies not only create proliferation risks, but also

present environmental and safety risks. Interim storage facilities cannot resolve the problem of long-term storage, and the international community has yet to see the first operational geologic repository for spent nuclear fuel and HLW.

A multilateral approach to reprocessing and final disposal of spent nuclear fuel can provide clear benefits. In fact, the IAEA Joint Convention mentioned previously stipulates that "safe and efficient management of spent fuel and radioactive waste might be fostered through agreements among Contracting Parties to use facilities in one of them for the benefit of the other Parties".[69] Here multilateralization of back-end operations could be of help.

The multilateralization of reprocessing facilities would present the following advantages:

- **Economies of cooperation**. The economies of scale favour facilities of large size. But such facilities have high fixed start-up costs. The French UP2 and UP3 facilities at La Hague cost over US$ 16 billion to build,[70] while the Japanese Rokkasho reprocessing plant cost about US$ 20 billion.[71] Many states, especially those with relatively small nuclear power programmes, will not be able to afford such large plants and, moreover, they will not actually need them. However, states wishing to begin reprocessing their spent fuel could take part in multilateral facilities.

- **Non-proliferation**. Plutonium extracted from spent fuel can potentially be diverted for use in nuclear weapons. By making reprocessing facilities multilateral, this would function as a confidence-building mechanism among participating states by restricting possibilities for diversion of nuclear materials. In addition, IAEA safeguards could be more easily applied (in terms of costs, work-load, access, etc.) to a smaller number of multilateral reprocessing facilities.

Denationalizing final disposal repositories could also provide far-reaching benefits to states with nuclear programmes. Currently, all proposed disposal repositories are to be national. The advantages of a multilateral disposal repository would be as follows:

- **Economies of scale**. A large amount of fixed capital must be initially devoted to site analysis, on-site research and facility construction to ensure that the site is perfectly acceptable for waste disposal. Expanding the capacity of an existing disposal facility is economically more efficient than installing a new facility.

- **Geology**. Some states may have territory that is simply more "repository friendly" than that of other states, which could reduce construction and operation costs.[72]

- **Non-proliferation**. Plutonium contained in spent fuel can potentially be diverted for use in nuclear weapons. With multinational management over spent fuel the likelihood of such diversion would be minimized, and IAEA safeguards could be more easily applied.

- **Overcoming political obstacles**. States have had considerable difficulty overcoming political obstacles to the construction of geologic repositories. It would be quite difficult for all states using nuclear power to overcome domestic politics to establish national repositories. Thus, a multinational repository would present fewer political obstacles for the bulk of participating states, if a willing host state could be found.

- **Time**. Geologic repositories may take a long time to prepare before they can accept nuclear waste—whether this is for practical, economic or political reasons.

The provision of a comprehensive service, which would combine back-end multilateral services with front-end services in a fuel leasing/fuel take-back model, would be a strong incentive for non-supplier states to sign up to a multilateral initiative. In this scenario, a multilateral mechanism would provide for fresh nuclear fuel to be leased to a non-supplier state for irradiation in a nuclear reactor. Then the spent fuel would be taken back for storage, reprocessing or disposal. However, it is important to note that back-end fuel cycle assurances will require from states the policies and laws, as well as political will, to allow take-back of spent nuclear fuel. On a national level this leasing system was effectively practiced by the Soviet Union (and is still practiced to a smaller degree by the Russian Federation), which supplied fresh fuel and took back spent fuel from many power reactors in Eastern Europe.

Unfortunately, there are currently no concrete proposals for a multinational back-end arrangements. The original GNEP proposal, which has been abandoned, envisaged multilateral collaboration to decrease the total number of reprocessing and repository facilities around the world, citing advantages such as economies of scale, ease of safeguards, and non-proliferation assurances. Overall, GNEP has promoted a consortium of supplier states that would provide a whole set of "reliable fuel services", including reprocessing and disposal where applicable, to non-supplier states that only operate nuclear power plants.

The Russian Global Nuclear Power Initiative (GNPI) envisaged a global system of "international centres providing nuclear fuel cycle services" including reprocessing and storage of nuclear fuel, but no clear and specific proposals have been made on the back-end part of the arrangement.

Establishing a multilateral geological repository could prove to be a daunting task as it may be extremely difficult to justify that it would meet geologic isolation requirements for a period of several hundred thousand years,[73] even if a willing host state could be found. At the same time, justifying the safety of a multilateral repository for 100 or 200 years will be much easier. A retrievable international interim storage facility could be a first practical step toward the multilateral back end of the nuclear fuel cycle. Such a facility could provide additional opportunities for states having problems with storage and disposal of spent nuclear fuel, as well as time for further scientific and technological advances in managing spent fuel and radioactive wastes.

Thus, multilateral approaches to the back end of the nuclear fuel cycle could provide substantial benefits to both supplier and non-supplier states. Ideally, multilateralization of the back end of the nuclear fuel cycle could help to make the peaceful use of nuclear energy sustainable and secure in the long term.

MULTILATERAL MECHANISMS SHOULD PROVIDE A PROPER ASSURANCE OF SUPPLY OF NUCLEAR FUEL, NOT ONLY LEU

The majority of proposed multilateral fuel cycle instruments actually deal with LEU not with fuel assemblies. Having guaranteed access to LEU will not necessarily help customer states because they require a reliable supply

of fabricated fuel assemblies to load into their power reactors. Typically, 12–18 months are required for fuel fabrication and delivery to a reactor.[74] This causes legitimate concern among non-supplier states that a fuel supply disruption, even backed-up by a LEU reserve, could result in a reactor shutdown.

Fuel fabrication is specific to each reactor design, which makes the creation of a physical bank of finished fuel assemblies a daunting task. Nevertheless, a report presented during the June 2007 session of the IAEA Board of Governors states that "there exists a number of [other] ways that nuclear power plant operators and countries can and do protect against [fuel assemblies] interruption risks".[75] These include assuring that there are several fuel assembly suppliers for each reactor, requiring that a reserve of fresh fuel be available at the reactor site, and building fuel assembly fabrication capacity within a country. To quench the concern of non-supplier states these options should be thoroughly investigated for inclusion in future multilateral instruments.

Today, fuel fabrication services are more widely dispersed than enrichment services: there are now 13 large enrichment facilities in nine countries versus 34 fuel fabrication plants in 18 countries.[76] Furthermore, fuel fabrication technology for LEU oxide is not generally of proliferation concern. Therefore it would not result in an increase in proliferation risks if some states decide to establish domestic production of fuel assemblies for their own nuclear power reactors, without developing uranium enrichment or spent fuel reprocessing technologies. So the initial focus on supply of LEU is justifiable. At the same time some multilateral mechanisms to assure supply of fabricated fuel assemblies could be considered later as multilateral arrangements evolve and mature.

MECHANISMS OF DETERMINING THE COST OF NUCLEAR FUEL AND ASSOCIATED SERVICES MUST BE MORE TRANSPARENT

In June 2009, the IAEA Board of Governors reviewed the NTI fuel bank proposal and the Russian proposal for a guaranteed LEU reserve in Angarsk. Both reserves aim to guarantee an uninterrupted supply of LEU to states. Both proposals state that the "LEU would be made available to a Member State at the market prices prevailing at the time of supply".[77] This would require the determination of the market price of LEU, so that

the fuel bank would not disturb the regularly functioning market. This is essential, as some opponents of LEU fuel banks fear that they might somehow compromise the current market. To assure that the mechanisms would be truly back-up reserves and would not disturb the market, the LEU must be appropriately priced. However, determining such a price is a not easy task.

The nuclear fuel market is complex. In fact, four quite interdependent components, which are actually separate markets themselves, comprise the front-end of the nuclear fuel market: uranium ore mining and milling; uranium refining, conversion and reconversion; uranium enrichment; and fuel fabrication. Utilities (nuclear reactor operators) may either purchase each component of the fuel cycle separately thus diversifying their suppliers or buy full fuel assemblies from one supplier, subject to their business plans.

Pricing has become an issue because of the market's opacity. For example, trading of uranium concentrate, "yellow cake", does not occur in a common physical exchange. Most transactions are conducted on a bilateral basis—between companies that already have a commercial and perhaps political relationship. Moreover, the arrangements are typically long-term contracts, so the price often does not reflect the market dynamics at the time of uranium delivery. Current attempts at pricing uranium (conducted by third parties through industry interviews and futures pricing) are unrepresentative of the broader market as they extrapolate from a small sample of the transaction population.

Non-supplier states want the criteria and factors used to determine the cost of nuclear fuel and services in the current market to be more transparent. These states want to avoid a situation similar to that in the oil market where pricing results from an arrangement between the supplier states.

Denationalizing enrichment facilities and perhaps other front-end services of the nuclear fuel cycle may provide some additional transparency in the nuclear fuel market, and lead to more straightforward determining of the costs of nuclear fuel. Operations under multinational management would involve more states in the decision-making process. These supply facilities might be more open than national facilities, and bilateral arrangements or contracts made under political or commercial influence would be less common, or at least more transparent. The participation of non-supplier

states in multilateral facilities would provide them with the opportunity to take part in the operation and management of these facilities, including pricing methods and strategies.

The bottom line is that determining the costs of nuclear fuel and services requires attention. Proposed mechanisms to assure the reliable supply of nuclear fuel depend on proper determination of nuclear fuel costs. And with the market's current complexity and opacity, it could be quite difficult for these mechanisms to accurately ascertain the market price of nuclear fuel. Denationalization of front-end facilities could lead to greater market transparency, for the sake of the mentioned proposals and for the health of the nuclear fuel market as a whole.

LEU BANKS SHOULD ONLY BE A BACK-UP MECHANISM TO THE EXISTING MARKET

It is widely agreed among the states parties to the NPT that the current nuclear fuel market has functioned reasonably well. If all states are completely content with the existing market mechanisms, then there is no reason to change them. However, some states have expressed their worries that the nuclear market is or may become unfair and unreliable. They are disturbed that the legitimate nuclear market is almost exclusively controlled by a limited number of states—the NWS and their close political allies. This situation raises concern among some states that unexpected and politically motivated interruptions of normal commercial fuel supplies might occur. Another concern stems from suspicion that current nuclear suppliers may be willing to keep the market, and its associated profits, for themselves. Political and economic resentment largely fuel a growing unwillingness of non-supplier states to depend exclusively on the existing market for nuclear supplies and services. They fear that this dependence could eventually harm their energy security and economic development. This explains, at least partially, the recent interest of these states in developing their own nuclear fuel cycle, including proliferation-sensitive technologies of uranium enrichment and plutonium separation.

To address these concerns, some have advocated the creation of "guarantees-in-depth" or supplemental instruments that would be triggered only in the event of a disruption of normal commercial supplies for reasons other than non-proliferation obligations and only if this disruption

cannot be restored through normal market mechanisms. A few such back-up mechanisms have been tabled by states, nuclear industry and non-governmental organizations. The most widely discussed is the creation of a nuclear fuel bank, actually a reserve of LEU, to assure supply to customer states in case of a politically motivated disruption of supply.

The three proposed fuel banks—the NTI-proposed LEU reserve, the Russian LEU reserve, and the US LEU reserve—all aim to operate as back-up instruments. NTI, in its proposal for the IAEA LEU reserve, envisions that the US$ 150 million fuel bank would create "a last-resort fuel reserve"[78] stockpile. The Russian Federation plans to set aside 120 tons of LEU in the form of UF_6 at the IUEC to "serve as a guaranteed supply to supplement the existing commercial market in nuclear fuel".[79] The US LEU reserve would support "a reliable mechanism to resolve problems should a disruption in supply arise".[80]

Although all three proposals focus on assuring a reliable supply of nuclear fuel without disrupting the current market, they differ in a few respects. NTI proposed that the IAEA LEU reserve be internationally owned and internationally managed by the Agency itself. This mechanism directly follows Article IX of the IAEA Statute, which states that "[m]embers may make available to the Agency such quantities of special fissionable materials as they deem advisable and on such terms as shall be agreed with the Agency". The Russian Federation, on the other hand, proposed that its guaranteed LEU reserve be owned and hosted by the Russian Federation, but be controlled by the IAEA—a mechanism also completely consistent with Article IX of the IAEA Statute. The delivery of supply would be based on an agreement between the IAEA and the Russian Federation, as well as an agreement between the IAEA and the requesting member state. Even though the proposed US fuel bank would be owned and operated on a national basis, it aims to serve the same purposes as the other two fuel banks, and purports to intervene only when there is a disruption in normal commercial supply.

While the three fuel banks alone would not solve all problems stemming from the current "two-tier" system, they would undoubtedly create an additional option and an additional assurance especially for newcomers to nuclear energy technology. As long as the fuel banks only perform their role in the nuclear fuel market when there is a disruption in supply for reasons other than commercial or non-proliferation ones, they will serve as

helpful tools for all states. And having three LEU reserves rather than just one also helps to assure states that there will always be a reliable supply of LEU. Those that argue that there is no reason to solve a problem that does not exist, implying that the existing global nuclear market works well, underestimate the power of precautionary measures—especially when these measures have already acquired most if not all of the resources necessary for operation.

CHAPTER 4

NON-PROLIFERATION AND NUCLEAR FUEL CYCLE

The issue of nuclear proliferation has always been at the core of debates surrounding the peaceful use of nuclear energy and the development of nuclear fuel cycle technologies. The dissemination of nationally owned and operated enrichment and reprocessing facilities as well as related technologies is undesirable from a proliferation perspective. Because of the dual-use nature of these technologies, the further spread of fuel cycle capabilities would have a negative impact on international security and undermine confidence in the non-proliferation regime. It would become more difficult, if not impossible, to effectively safeguard a growing number of uranium and plutonium facilities as more states obtain sensitive fuel cycle technologies. As Mohamed ElBaradei said, "This creates many new challenges, both for the international community and for [the IAEA], because verifying enrichment facilities or reprocessing facilities is quite difficult and the so-called conversion time is very short. So we are dealing with what I call 'virtual nuclear weapon States'".[81]

The NPT does not prohibit its state parties to develop their own nuclear fuel cycles, including such sensitive nuclear technologies as uranium enrichment and spent fuel reprocessing, and to produce materials suitable for use in nuclear weapons. Moreover, states party to the NPT have a right to withdraw from it retaining all technologies and facilities it acquired through international cooperation in the peaceful use of nuclear energy. As the IAEA Director General described it:

> Under the current regime, therefore, there is nothing illicit in a non-nuclear-weapon state having enrichment or reprocessing technology, or possessing weapon-grade nuclear material. And certain types of bomb-making expertise, unfortunately, are readily available in the open literature. Should a state with a fully developed fuel-cycle capability decide, for whatever reason, to break away from its non-proliferation commitments, most experts believe it could produce a nuclear weapon within a matter of months.[82]

The majority of NPT states parties recognize the risks arising from proliferation of these technologies and diversion or misuse of nuclear materials, but many find it difficult to accept arrangements that would codify a "two-tier" system, where some states are entitled to certain nuclear fuel cycle technologies, and others are not. Attempts to establish a new discriminatory regime of "haves" and "have-nots" in terms of the peaceful use of nuclear energy could be considered as inconsistent with the provisions of Article IV of the NPT and would meet with adverse reaction from many non-supplier states. It should also be taken into consideration that many non-supplier states might have other interests and priorities besides non-proliferation, for example commercial or energy security concerns.

To solve this non-proliferation conundrum, the growing emphasis has been placed on international cooperation and multilateral fuel cycle arrangements. Multilateral mechanisms could provide additional assurances of fuel cycle and energy security and thus reduce incentives to develop domestic fuel cycle capabilities. Strong oversight of technology and staffing, as well as effective safeguards and proper division of expertise at multilateral fuel cycle facilities could conceivably reduce the risk of proliferation and make a unilateral breakout extremely difficult. At the same time, such multilateral facilities could respond to the "entitlement" motivation of states in terms of their participation in ownership, management, operation, decision-making, profit-sharing, etc. Denationalization of the nuclear fuel cycle would also be able to impact "one of the most difficult aspects of restricting access to sensitive nuclear technologies like enrichment and reprocessing",[83] namely the symbolic element of national prestige associated with the possession of these technologies. Civilian nuclear energy is often identified with progress and modernity, not so much because of the resulting economic benefits, but because it is considered to be one of the most important technological developments of the present age. Therefore nuclear technologies have become an essential component for "catching up" with advanced states.

However, the non-proliferation value of the proposed multilateral supplemental instruments has been questioned. Recently, World Nuclear Association Director General John Ritch summed up these arguments:

> A bureaucratically controlled fuel bank would be fine if it accomplished something. But what security gain can we realistically expect?

> Countries that demonstrate adherence to the NPT have access to good commercial supply, while governments pursuing a weapons option will scoff at fuel assurances, arguing that they're unreliable. Whose behaviour then will the fuel bank change?[84]

Ritch may be right that many proposed multilateral backup mechanisms are rather limited in their ability to influence the worst case scenario of a state determined to pursue the "weapons option". But, as Lao Tzu once said, a journey of a thousand miles begins with a single step. However long and complicated any endeavour might be, it always needs to be initiated with something simple. The same is true for a multilateral approach to the nuclear fuel cycle: it should be implemented step by step, moving from simple and more straightforward mechanisms to more complex arrangements while learning lessons and making required adjustments along the way.

CHAPTER 5

NEXT STEPS

1. The central problem hampering the further progress of a multilateral approach to the nuclear fuel cycle is distrust among states. There are no technical or legal questions that cannot be resolved in due course. The problem of building trust is a political problem that needs to be tackled using political means. To be successful, multilateral fuel cycle arrangements will inevitably require a broad political consensus on how the international community can limit access to these technologies, while protecting states' rights to develop nuclear energy for peaceful purposes.

   Any real progress toward a multilateral approach to the nuclear fuel cycle can be achieved only in the context of broad agreement that in the face of global problems such as nuclear proliferation and nuclear terrorism, curbing the spread of sensitive nuclear technologies and nuclear weapons-usable materials, while promoting better access to safe and clean energy, is undoubtedly in the interest of the world community.

2. A serious weakness of current proposals on multilateralization of the nuclear fuel cycle lies in their failure to consult with non-supplier states. To be successful these initiatives should take into account the interests and needs of all states, not just supplier states. It is imperative for the international community to conduct in-depth discussions of the technical, legal, political and economic aspects of proposals to establish multilateral nuclear fuel cycle mechanisms, under the auspices of the IAEA and in other international fora.

3. Confidence-building measures are very important. They could range from an open dialogue among states to practical implementation of specific multilateral arrangements. In November 2009, the IAEA Board of Governors approved the establishment of a Russian guaranteed reserve of LEU in Angarsk.[85] Together with the IUEC, this

reserve will provide important experiences and lessons applicable to future implementation.

The participation of states in multilateral nuclear fuel cycle arrangements could take different forms depending on the specific mechanism. There is no uniform formula that would be satisfactory for all technologies, regions and states. Successful implementation of multilateralization would depend on the flexibility of application. The establishment of multilateral fuel cycle arrangements should be implemented step by step, with existing proposals pursued on their own merits drawing important lessons for the future.

4. Fuel assurance mechanisms supplementary to the existing market, such as fuel banks or guaranteed export licences, are capable of offering additional energy security but still may be considered insufficient by some non-supplier states. Generally a mechanism that could provide any state that wishes to use this option with some vested interest in the major elements of fuel cycle services would be desirable. This interest can be satisfied by participation in ownership, management, operation, decision-making, profit-sharing and other activities short of direct access to sensitive nuclear technologies, while at the same time allowing full access for all states to the benefits of peaceful use of nuclear energy.

5. Such broad participation may satisfy the economic and political interests of many non-supplier states while simultaneously guarding against a "cartel" of nuclear suppliers. Certain concerns of states (for example, the concentration of enrichment and reprocessing facilities in the United States and Europe) may also be assuaged by tackling the issue of multilateralization at the regional level. Non-supplier states should have a right to establish multilateral facilities with partners of their choice and in the locations of their choice, providing that these facilities are justified economically and black-box technology is furnished by one of the suppliers. The regional cooperation in multilateral nuclear fuel cycle projects would serve as an important confidence-building measure contributing to regional security and helping to reduce suspicions among participating states about others' nuclear intentions.

   In 2008, head of the IAEA Mohamed Elbaradei announced that some 50 states have expressed interest in considering the possible

introduction of nuclear power into their energy mix, including states in South America, Africa, the Middle East, and South and East Asia. There are opportunities for cooperation in these areas, and there are current examples of such cooperation as well. For example, Argentina and Brazil are seen, despite certain political tensions, as having been successful in turning their nuclear competition into cooperation through mutual confidence.

The only multilateral proposal that originated from non-supplier states was an initiative of the Gulf Cooperation Council (GCC), an organization that includes Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. In October 2007 the GCC put forward an initiative that invited all interested states of the Middle East to participate in the establishment of a Uranium Enrichment International Consortium, which could be based in a neutral country outside the region.[86] All states in the region could thus secure the supply of nuclear fuel for all power plants of member states of the consortium, but they would not have access to enrichment technology (the supplier of the technology was not specified). This initiative can serve as an example, even if not practically implemented, of a regional approach to multilateralization.

6. The majority of the existing proposals for a multilateral approach to the nuclear fuel cycle focus on the front-end problem, dealing with LEU and nuclear fuel supply and production. However, satisfactory arrangements (in terms of economics, environment, non-proliferation, etc.) for the back end of the nuclear fuel cycle are necessary to make nuclear energy a sustainable process in the long run, as the management of spent nuclear fuel remains one of the greatest challenges of nuclear power. Multilateral approaches to the back end of the nuclear fuel cycle could provide substantial benefits to both supplier and non-supplier states.

   Establishing a multilateral geological repository for final disposal of spent fuel and radioactive waste could prove to be a daunting task as it may be extremely difficult to prove that this repository would meet geologic isolation requirements several hundred thousand years into the future. At the same time, establishing the safety of a multilateral repository for 100 or 200 years would be much easier. A retrievable international interim storage facility could be a first practical step toward the multilateral back end of the nuclear fuel

cycle. Such a facility could provide additional opportunities for states having problems with storage and disposal of spent nuclear fuel, as well as allow time for further scientific and technological advances in managing spent fuel and radioactive wastes.

7. It is not impossible to imagine a new binding international norm that would stipulate that all sensitive nuclear fuel cycle activities worldwide should be restricted exclusively to multilateral mechanisms rather than national undertakings. Such a norm would effectively denationalize certain nuclear fuel cycle activities by requiring that future facilities be multilaterally owned and operated while existing facilities be converted to multilateral ownership and operation as well. This would require a consensus of states parties to the NPT to agree to a fundamental change of the current regime based on a conceptually new level of mutual confidence and international cooperation.

   The ultimate denationalization of sensitive facilities, which implies putting all sensitive fuel cycle facilities under multilateral control, would fundamentally change how the international nuclear market functions. The conversion of the current "two-tier" system of suppliers and non-suppliers into a truly multilateral fuel cycle arrangement of equal rights and obligations could be a way to establish a truly non-discriminatory and equitable international fuel cycle infrastructure.

8. It is very important to carefully design multilateral fuel cycle mechanisms so that they do not become self-defeating. For example, the situation should be avoided where international fuel cycle centres end up spreading sensitive technology, especially taking into account that such technology has been illegally acquired from a multinational fuel cycle company in the past. Thus, Pakistani scientist A.Q. Khan, while employed by a subcontractor for the URENCO consortium, obtained centrifuge enrichment technology to build Pakistan's enrichment complex, and exported it to other states.

9. The existing proposals are not carved in stone. They should be considered as dynamic proposals contributing to the international processes of strengthening the non-proliferation regime and developing the peaceful uses of nuclear energy. Understanding of the key elements and objectives of each proposal, coupled with an open dialogue between supplier and non-supplier states, will go a long

way toward establishing a basis of trust and confidence for further discussions on the viability of a multilateral approach to the nuclear fuel cycle. More detailed discussion of existing proposals and more creative thinking are needed from both supplier and non-supplier states. The task is tremendous: it is not easy getting international support for dramatic changes in the way we manage nuclear energy. Nonetheless, we have little choice if the world is to be protected from the misuse of sensitive nuclear technologies.

Notes

1 Fissile material is nuclear material that can be made to fission by neutrons of all energies.

2 David Albright, Frans Berkhout and William Walker, *World Inventory of Plutonium and Highly Enriched Uranium, 1992*, SIPRI/Oxford University Press, 1993, p. 10. Theoretically, however, a nuclear explosive device could be constructed using enriched uranium with a U-235 fraction of 20% or even less.

3 David Albright, Frans Berkhout and William Walker, *World Inventory of Plutonium and Highly Enriched Uranium*, *1992*, SIPRI/Oxford University Press, 1993, p. 15.

4 *IAEA Safeguards Glossary*, IAEA, 2002, p. 33. The IAEA does not include material that is greater than 80% plutonium-238, as this isotope is very difficult to use for explosives due to its high heat and radiation emission. Because of its properties, this plutonium isotope is used for radioisotope thermoelectric generators and radioisotope heater units.

5 "Multilateral Approaches to the Nuclear Fuel Cycle: Expert Group Report to the Director General of the International Atomic Energy Agency", IAEA, 2005, pp. 17–8.

6 It is generally agreed that the term "multilateral" is the broadest and most flexible term, referring to the participation of more than two actors, be they states or international organizations, while the term "multinational" implies several actors from different states. In this study paper the terms "multilateral" or "multinational" are used interchangeably as they refer to any approach to the management of the nuclear fuel cycle that goes beyond purely national control, i.e. transcends national sovereignty.

7 Mohamed ElBaradei, "Nuclear Energy: The Need for A New Framework", statement to the International Conference on Nuclear Fuel Supply, Berlin, 17 April 2008, <www.iaea.org/NewsCenter/Statements/2008/ebsp2008n004.html>.

[8] For details and discussion of the main proposals, see Yury Yudin, *Multilateralization of the Nuclear Fuel Cycle: Assessing the Existing Proposals*, UNIDIR, 2008.

[9] "President Announces New Measures to Counter the Threat of WMD. Remarks by the President on Weapons of Mass Destruction Proliferation, Fort Lesley J. McNair—National Defense University", White House Office of the Press Secretary, 11 February 2004.

[10] The NSG is a group of nuclear supplier countries which seeks to contribute to the non-proliferation of nuclear weapons through the implementation of guidelines for nuclear exports and nuclear-related exports. The NSG Guidelines are implemented by each participating government in accordance with its national laws and practices. Decisions on export applications are taken at the national level in accordance with national export licensing requirements. See <www.nuclearsuppliersgroup.org/Leng/default.htm>.

[11] *Statement by the Head of the Delegation of Brazil, Ambassador Ronaldo Sardenberg*, Seventh NPT Review Conference, New York, 2 May 2005, <www.un.org/events/npt2005/statements/npt04brazil.pdf>; *Statement by H.E. Ambassador Ahmed Fathalla*, Seventh NPT Review Conference, New York, 2 May 2005, <www.un.org/events/npt2005/statements/npt03egypt.pdf>; *Statement by H.E. Dr. Kamal Kharrazi, Minister of Foreign Affairs of the Islamic Republic of Iran*, Seventh NPT Review Conference, New York, 3 May 2005, <www.un.org/events/npt2005/statements/npt03iran.pdf>; *Statement by the Hon. Syed Hamid Albar, Minister of Foreign Affairs of Malaysia*, Seventh NPT Review Conference, New York, 2 May 2005, <www.un.org/events/npt2005/statements/npt02malaysia.pdf>.

[12] *Substantive issues to be considered by Main Committee III of the 2005 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons*, document NPT/CONF.2005/WP.20, 2 May 2005.

[13] For information on GNEP, see the presentation by Vic Reis, Senior Advisor, US Department of Energy, to the American Nuclear Society, 5 June 2006, <www.sustainablenuclear.org/PADs/pad0606reis.pdf>.

[14] Author's communication with WNA, 27 January 2010.

[15] Mohamed ElBaradei, statement to the Fifty-Third Regular Session of the IAEA General Conference, Vienna, 14 September 2009.

[16] *Proposal for the Establishment of an IAEA Low Enriched Uranium (LEU) Bank*, IAEA document GOV/2009/30, 20 May 2009.

[17] Ibid.

[18] Ibid.

[19] *Communication received from the Resident Representative of the Russian Federation to the Agency transmitting the text of the Statement of the President of the Russian Federation on the Peaceful Use of Nuclear Energy*, IAEA document INFCIRC/667, 8 February 2006.

[20] *Russian Federation Initiative to Establish a Reserve of Low Enriched Uranium (LEU) for the Supply of LEU to the IAEA for its Member States*, IAEA document GOV/2009/31, 21 May 2009.

[21] Ibid.
[22] Ibid.
[23] Ibid.
[24] *Communication dated 22 September 2008 received from the Permanent Missino of Germany to the Agency regarding the German proposal on a Multilateral Enrichment Sanctuary Project*, IAEA document INFCIRC/735, 25 September 2008.
[25] *Establishing an Independent Access to Nuclear Fuel Cycle Services: The Multilateral Enrichment Sanctuary Project (MESP)*, IAEA document GOV/2009/32, 22 May 2009.
[26] *Multilateralization of the nuclear fuel cycle: increasing transparency and sustainable security*, document NPT/CONF.2010/PC.III/WP.34, 13 May 2009.
[27] *Multilateral Approaches to the Nuclear Fuel Cycle: Expert Group Report submitted to the Director General of the International Atomic Energy Agency*, IAEA document INFCIRC/640, 2005, p. 12.
[28] "Treaty on the Non-Proliferation of Nuclear Weapons", statement by IAEA Director General Mohamed ElBaradei, 2005 Review Conference of the Treaty on the Non-Proliferation of Nuclear Weapons, New York, 2 May 2005.
[29] Lawrence Scheinman, "The Nuclear Fuel Cycle: A Challenge for Nonproliferation", *Disarmament Diplomacy*, no. 76, 2004.
[30] Alexander Glaser, "Safeguarding Nuclear Materials Intended for Commercial Uses Through Internationalization of the Fuel Cycle in a World Without Nuclear Weapons", paper prepared for Global Zero, June 2009, p. 17.
[31] James E. Goodby, "Internationalizing the nuclear fuel cycle", *Bulletin of the Atomic Scientists*, 4 September 2008.
[32] *Multilateral Approaches to the Nuclear Fuel Cycle: Expert Group Report submitted to the Director General of the International Atomic Energy Agency*, IAEA document INFCIRC/640, 22 February 2005.
[33] "Uranium Report: Plenty More Where That Came From. Supply Sufficient for Next Century Amid Robust Demand Growth", IAEA Staff Report, 3 June 2008, <www.iaea.org/NewsCenter/News/2008/uraniumreport.html>.
[34] Statement by Ms Buyelwa Sonjica, Minister of Minerals and Energy of the Republic of South Africa, at the Special Session on "New Framework for the Utilization of Nuclear Energy in the 21st Century: Assurances of Supply and Non-proliferation", Vienna, 19 September 2006, <www-pub.iaea.org/mtcd/meetings/PDFplus/2006/cn147_sonjica.pdf>.
[35] A "black box" approach means an arrangement in which the sensitive technology (e.g. centrifuge equipment for uranium enrichment) is supplied on a pre-fabricated basis, while the operators—or even owners—of the plant do not have access to any proprietary or proliferation-sensitive information. Two major holders of enrichment technology—European ETC (a joint venture between URENCO and AREVA) and Russian Rosatom—have supplied centrifuge equipment on a black-box basis in the past: Russia has built an enrichment facility in China and ETC is provided the technology for two new enrichment plants in the United States and for one plant in France.

[36] Alexander Glaser, "Safeguarding Nuclear Materials Intended for Commercial Uses Through Internationalization of the Fuel Cycle in a World Without Nuclear Weapons", paper prepared for Global Zero, June 2009.

[37] *The Agency's Safeguards*, IAEA document INFCIRC/26, 1961.

[38] See "NPT Comprehensive Safeguards Agreement. Overview of Status", IAEA, <www.iaea.org/Publications/Factsheets/English/nptstatus_overview.html>.

[39] "Ensuring Security of Supply in the International Nuclear Fuel Cycle", World Nuclear Association, 2006.

[40] Speech by Sam Nunn, 50th IAEA General Conference Special Event, Vienna, 19 September 2006, <www.nti.org/c_press/speech_Nunn_IAEAFuelBank_FINALlogo.pdf>.

[41] *Communication received on 12 September 2006 from the Permanent Mission of Japan to the Agency Concerning Arrangements for the Assurance of Nuclear Fuel Supply*, IAEA document INFCIRC/683, 15 September 2006.

[42] *Communication Received from the Resident Representative of the Russian Federation to the Agency Transmitting the Text of the Statement of the President of the Russian Federation on the Peaceful Use of Nuclear Energy*, IAEA document INFCIRC/667, 8 February 2006.

[43] S.V. Ruchkin and V.Y. Loginov, "Securing the Nuclear Fuel Cycle: What Next?", *IAEA Bulletin*, vol. 48, no.1, 2006, p. 25.

[44] *Possible New Framework for the Utilization of Nuclear Energy: Options for Assurance of Supply of Nuclear Fuel*, IAEA document GOV/INF/2007/11, 13 June 2007, annex 7.

[45] *Communication Received from the Federal Minister for European and International Affairs of Austria with Regard to the Austrian Proposal on the Multilateralization of the Nuclear Fuel Cycle*, IAEA document INFCIRC/706, 31 May 2007.

[46] Iran remains a shareholder of EURODIF via SOFIDIF, a Franco-Iranian consortium shareholder that owns 25% of EURODIF. The Atomic Energy Organization of Iran holds 40% of SOFIDIF with AREVA holding 60%.

[47] *Statement by the Hon. Syed Hamid Albar, Minister of Foreign Affairs of Malaysia, On Behalf of the Group of Non-Aligned States Parties to the Treaty on the Non-Proliferation of Nuclear Weapons at the General Debate of the 2005 Review Conference of the Parties to Treaty on the Non-Proliferation of Nuclear Weapons*, New York, 2 May 2005, <www.un.org/events/npt2005/statements/npt02malaysia.pdf>.

[48] At the meeting of the IAEA Board of Governors in June 2009, ElBaradei expressed deep personal disappointment that board members refused to approve an 11% budget increase. He said this amounts to the "bastardization of an international organization" that is supposed to be a spearhead of peace and security and stressed that the Agency's activities to ensure nuclear safety and security would be seriously hampered if the IAEA budget is not increased. See <www.iaea.org/NewsCenter/Statements/2009/ebsp2009n006.html>.

[49] *Development of the Initiative of the Russian Federation to Establish a Reserve of Low Enriched Uranium (LEU) for the Supply of LEU to the International Atomic*

Energy Agency for its Member States, document NPT/CONF.2010/PC.III/WP.25, 6 May 2009.

50 *Communication Received from the Resident Representative of Germany to the IAEA with Regard to the German proposal on the Multilateralization of the Nuclear Fuel Cycle*, IAEA document INFCIRC/704, 4 May 2007.

51 Ibid.

52 Ibid.

53 See "Background on IAEA Board of Governors' Approval of Framework for Integrated Safeguards", at <www.iaea.org/NewsCenter/News/2002/sgarticle_02.shtml>.

54 *Rules Regarding Voluntary Contributions to the Agency*, IAEA document INFCIRC/370/Rev.2, 26 May 2004.

55 *Rules Regarding Voluntary Contributions to the Agency*, IAEA document NFCIRC/13, 6 November 1959.

56 According to the IAEA Statute.

57 *Rules Regarding Voluntary Contributions to the Agency*, IAEA document INFCIRC/370/Rev.2, 26 May 2004.

58 See Annex B.

59 Spent Fuel Reprocessing Options, IAEA document IAEA-TECDOC-1587, 2008, p. 2.

60 *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste management*, IAEA document INFCIRC/546, 24 December 1997, preamble.

61 Convention, <http://www.iaea.org/Publications/Documents/Infcircs/1997/infcirc546.pdf>.

62 "Poll Finds Nevada Voters Strongly Oppose Yucca. Survey Shows 76 Percent Are Against Nuclear Waste Project", *Las Vegas Review-Journal*, 28 November 2007.

63 "Four Score Organizations Express Opposition to Yucca Mountain Nuclear Waste Dump", CommonDreams.org, 11 January 2008, <www.commondreams.org/news2008/0111-03.htm>.

64 "Statement of Senator Harry Reid About Yucca Mountain Oversight Hearing", 1 March 2006, <http://democrats.senate.gov/newsroom/record.cfm?id=252165&>.

65 "Statement of Steven Chu Secretary, US Department of Energy, Before the House Committee on Appropriations Subcommittee on Energy and Water Development, and Related Agencies", 3 June 2009, <http://appropriations.house.gov/Witness_testimony/EW/Steven_Chu_06_03_09.pdf>.

66 "Senators Seek Explanation of Obama's Yucca Mountain Decision", US Senate Committee on Environment and Public Works, 29 April 2009, <http://epw.senate.gov/public/index.cfm?FuseAction=Minority.PressReleases&ContentRecord_id=f2cbe309-802a-23ad-4925-643845f220b5>.

67 *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, 3rd Finnish National Report as referred to in*

Article 32 of the Convention, Finnish Radiation and Nuclear Safety Authority, 2008, p. 19.

68 "Nuclear Power in Sweden", World Nuclear Association, updated September 2009, <www.world-nuclear.org/info/inf42.html>.

69 *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste management*, IAEA document INFCIRC/546, 24 December 1997, preamble.

70 Matthew Bunn et al., *The Economics of Reprocessing vs. Direct Disposal of Spent Nuclear Fuel*, Project on Managing the Atom, Harvard University, 2003, p. 26.

71 "Japan's Nuclear Fuel Cycle Program—An Economic Failure Providing No Waste Solution and No Energy for Japan", Green Action, 7 May 2007, <www.citizen.org/documents/JapaneseReprocessing.pdf>.

72 The principle of geological disposal is based on placing radioactive wastes deep underground inside a suitable rock formation, beyond disruption by natural or man-made events, to isolate the waste and ensure that no significant quantities of radioactivity ever reach the surface environment. Finding a favourable rock formation is a daunting task as a multiplicity of different factors—hydrology and geohydrology; the rock structural strength and fracture systems; earthquakes, volcanism, and other geological processes; changes in climate, etc.—should be taken into consideration. It can be impossible to find a suitable site in small and densely populated countries. The problem of assuring safety of geological repositories is closely linked to the selection of rock type. Currently the design philosophy for such repositories relies on multiple barriers—both the geological setting and engineered barriers. The more favourable is the geological setting the less sophisticated engineered barriers could potentially be needed to assure adequate waste isolation.

73 Actinides such as uranium, plutonium, neptunium and americium are the major contributors to the long-term radioactivity of nuclear waste. Many isotopes of these elements have half-lives from a few thousand to a few million years. Some radioactive fission products, like technetium-99 and iodine-129, also have long half-lives.

74 Alexander Glaser, "Safeguarding Nuclear Materials Intended for Commercial Uses Through Internationalization of the Fuel Cycle in a World Without Nuclear Weapons", paper prepared for Global Zero, June 2009, p. 19.

75 *Possible New Framework for the Utilization of Nuclear Energy: Options for Assurance of Supply of Nuclear Fuel*, IAEA document GOV/INF/2007/11, 13 June 2007.

76 Tariq Rauf and Zoryana Vovchok, "A Secure Nuclear Future", IAEA Bulletin 51-1, 2009, p. 10–13.

77 *Proposal for the Establishment of an IAEA Low Enriched Uranium (LEU) Bank*, IAEA document GOV/2009/30, 20 May 2009.

78 Laura Holgate, speech at 50th IAEA General Conference Special Event, 19 September 2006, <www.nti.org/c_press/speech_holgate_fuelbank_092006.pdf>.

[79] *Development of the Initiative of the Russian Federation to Establish a Reserve of Low Enriched Uranium (LEU) for the Supply of LEU to the International Atomic Energy Agency for its Member States*, document NPT/CONF.2010/PC.III/WP.25, 6 May 2009, p. 2.

[80] *Communication dated 28 September 2005 from the Permanent Mission of the United States of America to the Agency*, IAEA document INFCIRC/659, 29 September 2005.

[81] Mohamed ElBaradei, "Addressing Verification Challenges", Symposium on International Safeguards, Vienna, 16 October 2006, <www.iaea.org/NewsCenter/Statements/2006/ebsp2006n018.html>.

[82] Mohamed ElBaradei, "Towards a Safer World", *The Economist*, 16 October 2003.

[83] Sharon Squassoni, *Nuclear Energy: Rebirth or Resuscitation?*, Carnegie Endowment for International Peace, 2009, p. 76.

[84] "Brown calls for renewed nuclear bargain", *World Nuclear News*, 17 March 2009, <www.world-nuclear-news.org/NP_Brown_calls_for_renewed_nuclear_bargain_1703091.html>.

[85] "IAEA Board Adopts Resolutions", 27 November 2009, <www.iaea.org/NewsCenter/News/2009/bog271109.html>.

[86] Nicole Stracke, "Nuclear Non-Proliferation from a Gulf Perspective", FES Briefing Paper 3, Friedrich-Ebert-Stiftung, 2008, p. 5.

ANNEX A

PRESENTATION BY AMBASSADOR L.M. GUMBI

Presentation by Ambassador L.M. Gumbi on the preliminary views of non-supplier states on the multilateral control of the nuclear fuel cycle during the UNIDIR seminar on Multilateral Approaches to the Nuclear Fuel Cycle held on 12 March 2009 at the United Nations Office at Geneva[1]

Excellencies
Distinguished Delegates
UNIDIR Director and Staff
Program Coordinator
Ladies and Gentlemen

I would first like to thank UNIDIR in particular Dr. Yury Yudin for inviting me to make a presentation at this seminar on "Multilateral Approaches to the Nuclear Fuel Cycle". Though for different reasons, it is not the first time that the international community is again consider the question of establishing control over the nuclear fuel cycle.

Growing utilization of nuclear power in addressing energy needs has resulted in many states making huge investments towards mastering the nuclear fuel cycle. Advances in science, technology and engineering continue making the production of nuclear weapons much easier now than it was say some fifty years ago. The fast flow of goods and technology including that for making nuclear weapons is increasingly making it harder to control nuclear material and nuclear material production. The existence of "… nearly 3,000 tons of fissile material—enough to produce over 250,000 nuclear bombs—stored in more than 40 countries"[2] is one of the

1 The audio recording of this presentation is available at <www.unidir.org/bdd/fiche-activite.php?ref_activite=439>.

2 Ivor Daalder and Jan Lodel, "The Logic of Zero. Toward a World Without Nuclear Weapons", *Foreign Affairs*, vol. 87, no. 6, 2008, p. 81.

factors that might have given rise to the need for the ongoing discussion on the control of the nuclear fuel cycle.

The current discussion on the control of the nuclear fuel cycle also has some specific things associated with it. For example, progress or lack of it in the area of nuclear disarmament will have a direct bearing on the course and outcome of the ongoing discussions on the multilateral control of the nuclear fuel cycle. Just like the NPT, there are two distinct sides in the discussion on the multilateral control of the nuclear fuel cycle. The NWS and its allies are, in the context of this discussion, the "haves" that produce and supply nuclear fuel and the NNWS happen to be the "have nots" that are recipients of nuclear fuel and constitute the non-suppliers' side. The unfolding nuclear fuel control discussion is largely premised on proposals tabled by the suppliers' side and as a result of this the non-supplier side in this discourse has been merely reactive. Before elaborating on these reactions I would first like to provide a brief account of what are the views of the non-suppliers regarding the intentions of efforts to control the nuclear fuel cycle.

Real or perceived, the non-suppliers of nuclear fuel are of the view that control of the nuclear fuel cycle is intended to curb nuclear proliferation by limiting the production of new material through in civilian reactors through an assured supply of LEU. Dealing with nuclear proliferation concerns in this manner would pave the way towards confining enrichment and reprocessing operations exclusively to facilities under multilateral control and verification. The non-suppliers argue that this alone would not suffice without appropriate rules of transparency and assurance of supply for would-be users along with a verifiable fissile material arrangement.

If the real intention of multilateral control of the nuclear fuel cycle is to deal with nuclear proliferation it is important that this intention is matched by the reinforcement of the obligation to achieve nuclear disarmament because you cannot proliferate what you do not have. This is of utmost importance now that "The world … is on a verge of entering an age of more nuclear weapon states, more nuclear materials, and more nuclear facilities that are poorly secured—making the job of the terrorists seeking the bomb easier and the odds that a nuclear weapon will be used greater".[3] I am

[3] Ibid., p. 82.

also of the view that high-risk nuclear material that constitutes a serious threat is material that is not safeguarded or properly secured in terms of the necessary physical protection measures. International efforts should therefore focus on these high risk materials rather than on safeguarded material that already enjoys the necessary levels of physical protection.

The other intention of the multilateral control of the nuclear fuel cycle according to the non-suppliers is to impose limitations on the transfer of sensitive technologies through among others the "black box" approach. To support this approach it is argued that "The lower costs of nuclear fuel provided by large, modern centrifuge facilities should help to discourage, on economic grounds, the building of small, high-cost enrichment facilities. It would be far less expensive for nations and companies to take part ownership in a multinationally-owned facility, perhaps using leased centrifuge machines under 'black box' conditions, than to build their own".[4] The fact that centrifuge technology is becoming more efficient, less expensive to operate, and more widely available is a compelling counter argument against the black box approach.[5] Putting limitations to sensitive nuclear fuel cycle technologies will be difficult because the fast flow of goods and technology including that for making nuclear weapons is increasingly making it harder to control nuclear material and nuclear material production.

This said, what then are the most common reactions to the proposals of the suppliers' side in the discussion on multilateral nuclear fuel supply arrangements and services and its various dimensions such as the nuclear fuel market, the establishment of a nuclear fuel bank, the assured supply of nuclear fuel, and the control of technologies associated with the nuclear fuel cycle?

(i) All issues related to the nuclear fuel cycle are regarded as extremely sensitive hence the need to approach this matter with utmost caution and with the necessary transparency and inclusiveness.

(ii) A safe orderly system to fuel civilian nuclear reactors that would not exacerbate nuclear proliferation is needed. However, states should

4 See James E. Goodby, "Internationalizing the Nuclear Fuel Cycle", May 2008, p. 10, <http://web.mit.edu/stgs/pdfs/Goodby--Internationalizing the nuclear fuel cycle.pdf>.

5 Ibid.

have reliable access to fuel for civilian nuclear reactors at reasonable cost.

(iii) It is imperative to guard against the creation of a cartel that would exclude full participation particularly by states in full compliance with their safeguards obligations and also taking into full consideration Article IV of the Nuclear Non-Proliferation Treaty.

(iv) Tabled proposals should not foreclose the possibility of other states to have nuclear enrichment facilities by encouraging the perpetuation of the existing status quo where these facilities are in a few states.

(v) There should be no presumption that advanced technologies, especially the most sensitive parts of the nuclear fuel cycle are safe in the hands of some and not others, more especially under the guise of non-proliferation.

(vi) There should be no preconditions that would even hint at the possibility that NNWS in conformity with their legal obligations under the NPT should forgo their Article IV inalienable right including the right to pursue domestic nuclear fuel capabilities, as well as access to advanced technologies.

(vii) There should be no imposition of additional obligations on those countries wishing to make use of existing and future proposals on assured nuclear fuel supply.

(viii) The establishment of credible mechanisms to assure the reliable supply of nuclear fuel should involve the International Atomic Energy Agency because the Agency has to assure access for all countries to nuclear fuel and reactor technology as envisaged in the IAEA Statute.

(ix) The political, economic, energy and security benefits of multilateral approaches to nuclear fuel cycle participation must be easily recognizable to states.

(x) It is also argued that:

> If the manufacturing and sale of nuclear material and services is profitable, why should the business be reserved to a few countries? If it is not, what explains their keenness [the supplier states] to maintain their cartel-like monopoly? Underlying the rationale for these and similar questions is the fact that the

> five permanent members of the UN Security Council are also the only five countries officially classified as nuclear weapon states (NWSs) and that among them they control the bulk of the legitimate market in nuclear sales. The other countries with significant share—Germany, Canada, and Japan—are closely associated with the three Western permanent members. The 'big boys' seem to have the nuclear power market sewn up.[6]

(xi) It is a cause of concern that the proposals are generally silent on NPT membership and the requirement to have comprehensive safeguards agreements with the Agency.

(xii) Tabled proposals should not end up assuming the character and purposes of an export control regime

(xiii) Given the current financial and administrative challenges being faced by the Agency, extreme caution is also required before further burdens are imposed on Member States as a result of the activities that might be carried out in connection with the tabled proposals.

(xiv) Consensus would be elusive if not difficult to obtain in respect of authorizing the Agency to accept any financial pledges directed at financing proposals aimed at establishing any mechanism related to nuclear fuel supply assurances.

(xv) Participation in any multilateral nuclear fuel supply arrangements should be on a voluntary basis.

(xvi) A nuclear fuel bank should function as a back up to the well functioning fuel market which has proven to be successful and problem free. The nuclear fuel bank should create an additional option for Member States.

(xvii) Member States should be able to obtain nuclear fuel in a predictable, stable and cost effective manner without undue interference. In order to avoid interference some nonsupplier states are of the view that production or storage facilities should not be under the control or jurisdiction of any state or group of states.

---

[6] John Thomson and Geoffrey Forden, "Multilateralism as a Dual-Use Technique: Encouraging Nuclear Energy and Avoiding Proliferation", The Stanley Foundation, 2008, p. 2.

(xviii) Reference to unforeseen disruptions in nuclear fuel supply assurance is what precipitates suspicion and distrust on proposed multilateral nuclear fuel supply arrangements and services.

(xix) For various reasons and national interest considerations the Russian, German and Nuclear Threat Initiative seem to be the most widely spoken of proposals.

(xx) Acceptance that the multilateralization of the nuclear fuel cycle could help in limiting the spread of the problem of dealing with problems at the back end of the nuclear fuel cycle such as spent fuel and radioactive waste.

(xxi) Mechanisms of determining the costs of nuclear fuel and associated services require attention.

In conclusion Ladies and Gentlemen I share the view that there is an urgent need for a new architecture of nuclear energy use and that this new framework[7] should seek to achieve the following:

- robust technological development and innovation in nuclear power and nuclear applications;
- a new multinational framework for the fuel cycle, both the front end and back end, to assure supply and curb proliferation risk;
- universal application of comprehensive safeguards and the additional protocol as the standard for nuclear verification, to enable the Agency to provide assurance about declared material/activities as well as the absence of undeclared material/activities;
- recognition of the linkage between non-proliferation and disarmament and therefore the need for concrete and rapid progress towards nuclear disarmament-through deep cuts in existing arsenals, downgrading of alert levels of deployed nuclear weapons, and the resuscitation of multilateral disarmament efforts-starting with bringing into force the CTBT and beginning negotiations on a verifiable FMCT;

[7] Tariq Rauf, "Assurances of Supply vs. Proliferation: A New Framework for Nuclear Energy", 2009, <www.nap.edu/openbook.php?record_id=12590&page=59>. The concept of a new nuclear-energy-use architecture is also mentioned in the statement by the United States delivered at the IAEA Board of Governors meeting on 5 March 2009 under the agenda item on any other business.

- a robust international nuclear security regime, in light of the diverse threats we face;
- an effective and universal nuclear safety regime, a cornerstone for any expansion in the use of nuclear power;
- sufficient funding for the Agency to meet its increasing responsibilities in an effective and efficient manner;
- the wider spread of nuclear material, technology and know-how, coupled together with the effects of globalization, will only reinforce the importance and value of effective, independent and objective verification function; and
- the nuclear renaissance need not significantly add to the verification work load of the IAEA, if States commit to a new verification standard, allowing the IAEA to optimize its safeguards activities.

Even if the fast flow of goods and technology including that for making nuclear weapons is increasingly making it harder to control nuclear material and nuclear material production, non-supplier states would take a long time to amass the required technical and material resources to master sensitive nuclear fuel cycle technologies due for example to the high costs of uranium enrichment and reprocessing.

As a number of countries, non-suppliers and those under the NATO security umbrella might head down the nuclear energy route in order not to be left behind from accruing nuclear energy benefits, the back end of the nuclear fuel cycle will continue to pose challenges just like dealing with tendencies fostering unequal rights to nuclear fuel products and services.

I thank you for your attention.

ANNEX B

STATEMENT OF THE G-77 AND CHINA

Statement of the G-77 and China during the IAEA Board of Governors, 15–18 June 2009, delivered by Ms. María de los Milagros Donna Raballo, Chargé d'Affaires, Permanent Mission of Argentina*

…

Agenda Item 6: Assurance of Supply

Madam Chair,

Regarding the issue of Assurance of Supply, on which documents GOV/2009/30, 31 and 32 are presented, the Group has always stated that there is a need for caution while addressing thoroughly the associated technical, legal and economic aspects, as well as the underlying political dimensions of this issue. So that any proposal that eventually emerges in this regard is in full accordance with the Statute and takes into account the respective legal obligations of Member States, and the principle of non-discrimination. Therefore, the Group is of the view that no decision or recommendation can be made regarding this issue at this stage. However, the Group would like to put on record the following preliminary ideas and concerns.

The Group reiterates that concerns related to nuclear proliferation must not in any way restrict the inalienable right of all States to develop all aspects of nuclear science and technology for peaceful purposes, in particular given its relevance for the sustainable socio-economic uplift of developing nations. The Group, in principle, reiterates its strong rejection of any attempts aimed to discourage the pursuit of any peaceful nuclear technology on the grounds of its alleged "sensitivity".

---

* The full text of the statement is available at <www.g77.org/vienna/IAEAJUNEBOARD09.htm>.

The Group is of the view that any proposal for the assurance of supply should not be designed in a way that discourages States from developing or expanding their capabilities in the area of the nuclear fuel cycle, nor to hamper research and development and international cooperation in the field of peaceful nuclear activities. The Group reiterates that it is the sovereign right of all States without discrimination to develop or expand their capabilities in the field of peaceful nuclear activities including the nuclear fuel cycle.

The Agency should not lose its main focus on promoting the peaceful uses of nuclear science and technology, including national fuel cycle capabilities, through national capacity building and transfer of technology. Any proposal which may contain any element that is not in full accordance with the IAEA Statute cannot be acceptable to the Group.

Furthermore, from a technical point of view, none of the proposals provide a proper assurance of supply of nuclear fuel. Rather they merely create a backup mechanism to provide LEU when the supply of fuel is disrupted for political reasons. However, having guaranteed access to LEU will not help the recipient states because they require a supply of nuclear fuel assemblies to load into their power reactors. In practical terms, this would mean that it will be impossible on a short notice to supply nuclear fuel where required through the proposed backup mechanisms, especially if the receiving State does not possess fuel fabrication plants. Another difficulty of a legal nature derives from the fact that fuel assemblies and their fabrication methods normally are proprietary technology belonging to the reactor manufacturer.

The proposals do not address the supply of natural uranium which fuels a large number of reactors world over. The Group believes that it is important to address this issue in order to dispel perceptions that the real aim of these proposals is to restrict and discourage States from developing or expanding their national enrichment capabilities on the ground of their alleged "sensitivity" instead of providing a technically viable assurance of supply of nuclear fuel.

The reliability of the triggering mechanism under the proposals also needs further reflection. The State that disrupts supplies can easily claim that any disruption was due to technical or commercial considerations, thereby blocking the possibility to resort to the suggested mechanisms within the

framework of the Agency. Furthermore, there can be no real guarantee that a State that has interrupted the commercial supply of fuel will not attempt to block the triggering of backup mechanisms within the Agency.

As far as the financial implications are concerned, the proposal to establish an Agency LEU Bank will surely entail significant financial burdens both for its associated initial establishment and for its maintenance and operation. Unless the political considerations as well as the technical and practical limitations stated above are sufficiently addressed, such a mechanism and its related funding, even if totally dependent on extrabudgetary resources, will divert high level attention while having very little added value to the Member States.

In this connection, the Group recognizes that the unilateral proposal put forward by the Russian Federation might entail less financial burdens as far as the Agency is concerned. However, the costs related to the conclusion and the implementation of the relevant agreements should be carefully assessed against the background of the actual reliability of the assurance provided for in this proposal.

Regarding the eligibility criteria, the above mentioned documents are not in conformity with the Statute or the legal obligations of Member States. For example, they make access to the backup mechanisms conditional upon a Member State being one "with respect to which … no specific report relating to safeguards implementation …. is under consideration by the Board of Governors". The Group is of the view that this is not an acceptable or credible eligibility criteria. For example, there have been cases where specific safeguards reports were issued in response to allegations, and other cases where these reports contained requests for Member States to take measures that exceed their legal obligations. The Group believes that these reports cannot form the basis for an eligibility criteria.

The Group stresses that any further consideration of the issue of assurances of supply of nuclear fuel must be based on a coherent and comprehensive conceptual framework that adequately addresses the views and concerns of all Member States.

In light of the above, regarding the recommended action in document GOV/2009/30, the Group does not consider that the document presents

a coherent and comprehensive conceptual framework that can form a basis for a more detailed proposal for an IAEA LEU bank to be brought forward for the Board's consideration. The Group maintains its view that the various technical, economic, legal, and political considerations need to be properly addressed in a transparent and open-ended manner.

The Group also stresses the importance of strict adherence by the Secretariat to the Rules Regarding the Acceptance of Voluntary Contributions as approved by the General Conference on 21 September 2001. Given the above-mentioned considerations, the Group finds it premature to authorize the Agency to accept any financial pledges directed to finance the proposed LEU bank. The Group underscores that the mere availability of extrabudgetary resources does not in itself justify rushing the Secretariat into engaging in new activities unless duly approved.

Furthermore, regarding the recommended action in document GOV/2009/31, the Group does not consider that the document contains a comprehensive conceptual framework that can form a basis for developing the draft model agreements that could be approved by the Board on this proposal.

On document GOV/2009/32 regarding the Proposal of Germany, the Group stresses that an intergovernmental organization such as the IAEA should not administer a commercial company for the supply of nuclear fuel or enrichment services.

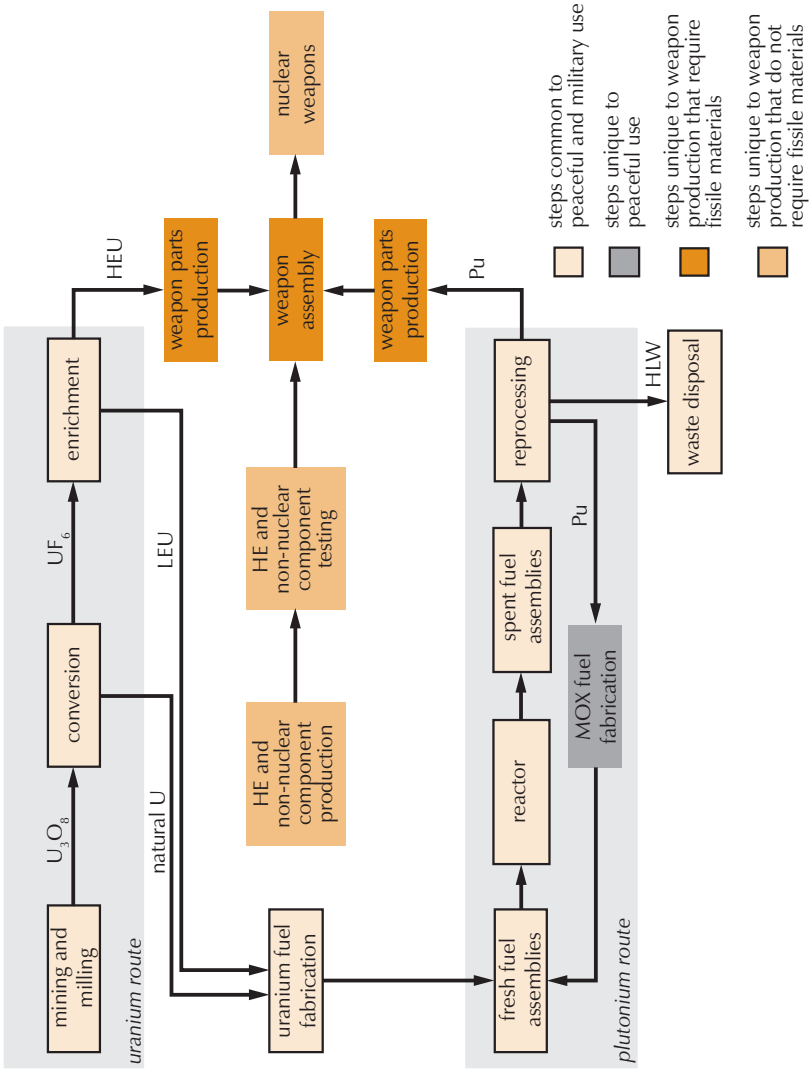
Based on the above views and concerns, the Group reiterates that no decision or recommendation can be made regarding this issue at this stage. The Group is not in a position to endorse any of the proposals contained in the above mentioned documents.

Finally, the Group recommends that, subject to the provisions of the Statute, any decision regarding the implementation of these proposals be taken by consensus by the General Conference, to take into account the views and concerns of all Member States.

Thank you, Madam Chair.

ANNEX C

OVERLAP OF NUCLEAR ENERGY AND NUCLEAR WEAPON PRODUCTION CYCLES



ACRONYMS

AP	Additional Protocol
CSA	comprehensive safeguards agreement
GCC	Gulf Cooperation Council
GNEP	the US Global Nuclear Energy Partnership
GNPI	the Russian Global Nuclear Power Infrastructure
HEU	high-enriched uranium
HLW	high-level wastes
IAEA	International Atomic Energy Agency
LEU	low-enriched uranium
LWR	light water reactor
MESP	the German Multilateral Enrichment Sanctuary Project
MOX	mixed-oxide fuel
NAM	Non-Aligned Movement
NNWS	Non-Nuclear-Weapon State(s)
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
NSG	Nuclear Suppliers Group
NTI	Nuclear Threat Initiative
NWS	Nuclear-Weapon State(s)
UNIDIR	United Nations Institute for Disarmament Research