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PLANNING PROLIFERATION:
THE GLOBAL EXPANSION OF NUCLEAR POWER AND MULTINATIONAL APPROACHES

The most effective way of reducing the risk of nuclear weapons proliferation is to reduce the number of nations that will base their energy needs on nuclear energy."
Joseph Rotblat

"Essentially, the non-proliferation regime has a choice to make: end the discriminatory system either by making the technology available to all or by foreclosing the option for all. The correct choice is obvious."
Paul Leventhal

"If the world does not change course, we risk self-destruction."
Mohamed ElBaradei

May 18th 2010

Frank Barnaby and Shaun Burnie

Commissioned by Greenpeace International

Front page quotes:

Professor Joseph Rotblat, Nobel Peace Prize winner, resigned from the Manhattan project, former President of the Pugwash group, see, Internationalization to Prevent the Spread of Nuclear Weapons, ed. Barnaby, Jasani, Goldblat, Levinson and Rotblat, Stockholm International Peace Research Institute, 1980.

Paul Leventhal, President of the Nuclear Control Institute, Washington DC, see, "Cirus reactor's role in a U.S.-India nuclear agreement" Presentation to Center for Nonproliferation Studies, Washington, DC, December 19th, 2005.

Dr Mohamed ElBaradei, IAEA Director General, joint winner Nobel Peace Prize with IAEA, "Saving Ourselves From Self-Destruction" New York Times, February 2004.

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List of Tables, Textboxes, Charts and Graphics

EXECUTIVE SUMMARY

The greatest proliferation danger that will result from the growth of nuclear power will be the production of plutonium. A 1000MWe reactor loaded with around 100 tons of low-enriched uranium fuel, will produce around 230-260kg of plutonium each year of operation. It requires around 5kg of this so-called reactor grade plutonium to make one nuclear weapon.[1] Even one commercial Light Water Reactor (LWR) will provide a state with sufficient plutonium for tens of nuclear weapons each year. The proposals for revising the nuclear non-proliferation regime will fail to address this fundamental problem. The states, which are proposing changes to the current regime with the stated aim of restricting access to uranium enrichment technology, are those with the largest existing stocks of weapons plutonium while also promoting global nuclear power expansion.

The report looks at the ability of states with any amount of nuclear power to separate plutonium through the operation of a clandestine reprocessing facility. Whereas more than 250,000 tons of spent fuel from nuclear power reactors remain in storage, 100,000 tons have already been reprocessed in large commercial reprocessing facilities. While most future reprocessing is likely to take place in existing plants, states operating nuclear power plants will have the option to extract or separate the plutonium in small clandestine facilities. Designs and assessments made by U.S. nuclear research institutions conclude that such facilities could be built in less than six months, with plutonium capable of being used in nuclear weapons available within days of operation.[2] All of this – removal of spent fuel from reactor storage ponds, to construction and operation of clandestine facilities could take place without detection by the International Atomic Energy Agency (IAEA). The proliferation implications of global expansion of LWRs is largely ignored by the international non-proliferation community, dominated as they are by commercial nuclear interests.

This report assesses proliferation implications of the large scale growth of nuclear power, the development of fuel cycle needs, including laser enrichment, and the effect of proposed new mechanisms for controlling international nuclear trade, through so-called Multilateral Nuclear Approaches (MNAs).

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1 The critical mass of a bare sphere of typical reactor-grade plutonium is about 13 kilograms compared with about 10 kilograms for weapon-grade plutonium. Both have an alpha-phase metal of density 19.6 grams per cubic centimetre. The use of a reflector a few inches thick (of say uranium) would reduce the critical mass by at least a factor of two, to say 5 or 6 kilograms. Fast implosion technology would reduce it more. For analysis on reactor grade plutonium and nuclear weapons use See, J. Carson Mark, Explosive Properties of Reactor-Grade Pluto Science and Global Security, Vol.4, pp.111-128, Vol.4, pp.111-128, 1993

2 See, A fresh examination of the proliferation dangers of light water reactors, Gilinsky, Miller and Hubbard. Victor Gilinsky, Marvin Miller, and Harmon Hubbard, The Nonproliferation Policy Education Center, Washington, D.C., 22nd October 2004.

Multilateral Approaches to the Nuclear Fuel Cycle

Plans to expand nuclear power face many obstacles in the coming decades, including economics, radioactive waste and reactor safety. However, in recent years governments and international bodies have been confronted with the inherent link between commercial nuclear power and nuclear weapons proliferation. Disclosures over the past ten years of the global reach of the A.Q Khan uranium enrichment network, North Korea's nuclear weapons development and the dispute over Iran's nuclear program have raised the proliferation of nuclear technology to the centre of international diplomacy. This reality directly undermines the prospects for the global expansion of nuclear power. However, rather than reconsidering the wisdom of expanding nuclear power, leading nuclear export nations and the IAEA have proposed new mechanisms for controlling international nuclear trade, through so-called MNAs to the nuclear fuel cycle. Except these are not new ideas. Throughout the seven decades of the nuclear age, mechanisms have been proposed to permit expansion of nuclear power while seeking to minimise proliferation hazards. None of the past proposals have ever materialized. Many of the same obstacles that prevented past MNAs from being established remain today. However, this history has not deterred a few states and the IAEA leadership from pushing MNAs to the front of the non-proliferation agenda.

The MNAs are being proposed with the stated aim of providing assurance to nuclear reactor operators that they will have access to nuclear supplies, in particular low enriched uranium, while at the same time discouraging them from developing their own nuclear fuel cycle facilities. The technologies of particular concern are uranium enrichment and plutonium reprocessing. Both capable of producing nuclear material that can be used for peaceful energy production, enrichment and reprocessing technology can also provide the material for nuclear weapons. Through deployment of MNAs, those proposing them contend that nuclear power can be expanded globally while at the same time reducing the risk of nuclear weapons proliferation.

The report reviews the history of past attempts to control atomic energy in the interests of non-proliferation through multinational arrangements, and why they failed. From the immediate post-war period the threat of nuclear proliferation resulting from peace fission energy was understood. The Acheson-Lilienthal report prepared for U.S. President Truman, called for international control of all aspects of the nuclear fuel cycle. including power plants, as the only way of minimizing proliferation risks. Their recommendations were never accepted. Instead through President Eisenhower s Atoms for Peace, the formation of the IAEA in 1957, and the drafting of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), nuclear energy was promoted worldwide, with multinational approaches cited to varying degrees as a non-proliferation measure worth exploring. By the 1970's, and in particular in the aftermath of India's nuclear weapons test in 1974, multinational approaches were considered in great detail, led by the IAEA. Right through into the late 1980's these issues were analysed and debated by governments while the nuclear industry generally opposed any possible limitation on their operations. Economic and political factors prevented any of these proposals from being realised.

This report then summarizes the proposals put forward since 2003 when the then IAEA Director Mohamed ElBaradei warned that the non-proliferation regime was close to collapse.[3] As a result of the spread of nuclear power during previous decades, 35-40 nations were capable of developing nuclear weapons, warned the IAEA Director. ElBaradei argued that if global nuclear power expands to meet the challenge of climate change, many more nations would have the ability to develop nuclear weapons and that therefore a new approach to non-proliferation was required. The resulting IAEA Expert Report on MNAs recommended a range of measures from strengthening existing commercial markets, developing supply arrangements with IAEA backing, to conversion of national facilities to multinational control, to the construction of new facilities under multinational control.[4]

Of all the MNA proposals put forward so far, two have advanced the furthest. These are a proposal for an IAEA nuclear fuel bank, possibly located at the Ulba Metallurgical Plant in Ust Kamenogorsk, Kazakhstan,[5] and the Russia proposal for an International Uranium Enrichment Center, IUEC, located at the Angarsk Electrolysis Chemical Complex (AECC).[6] An IAEA fuel reserve has also been proposed to be located at the Angarsk site.

The proposals for MNAs have generated hostility from developing states concerned that they will constrain their options to develop nuclear energy including uranium enrichment and reprocessing. Opposition to MNAs is driven by a combination of factors. The opposition to MNAs from major developing nations is in part based on the legitimate grievance of an already discriminatory non-proliferation regime being made more so in the future. However, many of those most vocal in their opposition are planning or considering the construction of nuclear reactors, which will give them access to weapons-usable plutonium. There exists frustration that the bargain enshrined in the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) is being threatened by MNAs. This resentment is made worse when states outside the NPT, in particular India[7], are being provided access to the global nuclear market with no non-proliferation benefit. At the same time, some of those states opposing MNAs have a nuclear self-interest, with MNA proposals prompting South Africa, Argentina and Brazil to announce plans to develop uranium enrichment. The fundamental contradiction of the NPT promoting nuclear power expansion that provides states the means to develop nuclear weapons is highlighted by MNA proposals but not

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3 ***"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.", ElBaradei, The Economist.*** Statement by Director General to the 47th Regular Session IAEA General Conference, September 2003; these points were further explained in Towards a Safer World by IAEA Director General Dr. Mohamed ElBaradei, Op-Ed, published in The Economist 16 October 2003.

4 See, INFCIRC/640 - 22 February 2005.

5 See, International Fuel Bank – helping world peace, BBC, January 8th 2010, www.bbc.co.uk/1/hi/8445539.stm

6 See, Communication received from the Resident Representative of the Russian Federation to the IAEA on the Establishment, Structure and Operation of the International Uranium Enrichment Centre INFCIRC/708 8 June 2007. The venture as of 2009 had two shareholders, Russia's Tenex and Kazakhstans, Kazatomprom. Armenia has also signed up to the venture.

7 See, The U.S. India nuclear cooperation agreement – the end of the nuclear non-proliferation regime? A report commissioned by Greenpeace Germany, Shaun Burnie, August 28th 2008. http://www.greenpeace.de/fileadmin/gpd/user_upload/themen/frieden/The_US_India_nuclear_cooperation_agreement.pdf

challenged.

The report will relate the proposed MNAs to the existing complex and secretive international nuclear fuel market. The conclusion reached is that proposed MNAs will have no significant role in the nuclear fuel market other than at the margins with newly emerging nuclear states. As far as new uranium enrichment, apart from the highest growth scenarios for nuclear power, existing and planned uranium enrichment plants will be capable of meeting projected demand in the coming two decades. The multibillion-dollar nuclear fuel market overwhelms in scale any prospects for MNAs. Also there are doubts about the practicality of the IAEA being able to make judgements in disputes prior to approval of access to multilateral holdings.

The one MNA that has been endorsed by the IAEA Board of Governors is the Russian IUEC at Angarsk, despite opposition from major developing nations.[8] The report details how rather than being driven by non-proliferation concerns, Russia is using the facility to further enable its strategy of capturing a larger share of the global nuclear market. This is intended to fund its domestic expansion of its nuclear program including Generation IV fast breeder reactors. With ambitions to import thousands of tons of spent fuel for reprocessing and disposal, secure new sources of uranium, and build nuclear reactors, Russia is also aiming to increase its share of the global enrichment market. By promoting itself as playing a positive non-proliferation role it is seeking to create a mirage. One imminent prospect is that Russia will secure a first of its kind nuclear cooperation agreement with the United States, with active support from the Obama administration.[9] President Putin's ambitions to create a so-called Global Nuclear Power Infrastructure is being aided by the IAEA and those promoting MNAs the consequences of which will be to make worse an already dire situation within Russia's nuclear security and safety infrastructure and environment, while also increasing nuclear proliferation threats.

Nuclear power proliferation

The assessment made in this report is that if there is an increase in nuclear power, and it is a big if,[10] the largest share will take place in those states already operating reactors. However, even if only a fraction of the unreliable high nuclear growth projections materialises, it will lead to increased proliferation due to the higher volumes of spent fuel containing weapons-usable plutonium. While global nuclear energy projections show that nuclear power will play an insignificant role in meeting developing countries electricity needs, it will provide many more countries access to nuclear weapons material. The proposed MNAs will play no role in preventing this new global threat.

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8 IAEA Board Backs Russian Fuel Bank Proposal, Deutsche Presse-Agentur, November 30th 2009, www.globalsecuritynewswire.org/gsn/nw_20091130_7814.php

9 Obama rekindles nuclear deal with Russia, Daniel Dombey, May 12th, 2010, http://www.ft.com/cms/s/0/ed253d6e-5d5d-11df-8373-00144feab49a.html

10 See, The World Nuclear Industry Status Report 2009 With Particular Emphasis on Economic Issues Mycle Schneider, Steve Thomas, Antony Froggatt, Doug Koplow, and Julie Hazemann, commissioned by the German Federal Ministry of Environment, Nature Conservation and Reactor Safety, August 2009.

The focus of those promoting the multinational approach to the fuel cycle is centred on uranium supply and enrichment. Very few states new to nuclear power are likely to build uranium enrichment facilities and will rely instead on the existing market. That said there is a significant risk that new laser enrichment technology being developed by a U.S.-Japanese-Canadian partnership, which could be less expensive than gas centrifuge, and for which no effective safeguards system exists, will proliferate to a number of countries.[11]

As with today, the largest concentrations of weapons material will take place in the existing nuclear states. In the case of North-east Asia and South Asia regional proliferation dynamics are already threatening greater nuclear weapons proliferation. Nuclear power expansion will make this situation worse.

Conclusion

> "***The more countries which have the potential to make nuclear weapons, the greater the likelihood of these weapons being used in a conflict...From the point of view of proliferation it is not the power output but the number of countries involved that matters."***[12]

When Joseph Rotblat wrote these words more than 30 years ago, multinational approaches to the nuclear fuel cycle were like today high on the diplomatic agenda. The IAEA and nuclear industry in the 1970's projected hundreds and eventually thousands of new nuclear power plants worldwide, including in the developing world. Those same forces are still at work today, promoting nuclear expansion and multinational approaches, while the crisis in the non-proliferation regime is greater. The nuclear industry and the IAEA need the non-proliferation veneer of MNAs to the fuel cycle to legitimize their 21st century plans for nuclear power expansion. But the warning from Nobel prize winner Rotblat is even more relevant today. The proliferation threat will not be resolved by MNAs, but through nuclear disarmament, a Comprehensive Fissile Material Treaty[13] and the global phase out of nuclear power. The inalienable rights of humanity are to have their long term interests protected by their governments. Nuclear energy with or without MNAs, puts that future under severe threat.

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11 The development of the Global Laser Enrichment Commercial Facility (GLE-CF) in North Carolina, U.S. directly threatens efforts to curtail enrichment technology proliferation, see, Request to prepare nuclear nonproliferation impact assessment for laser enrichment technology, Michael F. Weber, Director office of Nuclear Material Safety and Safeguards docket no.: 70-7016, U.S. Nuclear Regulatory Commission, Washington DC. response to Tom Clements, Nuclear Campaign Coordinator, Southeastern Office, Columbia South Carolina, Friends of the Earth U.S., March 15th , 2010.

12 Professor Joseph Rotblat, Nuclear Proliferation: arrangements for international control, in Nuclear Energy and Nuclear Weapon Proliferation, Ed. Barnaby/Goldblat/Jasani/Rotblat, Stockholm International Peace Research Institute, SIPRI, 1979.

13 In 1994-5 Greenpeace International lobbied the Conference on Disarmament in Geneva to negotiate a comprehensive fissile material treaty. Due to the politics of the CD, no progress has been made since the agreement of the Shannon mandate in April 1995. In 2006, Greenpeace International presented to CD delegates a draft comprehensive treaty (originally prepared in 1997), see, http://www.greenpeace.org/international/Global/international/planet-2/report/2006/4/comprehensive-fissile-material.pdf

1. INTRODUCTION

Plans to expand nuclear power face many obstacles in the coming decades, including economics, radioactive waste and reactor safety. However, a further impediment to global nuclear power expansion is the linkage between nuclear power and nuclear weapons proliferation.[14]

In the mid-1940's, several years before the first commercial nuclear reactor began operation, it was understood that widespread nuclear reactor operation would lead to the proliferation of nuclear weapons. After seven decades of the atomic age that linkage between nuclear power to generate electricity and nuclear weapons remains unbroken.

While the nuclear industry seeks to deny and would prefer to ignore that linkage, the major industrialised powers and international institutions, in particular the International Atomic Energy Agency (IAEA) have adopted a different approach.

The IAEA position is that nuclear power can and must be expanded to meet the global energy challenge and climate change but that such an expansion will have proliferation consequences. The solution being proposed by the IAEA and leading industrial nuclear power nations is to establish multinational mechanisms for assuring nuclear fuel supply, and that having received this assurance, states would not embark on the construction and operation of sensitive nuclear facilities, in particular uranium enrichment plants and plutonium reprocessing facilities. The underlying motive of governments and the IAEA is to convince themselves and the wider international community that nuclear power growth is possible without increasing proliferation risks. The proposals announced in the last five years under the banner of Multinational Approaches (MNAs) to the nuclear fuel cycle have permitted politicians and commentators to claim that the proliferation problem can be contained in a world with hundreds and eventually thousands more nuclear reactors.

What is poorly understood, or conveniently forgotten, is that such proposals have run as a constant through the past seven decades of the nuclear age. They have ebbed and flowed as the international context has evolved. Today's context has parallels with the 1970's. Then as now, governments and the IAEA promoted nuclear power growth to meet the energy challenge. Then it was the oil crisis, today it is climate change and the need for low carbon energy. Like today, projections for reactor numbers were measured in the thousands. But against this background along came a proliferation challenge. In 1974 it was India's first nuclear weapons test, utilising technology and materials provided by the U.S., Canada and others through atoms for peace. It exposed the inherent threat of widespread access to peaceful nuclear technology and was seen as a direct challenge to the future prospects of nuclear power. Today it is Iran's nuclear program that sits atop the non-proliferation agenda of the major nuclear powers. Iran is committed to developing a civilian nuclear infrastructure, including

14 See, Dual capable nuclear technology, Report ref no la rl2084-a Large and Associates, Greenpeace, 1995, available at http://archive.greenpeace.org/comms/nukes/nukes.html

uranium enrichment. This enrichment technology will in future provide it with feedstock for fuelling nuclear reactors, but also the means to produce highly enriched uranium capable of being used to make nuclear weapons.

As with the 1970's, today's world leaders, many of whom advocate expansion of nuclear power, are struggling to answer the question, how can tens of countries be provided with nuclear generation without at the same time giving them access to nuclear weapons materials? The solutions to this dilemma originally proposed in the 1940's and 1970's are now back on the international agenda.

It will be the contention of this paper that concern over nuclear power growth and its proliferation consequences is correct. It will lead inevitably to greater nuclear proliferation. However, the proposed solutions will have no impact on reducing the risks, but actually will increase them. The very states that are proposing a new non-proliferation regime are in fact driving proliferation. These states base their domestic energy policy on nuclear power expansion and nuclear exports, and thereby encourage the uptake of nuclear power in the developing world. At the same time these same states highlight proliferation threats and adopt a counter productive policy of selective discrimination in access to nuclear technology. Atomic schizophrenia would be its clinical term. As a consequence the international nuclear non-proliferation regime founded on flawed principals and encoded in the Treaty for the Non-Proliferation of Nuclear Weapons (NPT), is unsustainable.

The paper will firstly assess projections for nuclear power expansion and what that means in terms of proliferation. This will include a summary of current knowledge on proliferation hazards from light water reactors, specifically plutonium bearing spent fuel discharged from the reactor. The paper will then assess the proposals for international fuel cycle centres, including fuel banks, their prospects and impact on nuclear non-proliferation, including the NPT.

Textbox 1: Nuclear Power

Nuclear power factbox

The standard nuclear power plant operating today is the Light Water Reactor, LWR. It operates on low enriched uranium with an enrichment of between 3-4.5% of the fissile isotope U-235.To produce fuel suitable for loading into a nuclear power plant's reactor core, naturally occurring uranium must undergo the following manufacturing steps: (1) extracting and processing ore to produce uranium concentrate (U_3O_8), (2) conversion, (3) enrichment, and (4) fuel fabrication. These steps are referred to as the "front end" of the nuclear fuel cycle. In contrast, the management of spent fuel discharged from reactors is referred to as the "back end" of the nuclear fuel cycle and includes plutonium reprocessing, and spent fuel storage.

Enrichment is the process of concentrating the fissile isotope of natural uranium, U235 (0.711% by weight in natural uranium). Higher concentrations of U235 make nuclear fission chain reactions easier to maintain. LEU (less than 20% U235) allows some nuclear reactor designs to produce sustained power for electricity production, while HEU (greater than 20% U235) allows the possibility that a chain reaction will exponentially increase, resulting in a nuclear explosion.

Currently, the world enrichment capacity is approximately 55.7 million kilogram separative work units (kg SWU, often referred to merely as SWU) per year, with 22.5 million in gaseous diffusion and 33.2 million in gas centrifuge plants. Plants to produce another 33.9 million SWU/year are under construction or planned for the near future, almost entirely using gas centrifuge separation.

Plutonium reprocessing refers to the chemical separation of plutonium contained in spent or used nuclear reactor fuel. The plutonium is produced as a result of neutron capture by the uranium isotope U238. Originally developed as a technology for acquiring plutonium for nuclear weapons use, large scale commercial reprocessing today takes place in large industrial chemical plants in the UK, France, Japan and Russia. As a result of this reprocessing, commercial stockpiles of plutonium are approximately 250 tonnes. After reprocessing most plutonium is stored in the form of plutonium dioxide. A percentage of this plutonium is fabricated into Mixed Oxide fuel or MOX – a combination of plutonium dioxide (4-8%) and uranium dioxide. This MOX fuel is then loaded into a commercial nuclear reactor.

The plutonium produced in commercial nuclear power plants is so called reactor-grade plutonium. It contains a higher proportion of the isotope plutonium-240 than that preferred by nuclear-weapon designers. Typical reactor-grade plutonium contains 1.3 per cent plutonium-238, 56.6 per cent of plutonium-239, 23.2 per cent of plutonium-240, 13.9 per cent plutonium-241, and 4.9 per cent plutonium-242. Nuclear-weapon designers prefer plutonium containing, typically, 0.012 per cent of plutonium-238, 93.8 per cent of plutonium-239, 5.8 per cent of plutonium-240, 0.35 per cent of plutonium-241, and 0.022 per cent of plutonium-242, called weapon-grade plutonium. The major difference is that weapon-grade plutonium is richer in plutonium-239 and poorer in plutonium-240 than weapon-grade plutonium.

Despite these differences, reactor-grade plutonium produced in today's Light Water reactors is capable of being used to manufacture nuclear weapons.[15]

For details on uranium enrichment see: Uranium Enrichment and Nuclear Weapon Proliferation by Allan S. Krass, Peter Boskma, Boelie Elzen and Wim A. Smit; also A fresh examination of the proliferation dangers of light water reactors Victor Gilinsky Marvin Miller Harmon Hubbard October 22, 2004 The Nonproliferation Policy Education Center

15 See, J. Carson Mark, Explosive Properties of Reactor-Grade Pluto Science and Global Security, Vol.4, pp.111-128, Vol.4, pp.111-128, 1993, and section of this report below.

2. NUCLEAR POWER GROWTH AND PROLIFERATION

The global expansion of nuclear power for peaceful purposes will lead to the production of tens of thousands of tonnes of spent fuel containing plutonium capable of being used for nuclear weapons. This section looks at the ability of states with any amount of nuclear power reactors to separate plutonium through the operation of a clandestine facility. The probability of the nuclear growth projections of the IAEA, World Nuclear Association becoming reality is low.[16] Whatever the future for nuclear power there is already a very large stockpile of spent fuel containing more than 1300 tonnes of plutonium.[17] Any plans to expand nuclear power will inevitably lead to an increase in spent fuel and plutonium. Whereas more than 250,000 tonnes of spent fuel remains in storage, 100,000 tonnes has been reprocessed in large commercial reprocessing facilities. While future reprocessing is likely to take place in existing plants, states operating nuclear power plants also have the option to extract or separate the plutonium in small clandestine facilities. Designs and assessments made by U.S. nuclear research institutions conclude that such facilities could be built in less than six months, with plutonium capable of being used in nuclear weapons available within days of operation. All of this – removal of spent fuel from reactor storage pond, to construction and operation of clandestine facilities could take place without IAEA detection. The proliferation implications of global expansion of light water reactors, which produce hundreds of kilograms of reactor-grade plutonium capable of being used to manufacture nuclear weapons is largely ignored by the international non-proliferation community.

2.1 Nuclear power and plutonium

To understand the proliferation hazards from the global expansion of nuclear power, first some basics. The majority of the worlds commercial nuclear power plants, Pressurized or Boiling Light Water Reactors (LWR's) operate with uranium fuel enriched with around 3% U-235. As a result of reactor operation, a proportion of the natural uranium element U-235, through neutron capture, becomes plutonium. A 1000MWe reactor loaded with around 100 tonnes of low-enriched uranium fuel, will produce around 230-260 kg of plutonium each year of operation. The reactor operator typically shuts down the plant following 12-18 months of operation. During this period, between 25-30% of the reactor fuel is replaced with fresh fuel. The discharged or spent fuel weighing 25-30 tonnes, contains around 1% plutonium. A typical low-enriched uranium spent fuel element weighing 650 kg will contain about 4-5 kg of plutonium. It requires around 5kg of this so-called reactor grade plutonium to make one nuclear weapon.

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16 Opcit, Schneider, et al. See, The World Nuclear Industry Status Report 2009 With Particular Emphasis on Economic Issues Mycle Schneider, Steve Thomas, Antony Froggatt, Doug Koplow, and Julie Hazemann, commissioned by the German Federal Ministry of Environment, Nature Conservation and Reactor Safety, August 2009.

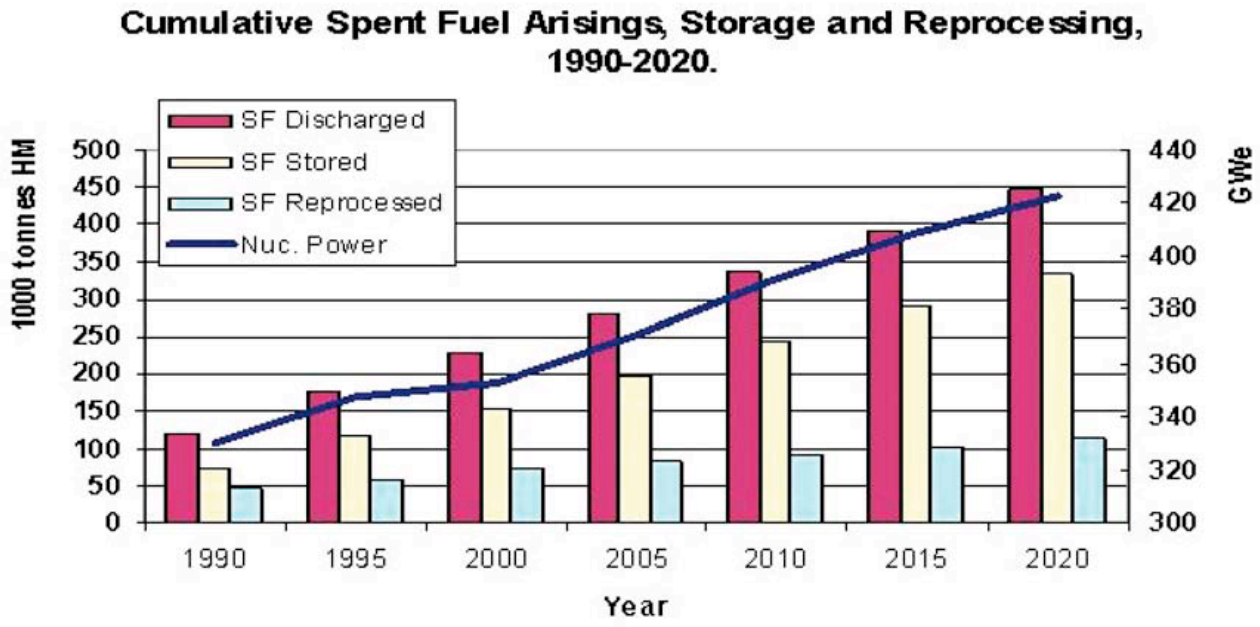
17 See, http://www.world-nuclear.org/info/inf15.html

One factor to be aware of is that the first discharge of spent fuel from an LWR will contain plutonium with a higher percentage of fissile plutonium. A typical LWR first core discharge will contain as much as 330 kg 84% Pu 239 – that is near weapons-grade and sufficient for 60 nuclear weapons.[18]

The global cumulative stocks of spent fuel generated over the past decades of commercial nuclear power plant operation, as of 2010, stand at around 340,000 tonnes. Around 250,000 tonnes of spent fuel remains in storage, in most cases at nuclear power plants. Just under 100,000 tonnes spent fuel has been reprocessed and the plutonium separated. As a result of commercial reprocessing, global stocks of reactor-grade weapons usable separated plutonium stands at around 250,000 kg, equal to all military stocks and sufficient for 50,000 nuclear weapons.

18 See, A fresh examination of the proliferation dangers of light water reactors, Victor Gilinsky Marvin Miller Harmon Hubbard October 22, 2004 The Nonproliferation Policy Education Center, http://www.npec-web.org/

Chart 1: Cumulative Spent Fuel Arisings, Storage Reprocessing 1990-2020, IAEA



Source: Costing of spent nuclear fuel storage IAEA Nuclear Energy Series No.NF-T-3.5, IAEA Vienna December 2009

Even without any new reactor operation, thousands of tonnes of spent fuel will continue to be discharged annually. However, the global expansion of LWR's will generate a great deal more spent fuel, and with it, plutonium.

3. THE CLANDESTINE REPROCESSING OF PLUTONIUM FROM LIGHT WATER REACTOR SPENT FUEL

The need to control nuclear technology and fissionable materials became clear in 1939 when it was shown that a fission chain reaction could be produced in uranium. It was soon foreseen that nuclear fission could be used to produce extraordinarily destructive weapons. This realisation led some of the scientists involved in the discovery of, and early research into, nuclear fission to suggest that exchanges of information about fission should be restricted in an attempt to prevent knowledge about fission from spreading.[19] The attempt failed.

It was apparent that secrets about nuclear technology and the materials needed to produce nuclear fission could not be confined to one nation. The development by the United States of nuclear weapons in the Manhattan Project during the Second World War and the post-war spread of nuclear weapons put paid to any hopes of keeping the genie in the bottle.

19 "The intrinsic link between peaceful and the military aspects of nuclear energy - the fact that it is impossible to generate electricity in a uranium based reactor without at the same time producing a nuclear weapon material, plutonium - means that eventually either civilization will be destroyed in a nuclear war or nuclear energy based on fission will have to be abandoned." Professor Joseph Rotblat, Nuclear Proliferation: arrangements for international control, in Nuclear Energy and Nuclear Weapon Proliferation, Ed. Barnaby/Goldblat/Jasani/Rotblat, Stockholm International Peace Research Institute, SIPRI, 1979.

Matters were made worse by the widespread use of civil nuclear-power reactors for the generation of electricity. This focused attention on the need to control plutonium as well as highly-enriched uranium, the two materials needed to fabricate nuclear weapons.

3.1 The reprocessing of plutonium from light water reactor spent nuclear-reactor fuel and MOX fuel

The large-scale separation of plutonium and uranium from LWR spent fuel requires the construction of large chemical reprocessing plants. Because of the presence of highly radioactive fission products in addition to plutonium and uranium, reprocessing of spent fuel must be done remotely or behind thick shields to prevent the workers at the plant being over exposed to the hazardous radiation emitted by the fission products.

A commercial plutonium-reprocessing plant is a complex industrial-scale process. All existing commercial reprocessing plants (in France, Russia, India, the UK, and Japan) use a chemical process called PUREX involving complex mixing and solvent extraction in a number of stages. The spent fuel is highly radioactive and it must be handled and processed remotely until the uranium and plutonium are separated in the early chemical stages. The first operation involves mechanically shearing or cutting the spent fuel elements into small lengths and dissolving them in tanks of concentrated nitric acid.

The fuel elements in LWRs are normally enclosed in stainless steel containers. The pieces of these containers (called waste hulls) removed during the shearing process are usually encapsulated in cement and stored and disposed of as radioactive waste. The nitric acid solution containing the dissolved spent fuel is allowed "to flow past another solvent stream that has an affinity for and so extracts the plutonium and uranium, leaving the radioactive fission products behind in the nitric acid stream".[20] In the solvent extraction stage of the PUREX process the solvent is an organic mixture of tributyl phosphate (TBP) and kerosene. After separation, the plutonium and uranium are purified using ion exchange. The efficiency of the recovery of the uranium and plutonium is normally as high as about 99 per cent. Three streams of liquid emerge from a reprocessing plant – solutions of uranium nitrate, plutonium nitrate, and fission products. The uranium and plutonium are then purified to a degree depending upon their ultimate use.

The plutonium is stored, usually as plutonium dioxide, some of which is used in the manufacture of Mixed Oxide or MOX nuclear reactor fuel. However, as a consequence of the failure of fast breeder programs which would have required fuelling with plutonium MOX, as well as the limited used of MOX fuel in LWR's, global stocks of plutonium unused has risen to over 250 tonnes.

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20 Opcit, A fresh examination of the proliferation dangers of light water reactors.

The nuclear weapon states developed specific types of reactors for producing plutonium for their nuclear weapons arsenals. Unlike today's LWR's they tended to be reactors (fuelled with natural uranium clad in aluminum or magnesium, and operated at relative low burn-up), such as the UK Magnox design. Historically they have been used specifically to produce weapons-grade plutonium (containing higher proportions of Pu-239). The concentration of weapon-grade plutonium in low burn-up uranium metal fuel is typically about 0.6 per cent, that is for every 100 tonnes of spent fuel, 600kg would be weapons-grade plutonium.

Plants used to reprocess fuel from these reactors, such as the B-205 plant at Sellafield and the North Korea facility at the Radiochemical Laboratory at Yongbyon, North Korea, are somewhat different from the reprocessing plants used to deal with fuel from high burn-up, enriched uranium oxide LWR fuel, such as the THORP plant at the Sellafield plant in the UK, La Hague plant in France, and the Rokkasho-mura plant in Japan.

The spent fuel elements of so-called lower burn up fuel can be decanned (decladded) chemically rather than mechanically and the plants need less shielding because they are less radioactive. But, because the low burn-up fuel contains less plutonium than the higher burn-up fuel, the reprocessing plant has to be physically larger for a given plutonium output. At Sellafield, for example, the B-205 plant is less complex but physically larger.

All the established nuclear-weapon countries (China, France, Russia, the UK, the USA, the P-5 countries) have operated PUREX reprocessing plants for nuclear-weapon fabrication, as have Israel (at Dimona), India (at Kalpakkam) and North Korea (at Yongbyon). Countries such as Iran have demonstrated that they have the capability to do so, if they took the decision to do so.[21]

Marvin Miller, a nuclear engineer at the Massachusetts Institute of Technology, has analyzed the difficulties a country with modest technological capabilities, such as North Korea, would have in clandestinely reprocessing spent reactor fuel, particularly fuel from LWRs. He concludes that countries that can operate LWRs

> ***"would generally be capable of building small-scale clandestine reprocessing plants"***.[22]

Miller calls these plants ***"quick and dirty"*** reprocessing plants. He reached this

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21 See, "In a letter delivered to the IAEA on October 21, 2003, Iran acknowledged that between 1988 and 1992 reprocessing-related experiments took place, irradiating a total of 7 kg of UO2 pellets, typically for two weeks at a time using the TRR reactor, in connection with a project to produce fission product isotopes of molybdenum, iodine, and xenon. According to the letter, the plutonium was separated at TNRC in three shielded glove boxes. Of the 7kg total irradiated UO2, 3 kg was processed to separate a small amount of plutonium." Assessing Iran's Plutonium cont/ reprocessing capabilities: a way to obtaining nuclear weapons material By Jack Boureston and Charles D. Ferguson FirstWatch International March 2003, http://www.iranwatch.org/privateviews/First%20Watch/perspex-fwi-plutoniumprocessing-0304.htm

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conclusion because: (1) such states have built and operated PUREX-type reprocessing plants, and (2) detailed commercial designs of small PUREX plants exist.

3.2 Designs of the Oak Ridge National Laboratory and the Sandia National Laboratory

Designs of "quick and dirty" reprocessing plants have been published by the U.S. Department of Energy's Oak Ridge National Laboratory in 1977 and by the Sandia National Laboratory in 1996. In 1978, the US General Accounting Office (GAO) evaluated the Oak Ridge report and concluded that without time constraints many non-nuclear-weapons countries have, or could acquire, the technical capability to build and operate reprocessing plants as described in the Oak Ridge report and such countries could recover weapons-usable plutonium from spent nuclear fuel.[23]

GAO concluded this because: there is considerable worldwide experience in building and operating reprocessing plants of various sizes, some of which are located in non-nuclear-weapons countries; and small reprocessing plants could be built by several countries by using materials and equipment that are commercially available. The GAO concluded that weapons-usable plutonium could be recovered from the reprocessing plants described in the Oak Ridge report.

The GAO stated that a country wanting nuclear weapons, but which did not have a commercial reprocessing plant, could extract enough plutonium from its spent LWR fuel to fabricate them.

The Oak Ridge report includes a plant diagram and a list of the equipment needed from the pool where the spent fuel is received to the last stage where the plutonium metal is produced. The plant would be 130 feet (40 metres) in length and much less in width. The plant, it is claimed, could be in operation within 4-6 months after the start of construction. The first 10 kg of plutonium metal would be available after one week of operation – sufficient for two nuclear weapons. Thereafter, it could reprocess one LWR assembly per day, yielding 5 kg or sufficient for a bomb per day. Of course the plant could be built in advance of any removal of LWR assemblies from reactor storage ponds, and without detection by the IAEA. The timeframe would be a matter of a few weeks from removal to separated plutonium capable of being used in nuclear weapons. The interval between safeguards inspection by the IAEA of spent fuel is currently 3 months, though the IAEA for the past few years has been seeking to increase the time interval to once every 12 months.[24] Even on today's inspection

23 See, Comptroller General of the USA, Quick and Secret Construction of Plutonium Reprocessing Plants: A Way to Nuclear Weapons Proliferation?, EMD-78-104, 6 October 1978.

24 These have been proposed for states that have signed a Comprehensive Safeguards Agreement (CSA) and an Additional Protocol (AP) with the IAEA, see, A fresh examination of the proliferation dangers of light water reactors Victor Gilinsky Marvin Miller Harmon Hubbard October 22, 2004 The Nonproliferation Policy Education Center.

routine the potential exists to remove spent fuel assemblies containing plutonium, either declaring to the Agency or doing it clandestinely, reprocess the fuel in a clandestine facility and fabricate a nuclear weapon between inspections.[25] A reduction to one inspection every 12 months gives even greater leeway to a would be nuclear state. As Sokolski and Miller have pointed out, IAEA surveillance cameras have only a limited view of the spent fuel area, and that 24 hour real-time monitoring remains not universal. Covert diversion of spent fuel is therefore possible.[26]

The Sandia design for a small reprocessing plant represents a

> ***"relatively simple process that might be operated by an adversarial group in makeshift or temporary facilities such as a remotely located warehouse or a small industrial plant".***[27]

Miller explains that:

> ***"The Sandia team also estimated the number and skills of personnel and the types of skills required to build and operate a facility to extract plutonium from LWR spent fuel using the suggested process as well as the length of time required to build and test the facility and operate it to produce 8 kg of plutonium...It was judged that 6 skilled people would be required"*** such as ***"one graduate chemist or chemical engineer, one mechanical engineer and one electrical engineer, or persons with equivalent experience"***.

The Sandia team estimated it would take about 6 months to prepare the plant and about another 8 weeks to produce the first 8 kg of plutonium.

Small reprocessing plants have been successfully operated clandestinely for a number of years by North Korea, at Yongbyon[28], and by Israel, at Dimona.[29] The North Korean plant is the larger of the two (about 190 meters long and 27 metres wide) and has a capacity to reprocess some 250 tonnes of spent fuel a year; the Dimona plant (housed in a building 60 metres long and 24 metres wide) has a capacity to reprocess

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25 Removal and inspection of spent fuel by plant operators and nuclear research institutions has been conducted by all major nuclear states. There are currently 367 so-called hot cells worldwide where inspection takes place. These hot cells conduct such things as shearing of weighed fuel pins, fuel treatment operations, dissolution of spent fuel, characterization and analysis in high-level radioactive media. Small scale separation of plutonium at microgram quantity is possible – not sufficient for nuclear weapons, but provising scientists with an understanding of plutonium chemistry Sixteen countries that operate hot cells are officially non-nuclear weapons states, with four declared weapon states – India, UK, France and Russia. The IAEA does not list the hot cells in the other declared weapon states. See, http://www-nfcis.iaea.org/PIE/PIEMain.asp?Order=1&RPage=1&Page=1&RightP=List One state that has raised proliferation fears that has conducted plutonium separation in hot cells is the Republic of Korea. See, Postirradiation examination of Kori-1 nuclear power plant fuels, Ro Seung-Gy, Kim Eun-Ka, Lee Key-Soon and Min Duck-Kee, Storage and Transportation Research Division, Nuclear Environment Management Center, Korea Atomic Energy Research Institute, Daeduk, South Korea, Journal of Nuclear Materials, Volume 209, Issue 3, May 1994.

26 Opcit, A fresh examination of the proliferation dangers of light water reactors.

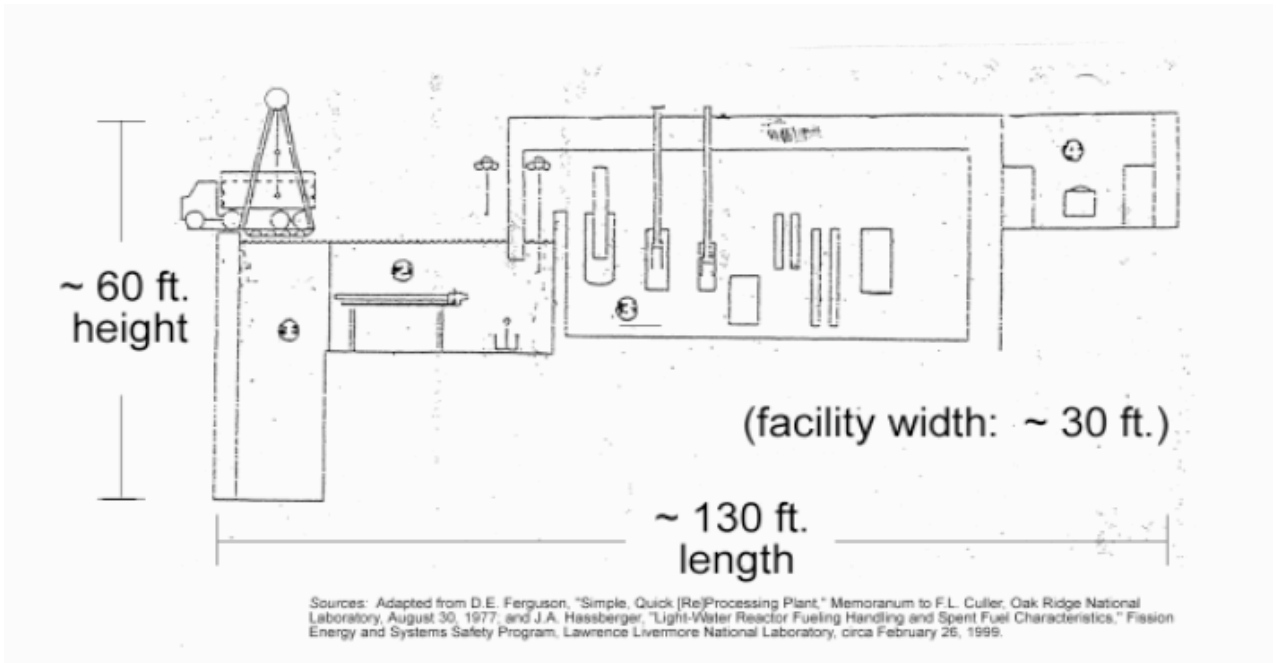
27 Sandia National Laboratories, Report number SAND97-8201, October 1996, Section 4.1.1.3 Recovery Process for LWR or MOX Spent Fuel.

28 See, Solving the North Korean Nuclear Puzzle, David Albright and Kevin O'Neill (eds.), The Institute for Science and National Security, Washington, D.C., Chapter VIII, pp.139-165.

29 See, The Invisible Bomb, Frank Barnaby, I.B.Tauris, London, 1989.

some 100 tonnes of spent fuel a year. Both plants reprocess spent fuel from Magnox-type natural uranium fuelled reactors. A plant of a capacity similar to the one at Dimona, reprocessing LWR spent fuel, could separate about 75 kg of plutonium a year from about 600 kg of spent fuel a year.

Graphic 1: Clandestine reprocessing facility Oak Ridge National Laboratory, U.S. DOE



This layout of small-scale clandestine reprocessing plant would be capable of separating sufficient plutonium each month for 20 nuclear weapons, following a ten day start up. See, Falling Behind: International Scrutiny of the Peaceful Atom Henry Sokolski Executive Director The Nonproliferation Policy Education Center Washington, DC 20036 www.npec-web.org npec@npec-web.org Briefing before American Association for The Advancement of Science Washington, DC March 24, 2008 http://cstsp.aaas.org/files/sokolskislides.pdf

Miller concludes that a small country with LWRs could with, high probability, reprocess clandestinely from a small plant enough plutonium to fabricate a few nuclear weapons without detection by the IAEA or by national intelligence. This is particularly true for the clandestine reprocessing of old spent fuel, which has been stored for many years, because, firstly, its lower radiation levels would present less problem of protecting personnel and, secondly, krypton-85 (a gas released by spent fuel and can be detected from outside it) which has a ten-year half-life and would have decayed to such an extent that it would be extremely hard to detect by a foreign or international agency.[30]

The implications of global LWR proliferation are clear to anyone who has read the Sandia, Oak Ridge, GAO and Miller reports. The IAEA remains utterly silent on the issue, as do governments actively supporting their nuclear industry export strategies. The scale of the current problem with several hundred operating nuclear reactors and 250,000 tonnes of spent fuel in storage is already a major proliferation problem

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largely ignored by policy makers. Projected growth of nuclear power, unrealistic as it is, will massively increase both the overall amount of plutonium available and the number of states with access to bomb material. Nuclear industry ambitions if realised would lead to millions of kilograms of plutonium sitting in 60-plus nations across the planet and capable of being reprocessed for weapons use within a matter of a weeks or a few months. The proposed MNAs to the nuclear fuel cycle, as we will see below, will provide nothing more than an illusion of non-proliferation protection.

3.3 The use of reactor-grade plutonium in nuclear weapons

World leaders recently gathered in Washington to address the issue of nuclear materials being used by states or sub-national/terrorist groups.[31] The headlines claimed that progress had been made. However, what was ignored was that the origin of much of the nuclear material is commercial nuclear power programs. The growth projections for commercial nuclear power plants in the so-called 'nuclear renaissance' if realised, will increase the availability of weapons material to an unprecedented level.

Plutonium production in commercial LWR's will be on an enormous scale. A proportion of this plutonium will be reprocessed in commercial reprocessing plants, but the majority will remain contained within the spent fuel. Those states new to nuclear power, perhaps as many as sixty if the IAEA is correct, will for the first time have access to nuclear weapons material contained in their nuclear reactor spent fuel. Most will opt to store the spent fuel, or seek to export it for disposal to another country, perhaps Russia. But some will retain the spent fuel, recognizing that they have a strategic asset that at some future date they could utilise either for generating electricity or manufacturing nuclear warheads. That this plutonium can be used by countries to fabricate effective nuclear weapons and by terrorists to make nuclear explosives is an obvious threat to global security. This proliferation crisis will be made worse by the IAEA and governments which today are promoting the multinational approach to the fuel cycle while also planning the expansion of the plutonium economy through increased MOX fuel use and the construction of Generation IV breeder reactors.

3.4 The nuclear security threat and commercial reactor grade plutonium

In April 2010, President Obama held a summit conference in which 47 countries agreed that

> ***"nuclear terrorism is one of the most challenging threats to international security"***.[32]

They set out a four-year timetable to collect and secure fissile materials usable to fabricate nuclear weapons. But the conference produced no binding agreements, and ignored the largest growing source of nuclear material – the commercial nuclear

31 See, http://www.america.gov/relations/nonproliferation.html
32 Ibid.

industry. While negotiating an effective agreement to achieve the security of weapon-usable fissile materials is today a huge challenge, the planned expansion of nuclear power and increased production of plutonium will make it impossible.

Undoubtedly the reason why nuclear power is being considered by some nations is that they want the option to acquire nuclear weapons, not yet, but perhaps at a later date. They also wish to retain the option of developing domestic uranium enrichment and/or reprocessing technologies. The right to develop these technologies is also asserted by those opposing MNAs to the fuel cycle such as Argentina, Brazil, South Africa, Egypt and Iran. (see below).

The question of whether or not the plutonium recovered from LWR spent fuel, so called reactor-grade plutonium, can be used to fabricate effective nuclear weapons has been the subject of much discussion since the end of the Second World War. It persists today even though there is very little doubt in the nuclear physics community that civil plutonium can be so used.

U.S. President Dwight Eisenhower's Atoms for Peace initiative in the 1950's, spread American nuclear knowledge and materials far and wide, believing that the proliferation risks could be contained. The belief that civil and military plutonium could be treated separately was inherent in the negotiation of the Nuclear Non-Proliferation Treaty (NPT) in 1967. This was in spite of the fact that civil and military nuclear technologies are identical.

Reactor-grade plutonium contains a higher proportion of the isotope plutonium-240 than that preferred by nuclear-weapon designers. Typical reactor-grade plutonium contains 1.3 per cent plutonium-238, 56.6 per cent of plutonium-239, 23.2 per cent of plutonium-240, 13.9 per cent plutonium-241, and 4.9 per cent plutonium-242. Nuclear-weapon designers prefer plutonium containing, typically, 0.012 per cent of plutonium-238, 93.8 per cent of plutonium-239, 5.8 per cent of plutonium-240, 0.35 per cent of plutonium-241, and 0.022 per cent of plutonium-242, called weapon-grade plutonium. The major difference is that weapon-grade plutonium is richer in plutonium-239 and with less plutonium-240 than reactor-grade plutonium.

As J.Carson Mark explained there are two major problems with using reactor-grade plutonium in a nuclear weapon.[33] Mark is undoubtedly an expert in the subject. He headed the Theoretical Division at the U.S. Los Alamos National Laboratory for decades and was intimately involved in the design of both nuclear fission weapons and thermonuclear weapons.

The first problem is that plutonium-240 has a high rate of spontaneous fission so that the device will continually produce many neutrons. One of these background neutrons may set off the fission chain reaction prematurely, a phenomenon called pre-initiation, causing the device to have a relatively low explosive yield when it is detonated. The spontaneous emission rate of reactor-grade plutonium is about 360 neutrons/second/gram. The figure for weapon-grade plutonium is about 66

33 See, J. Carson Mark, Explosive Properties of Reactor-Grade Pluto Science and Global Security, Vol.4, pp.111-128, Vol.4, pp.111-128, 1993

neutrons/second/gram. The probability of pre-initiation using reactor-grade plutonium is, therefore, much larger.

The second problem described by Mark is the heat produced by the alpha-particle decay of plutonium-238 in the plutonium. The energetic alpha-particles have a very short range in the plutonium, deposit their energy, and thereby heat up the plutonium.

The amount of plutonium-238 in reactor-grade plutonium is about one or two per cent. This contributes 10.5 watts of heat per kilogram of reactor-grade plutonium, compared with 2.3 watts per kilogram of weapons-grade plutonium. The design of a primitive nuclear explosive using reactor-grade plutonium would have to incorporate a method of dispersing the heat – such as the use of aluminium shunts (heat conductors). Otherwise, the core of a nuclear weapon using reactor-grade plutonium would get very hot and become distorted or even melt.

A larger amount of reactor-grade plutonium would be required to make a nuclear weapon than would be required if weapon-grade plutonium was used. The bare sphere critical mass of reactor-grade plutonium is about 13 kg; that of weapons-grade plutonium is 10 kg; in both cases these amounts apply to alpha-phase metal having a density of 19.6 grams per cubic centimeter. However, the use of a reflector a few inches thick (of say uranium) would reduce the critical mass of reactor-grade plutonium by at least a factor of two, to say 5 or 6 kg. Fast implosion technology would reduce it more.

Mark explained that, in spite of these problems, the difficulties of fabricating a nuclear weapon, of the most straightforward type, using reactor-grade plutonium is not much greater than those that have to be met if weapons-grade plutonium was used.

At a conference in Vienna in June 1997, Matthew Bunn, who chaired the U.S. National Academy of Sciences analysis of options for the disposal of plutonium removed from nuclear weapons, agreed with Mark.

> "***For an unsophisticated proliferator, making a crude bomb with a reliable, assured yield of a kiloton or more -- and hence a destructive radius about one-third to one-half that of the Hiroshima bomb -- from reactor-grade plutonium would require no more sophistication than making a bomb from weapon-grade plutonium. And major weapon states like the United States and Russia could, if they chose to do so, make bombs with reactor-grade plutonium with yield, weight, and reliability characteristics similar to those made from weapon-grade plutonium. That they have not chosen to do so in the past has to do with convenience and a desire to avoid radiation doses to workers and military personnel, not the difficulty of accomplishing the job"***.[34]

Mark's analysis was also supported by Richard L. Garwin, another leading American nuclear-weapon expert, who wrote that reactor-grade plutonium is usable in nuclear

34 Bunn, M, The US Program for Disposition of Excess Weapons Plutonium, Paper to International Atomic Energy Agency Conference, Vienna, June 1997.

weapons, whether by unsophisticated proliferators or by advanced nuclear-weapon states.[35] Garwin was a consultant for the Los Alamos National Laboratory from 1950 to 1993, mostly involved with nuclear weapon design, manufacture and testing.

He was an author of the report by the Committee on International Security and Arms Control of the U.S. National Academy of Sciences that concluded:

> ***"In short, it would be quite possible for a potential proliferator to make a nuclear explosive from reactor-grade plutonium using a simple design that would be assured of having a yield in the range of one to few kilotons, and more using an advanced design".***[36]

A report from a high-level panel of experts brought together by American Nuclear Society states that:

> ***"We are aware that a number of well-qualified scientists in countries that have not developed nuclear weapons question the weapons-usability of reactor-grade plutonium. While recognizing that explosives have been produced from this material, many believe that this is a feat that can be accomplished only by an advanced nuclear-weapon state such as the United States. This is not the case. Any nation or group capable of making a nuclear explosive from weapons-grade plutonium must be considered capable of making one from reactor-grade plutonium".***[37]

That reactor-grade plutonium can be used to fabricate nuclear weapons has also been recognized by the IAEA. Hans Blix, when Director-General of the IAEA, informed Paul Leventhal of the Nuclear Control Institute (NCI) that there is ***"no debate"*** on this point in the Safeguards Department of the IAEA, and that the agency considers virtually all isotopes of plutonium, including high burn-up reactor-grade plutonium, to be usable in nuclear weapons.[38]

A detailed description of the nuclear physics involved in the design of nuclear weapons was given by Amory B. Lovins in the British scientific journal Nature in 1980.[39] It gives the physical basis for understanding the scope for using reactor-grade plutonium in nuclear-fission weapons and shows that plutonium from nuclear-power reactors ***"can produce powerful and predictable nuclear explosions".***

That plutonium of lower quality than weapon-grade plutonium can be used to produce a nuclear weapon has been proved in practice by both the British and the Americans in tests designed specifically to prove that reactor-grade plutonium can be

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35 Richard L. Garwin, Reactor-grade plutonium canbeused to make powerful and reliable nuclear weapons: separated plutonium intheuel cycle must be protected as if it were nuclear weapons, Federation of American Scientists, August 26, 1998. www.fas.org/rlg/980826-pu.htm

36 Committee on International Security and Arms Control (CISAC) of the National Academy of Sciences, The Management and Disposition of Excess Weapons Plutonium, National Academy Press, Washington, DC (1994), pp32-33, text is available at http://www.nap.edu/readingroom/enter2.cgi?0309050421.html

37 American Nuclear Society, Protection and Management of Plutonium, Special Panel Report, August 1995, p. 25.

38 Letter from Hans Blix, to Paul Leventhal, head of the NCI, November 1, 1990; Blix Says IAEA Does Not Dispute Utility of Reactor-Grade Pu for Weapons, NuclearFuel, November 12, 1990, p. 8.

39 Lovins, A. B., Nuclear Weapons and Power-Reactor Plutonium, Nature, 28 February 1980, pp.817-823 and typographical corrections, 13 March 1980, p.190.

used in an effective nuclear weapon. In 1953, the British exploded a nuclear weapon at the nuclear test site in South Australia made from plutonium of a quality considerably below that of weapons-grade.[40] In 1962, the United States conducted a similar nuclear-weapon test.[41] The actual amount of Pu-240 in the plutonium used in these tests has not been made public.

In spite of this formidable body of evidence some still deny that reactor-grade plutonium can be used to fabricate nuclear weapons. The civil nuclear industry is understandably anxious to present itself as separate from military nuclear technology and to emphasis that its workers are only involved and interested in providing nuclear energy for peaceful purposes and have nothing to do with military nuclear programmes. But the reality is that the materials they produce have been and are capable of being used to construct nuclear weapons at all levels of sophistication.

4. MULTINATIONAL APPROACHES TO THE NUCLEAR FUEL CYCLE – A HISTORY

This section will summarize the history of multinational proposals for managing the nuclear fuel cycle. From the immediate post-war period, the threat of nuclear proliferation resulting from peace fission energy was understood. The Acheson-Lilienthal report called for international control of all aspects of the nuclear fuel cycle, including power plants, as the only way of minimizing proliferation risks. Their recommendations were never accepted. Instead through President Eisenhowers Atoms for Peace, the formation of the IAEA in 1957, and the drafting of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), nuclear energy was promoted worldwide, with multinational approaches cited to varying degrees as a non-proliferation measure worth exploring. By the 1970's, and in particular in the aftermath of India's nuclear weapons test in 1974, multinational approaches were considered in great detail, led by the IAEA. Right through into the late 1980's these issues were analysed and debated by governments while the nuclear industry generally opposed any possible limitation on their operations. Economic and political factors prevented any of these proposals from being realised.

As the first nation to build and detonate nuclear weapons, the United States in 1945 was well aware that the acquisition of nuclear technology and materials for generating energy would provide nations with the means to develop nuclear weapons. As Robert Oppenheimer saw it,

> ***"The "heart of the problem... (was) the close technical parallelism and interrelation of the peaceful and the military applications of atomic***

40 Arnold L., A Very Special Relationship: British Atomic Weapon Tests, Chapter 4, HMSO.

41 U.S. Department of Energy, *Additional Information Concerning Underground Nuclear Weapon Test of Reactor-Grade Plutonium*, Office of the Press Secretary, Washington, DC apollo.osti.gov/html/osti/opennet/document/press/pc29.html

energy."[42]

The paradox in wanting to stop one while promoting the other is lost on those promoting nuclear power today.

4.1 Acheson/Lilienthal and Baruch

How to control the atom was an early task set by President Truman in the aftermath of World War Two. The result was one of the most significant documents of the nuclear age, the Acheson and Lilienthal report.[43] Published in early 1946, it included the critical view that,

> ***"We have concluded unanimously that there is no prospect of security against atomic warfare in a system of international agreements to outlaw such weapons controlled only by a system which relies on inspection and similar police-like methods. The reasons supporting this conclusion are not merely technical, but primarily the inseparable political, social, and organizational problems involved in enforcing agreements between nations each free to develop atomic energy but only pledged not to use it for bombs."***[44]

Consequently the Acheson/Lilienthal report called for international control over all dangerous nuclear activities.

Due to their production of plutonium, and that there could be no confidence in inspections, Acheson/Lilienthal determined that uranium fuelled reactors would also have to be managed under international control.[45] This point alone should give pause for thought to those today who believe that the limited proposals for fuel banks and regional fuel Centres will make a significant contribution to reducing proliferation threats.

The recommendations were incorporated into the U.S. Baruch plan presented to the U.N. Atomic Energy Commission in June 1946. If Baruch's proposal for an International Atomic Development Authority had been adopted all uranium

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42 As cited in Nuclear Heuristics: selected writings of Albert and Roberta Wohlstetter Robert Zarate Henry Sokolski Editors January 2009, www.StrategicStudiesInstitute.army.mil/

43 See, "*A Report on the International Control of Atomic Energy.*" Prepared for the Secretary of State's Committee on Atomic Energy. U. S. Government Printing Office, Washington, D. C., March 16, 1946 The report was in large part drafted by Robert Oppenheimer, and other scientists who had worked on the Manhattan atomic bomb project, see, www.state.gov/r/pa/ho/time/cwr/88100.htm

44 Ibid.

45 The importance of this should not be understated. The specific language states, "What is true in respect to the dangers from national competition for uranium is similarly true concerning other phases of the development of atomic energy. Take the case of a controlled reactor, a power pile, producing plutonium. Assume an international agreement barring use of the plutonium in a bomb, but permitting use of the pile for heat or power. No system of inspection, we have concluded, could afford any reasonable security against the diversion of such materials to the purposes of war. If nations may engage in this dangerous field, and only national good faith and international policing stand in the way, *the very existence of the prohibition* against the use of such piles to produce fissionable material suitable for bombs would tend to stimulate and encourage surreptitious evasions." see, Acheson/Lilienthal report, as above, Chapter iv The Elimination of International Rivalry. Also David Fischer, former head of the IAEA safeguards department cites this in his History of the International Atomic Energy Agency, the First Forty Years, David Fischer, IAEA 1997; see also Congress of the United States, Nuclear Proliferation Factbook, Congressional Research Service, US Govt Printing Office, Washington, DC (1985) 21.

enrichment, plutonium reprocessing/fuel production plants, and all uranium fuelled reactors would have operated under the control of an international Commission.[46] Instead Cold War politics intervened and no such Commission was established. It's worth stating that both the United States and Soviet Union recognized that relying on inspection, or safeguards as they were to become known, would not be sufficient to detect the diversion of nuclear materials for weapons purposes. It is in this context that the establishment of the IAEA in 1957 with its duel function of promoting nuclear power and reliance on safeguards should be seen.

4.2 Atoms for Peace and the IAEA

Having failed to be adopted by the international community, the Acheson/Lilienthal and Baruch plans were also rejected by the Eisenhower administration with the announcement of the Atoms for Peace program in 1954. Under Atoms for Peace nuclear assistance including training, technology and materials were to be provided to states worldwide. This would take place under the concept of regulated transfers and safeguards. One result was the establishment of the International Atomic Energy Agency (IAEA) in 1957. While promoting the worldwide dissemination of nuclear power the other function of the IAEA would be to apply safeguards at facilities receiving or handling nuclear materials. The very thing that Acheson/Lilienthal had warned against became reality.

Eisenhower had intended that the IAEA act as a bank for nuclear materials, specifically fissile materials from U.S. and Soviet military stocks thus contributing to the reduction in nuclear weapons arsenals. Although the pledges were made by the U.S., Soviet Union and the UK, due to the politics of the time they did not materialise.[47]

One principle achievement of the Atoms for Peace program, and the establishment of the IAEA, was the widespread dissemination of dual use nuclear know-how, technology and materials, including highly enriched uranium to fuel research reactors. They were dual use because they could be used for peaceful or military application. Thus nations around the world were provided with the means to conduct fundamental nuclear research, generate electricity and/or produce nuclear weapons usable fissile materials.

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46 The authors of the Acheson/Lilienthal report stated that, "We have therefore reached these two conclusions: (a) that only if the dangerous aspects of atomic energy are taken out of national hands and placed in international hands is there any reasonable prospect of devising safeguards against the use of atomic energy for bombs, and (b) only if the international agency was engaged in development and operation could it possibly discharge adequately its functions as a safeguarder of the world's future. Such a development function also seems essential in terms of attracting to the international agency the kind of scientists and technicians that this problem requires, recognizing that a mere policing, inspecting or suppressing function would neither attract nor hold them." The plan called for "Managerial control or ownership of all atomic energy activities potentially dangerous to world security." see, The Baruch Plan, June 14th 1946.

47 The USA pledged 5000 kg of contained uranium-235 and whatever amount would be needed to match the other States' contributions; the United Kingdom pledged 20 kg of uranium-235 and the USSR 50 kg, see Fischer, opcit. The IAEA statute includes provisions for the Agency to play a role in the management of nuclear materials, including special fissionable materials, and to "acquire or establish any facilities, plant or equipment..." see, Statute of the IAEA.

4.3 The foundation of the NPT

The Treaty on the Non-Proliferation of Nuclear Weapons, (NPT) drafted in 1968, and open for signature in 1970, is at the heart of the global non-proliferation regime.[48] The bargain between signatories is that nuclear weapons states are required to negotiate complete nuclear disarmament, while non-nuclear weapons states would commit to not develop nuclear weapons. Unfortunately, the incentive to remain non-nuclear was the right of states to access nuclear technology and materials for peaceful use, the same technology and materials necessary for nuclear weapons development. In the forty years of its existence the Treaty may well have deterred states from developing nuclear weapons, but it has also led to the proliferation of technology and materials that now means that as many as 35-40 nations have the capability to develop nuclear weapons.[49] Most significantly the nuclear weapons states have failed to meet their commitments to disarm. This historical proliferation dynamic (failure to disarm and multiple states with access to bomb technology) has created today's crisis. A crisis that is predicted to get worse with the possibility of many more NPT non-nuclear states developing nuclear energy in the coming decades.

The proliferation threat from states developing peaceful nuclear energy was acknowledged in the NPT with the requirement that all non-nuclear weapon states have a comprehensive safeguards applied by IAEA. But as identified by Acheson/Lilienthal, Baruch and later critiques, such a regime is not designed to prevent diversion of nuclear technology and materials to military use. The IAEA safeguards system is intended to detect diversion, but due to the nature of nuclear technology and materials (specifically uranium enrichment, reprocessing, fuel manufacture and nuclear reactor spent fuel) it is incapable of meeting its detection goals.[50] The fact that the U.S. and European states are opposed to Iran operating a domestic uranium enrichment plant reveals that they have no confidence in the IAEA being able to safeguard nuclear material at an enrichment plant.

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48 The Irish Resolution of 1960, approved by the General Assembly, with the abstention of the United States and NATO allies, is recognized as the first major step towards the eventual drafting of the NPT. It was unanimously adopted by the General Assembly in 1961.

49 See IAEA Director Dr Mohamed ElBaradei, "In 1970, it was assumed that relatively few countries knew how to acquire nuclear weapons. Now, with 35-40 countries in the know by some estimates, the margin of security under the current non-proliferation regime is becoming too slim for comfort. We need a new approach." Towards a Safer World, The Economist, October 16th 2003.

50 Nuclear safeguards are a system of monitoring and control over nuclear material that can be used for both commercial nuclear power and to make nuclear weapons. They are applied globally by the Vienna-based IAEA. The two principle weapons materials covered by safeguards are plutonium and highly enriched uranium (HEU). The IAEA considers 8 kg of plutonium from a commercial power reactor sufficient to make one nuclear weapon. The figure is in fact considerably less – between 1 and 3 kg depending upon the degree of sophistication of the weapons designer. Similarly for HEU, the IAEA figure is 25 kg, whereas 5-10kg is sufficient. See for example, Are IAEA Safeguards on Plutonium Bulk-Handling Facilities Effective? Marvin M. Miller Department of Nuclear Engineering Massachusetts Institute of Technology, paper for the Nuclear Control Institute, May 1990, available at http://www.nci.org/k-m/mmsgrds.htm; Nuclear Safeguards and the IAEA, Office of Technology Assessment, Congress of the United States, OTA-ISS-615, Washington DC, June 1995; Falling Behind: International Scrutiny of the Peaceful Atom Henry Sokolski Executive Director The Nonproliferation Policy Education Center Washington, DC 20036 Briefing before American Association for The Advancement of Science Washington, DC March 24, 2008, available at http://cstsp.aaas.org/files/sokolskislides.pdf See, Planning for Failure: International nuclear safeguards and the Rokkasho-mura reprocessing plant, F. Barnaby, S Burnie, May 2002, available at: http://www.greenpeace.org/raw/content/international/press/reports/planning-for-failure-internat-2.pdf

4.4 The 1970's and 1980's

With the apparent assurance of peaceful use of nuclear power provided by the NPT, proliferation concerns in the early 1970's were muted. The IAEA was only one of many that projected dramatic growth for nuclear energy.[51] Then came the Indian nuclear test at Pokharan in May 1974. Although not an NPT state, India had produced the plutonium for the weapon test in a research reactor provided by Canada, fuelled by highly enriched uranium provided by the United States.

At the same time, Argentina, Brazil, the Republic of Korea, Japan, Taiwan and Pakistan were seeking to acquire uranium enrichment and plutonium reprocessing technology. France and Germany entered into negotiations to supply these technologies.

As a consequence of these developments, doubts about the wisdom of current nuclear export policies, the effectiveness of safeguards, and the risks from key technologies – specifically plutonium reprocessing led to a flood of domestic and international non-proliferation initiatives. The major ones relevant to this study were the Nuclear Suppliers Group, the IAEA Regional Nuclear Fuel Cycle Centre study, the International Nuclear Fuel Cycle Evaluation (INFCE), the IAEA International Plutonium Storage concept, the U.S. Nuclear Non-Proliferation Act of 1978, and the IAEA Committee Assurance of Supply.

All of these concepts to varying degrees were aimed at limiting access to key sensitive nuclear technologies. The focus tended to be on plutonium reprocessing as at the time the high nuclear energy growth scenarios combined with limited uranium reserves led most to conclude that the future of nuclear energy was in fast breeder reactors requiring large scale plutonium reprocessing.

The **Guidelines for Nuclear Transfers** (INFCIRC/254) was agreed at London on September 21st 1977, and became known as the **Nuclear Suppliers Group**, and included the following,

> **"The NSG guidelines also encourage move away from transfers of new national enrichment and reprocessing facilities, stating that "if enrichment or reprocessing facilities, equipment or technology are to be transferred, suppliers should encourage recipients to accept, as an alternative to national plants, supplier involvement and/or other appropriate multinational participation in resulting facilities. Suppliers should also promote international (including IAEA) activities concerned with multinational regional fuel cycle centres".**

The **Regional Nuclear Fuel Cycle Centres (RFCC)** study of 1975-1977 was created to provide a forum for countries to examine the possibility of joining together to set up fuel cycle centres at selected sites. It was largely focused on spent fuel, storage,

51 The IAEA makes a high and low projection for nuclear power growth twice each year. In the 1970's the IAEA were projecting a high of as 4,450GWe, whereas by 2000 installed capacity was 352GWe, see, The global nuclear decline, Antony Froggatt and Mycle Schneider, China Dialogue, 7th january 2008, available at www.chinadialogue.net/article/show/single/en/1602-The-global-nuclear-decline

reprocessing and MOX fuel production and radioactive waste. The U.S. withdrew its support for the RFCC following concerns that the approach being recommended could lead to greater dissemination of sensitive nuclear technology, leading to the construction of national reprocessing plants.[52] This issue remains relevant to some of the MNAs being proposed today.

The **International Nuclear Fuel Cycle Evaluation (INFCE)** from 1977-1980, consisted of 66 countries. In addition to recommending further study of international arrangements for the storage of spent fuel and the creation of international plutonium storage (whereby a countries plutonium would be stored under international control, with material released as and when required for fabrication into Mixed Oxide plutonium fuel) the INFCE did include the options for uranium fuel supply assurance. While it considered the establishment of a 'uranium emergency safety network' among nuclear power plant operators and based upon fuel loans in case of market failure, it concluded that the commercial market would continue to be the major instrument for ensuring supplies to nuclear power programs.[53]

The **U.S. Nuclear Non-Proliferation Act (NNPA)** of 1978 is largely known for taking a critical position against plutonium reprocessing and deferring commercial breeder reactor deployment. But it also endorsed the global expansion of nuclear power with the proliferation threat posed by uranium enrichment to be offset by the establishment of an International Nuclear Fuel Authority (INFA). The NNPA required the U.S. President to present to Congress within 6 months of the enactment of the Act,

> ***"proposals for initial fuel assurances, including an interim stockpile of uranium enriched to less than 20 percent...(and) proposals for the transfer of low-enriched uranium up to an amount sufficient to produce 100,000 MWe years of power from light water nuclear reactors and shall also include proposals for seeking contributions from other supplier nations such an interim stockpile pending the establishment of INFC."***[54]

No such plans were presented by President Carter nor his successors.

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52 See, Regional Nuclear Fuel Cycle Centres IAEA Study Project V. Meckoni, R.J. Catlin, L.L. Bennett International Atomic Energy Agency, Vienna Salzburg 1977: Intern. Conference on Nuclear Power and its Fuel Cycle, and, Regional Planning of the nuclear fuel cycle, the issues and prospects, BW Lee, Atomic Energy Commission, Ministry of Science and Technology, Republic of Korea, Seoul, as cited in Internationalization to Prevent the Spread of Nuclear Weapons, Stockholm International Peace Research Institute, SIPRI, 1980.

53 The INFCE evolved out of the heightened tensions over nuclear energy and proliferation. The more inteventionist policies adopted by President's Ford and Carter in the U.S. were strongly resisted by west European nations and Japan. The latter were determined to resist efforts to curtail plutonium reprocessing, while the U.S. was seeking greater control and to actively discourage industrialised nations from developing plutonium reprocessing and fast breeder reactors. Perspectives on INFCE and what it achieved or did not persist today. For background on INFCE see, A preliminary evaluation of the technical aspects of INFCE, U. Farinell, in Nuclear Energy and Nuclear Weapon Proliferation, eds. Barnaby, Jasani, Goldblat, Rotlblat, Stockholm International Peace Research Institute, 1979; see also, The reprocessing fallacy: an update, Paul Leventhal and Steven Dolley, Nuclear Control Institute Presented to The Special Panel Session on Spent Fuel Reprocessing Waste Management 99 Conference Tucson, Arizona 1st March, 1999, http://www.nci.org

54 International Undertakings, Sec.104Nuclear non Proliferation Act of 1978, available at.http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/v2/sr0980v2.pdf#pagemode=bookmarks&page=769

The IAEA´s **Committee on Assurances of Supply (CAS)** was convened in 1980 and assessed the options for multi-nationalisation of the nuclear fuel cycle. The Committee's agenda included examining the economic and non-economic factors which influence the international nuclear market; analysing methods to increase the assurances of supply, including multinational fuel-cycle centres, a fuel bank and relief and emergency mechanisms; and assessing common approaches to nuclear cooperation. The discussions were open to all IAEA member states, which included non-NPT signatory nations. After 21 sessions in Vienna, parties failed to agree on a set of principles with regard to assurances of supply[55] and the talks ended without consensus in 1987.

A further attempt at establishing multinational control of the nuclear fuel cycle was made in 1987 wit the **UN Conference for the Promotion of International Cooperation in the Peaceful Uses of Nuclear Energy (UNPICPUNE)**, but this failed to reach an agreement on such a set of principles because of the reluctance of the major supplier States to concede any advantages to the benefit of the recipient States.[56]

5. THE NUCLEAR 'RENAISSANCE' AND PROLIFERATION THREATS

This section describes the emergence of 21st century Multilateral Approaches prompted by the proliferation warnings of IAEA Director Dr Mohamed ElBaradei. In part due to the IAEA promoting worldwide expansion of nuclear power, and the nuclear industry presenting itself as a solution to meeting climate challenges, projections issued by these bodies are a re-run of the 1970s. This anticipated expansion also emerged at the same time as growing concern on the part of ElBaradei at the failure of nuclear weapon states to disarm, and the disclosure of non-proliferation failures, including the Urenco facilitated A.Q. Khan uranium enrichment network, Iran's nuclear program and growing stocks of fissile material. The end result was proposals to make nuclear power more proliferation resistant, including multinational approaches to the nuclear fuel cycle.

The high growth scenarios for nuclear power predicted during the 1970's did not materialize.[57] Instead, nuclear power by the mid-1990's provided around 15% of global electricity and prospects for future growth appeared limited. At the same time, unresolved issues of nuclear waste, safety, environmental factors and economics contributed to a decline in political and public support for new construction. The linkage between nuclear power and nuclear weapons proliferation also continued to

55 The way forward to internationalise the Nuclear Fuel Cycle and Waste Management A Non-Paper by Dr. Mohamed I. Shaker, later published in International Law Academy at the Hague, the Netherlands, 2007 .

56 Ibid.

57 See, OECD 1975 forecast for installed nuclear capacity, as cited in Uranium a strategic resource, Marian Radetzki, 1981, and see below for details on 21st century growth scenarios.

be exposed during the 1990's with the on-going crisis over North Korea's program, disclosure's of the A.Q. Khan network,[58] growing stocks of civilian but weapons-usable plutonium, and Indian and Pakistan nuclear weapons tests in 1998.

Despite these major impediments, the emergence of climate change and energy security as major politico-economic factors in the early 21st century was seized upon by the nuclear industry as justification for a nuclear resurgence.

High growth projections for nuclear growth are now back in vogue. Led by the IAEA, the Nuclear Energy Agency of Organization for Economic Cooperation and Development (OECD) as well as nuclear industry forums and national governments, many of these are the same bodies that made wildly inaccurate projections in the 1970's that thousands of light water reactors and fast breeder reactors would be deployed worldwide by 2000. Talk of a nuclear renaissance remains at this stage 'just' talk, with the global share of electricity provided by nuclear power declining from 15-14% in 2007.[59]

However, the threat of new nuclear power plant deployment and its proliferation consequences should not be dismissed. The nuclear industry and their supporters are certainly promoting and planning global expansion. While the largest share of nuclear growth is predicted to be in nations already operating nuclear power plants, a significant percentage of nuclear power plant operation is predicted in states that have never operated such plants before. One industry body has projected a range from 325GW to as much as 1900 GW of nuclear capacity being built in these new members of the nuclear club during the coming century.[60] This compares with today's total global installed capacity of 373 GW. While the nuclear industry looks at such prospects with relish, some of those charged with overseeing non-proliferation policy have begun to think about the implications.

In 2003 the Director of the IAEA, Dr Mohamed ElBaradei, made an astonishing admission that the nuclear non-proliferation regime was close to collapse.

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58 The so-called father of Pakistan's nuclear weapons program, Abdul Kadeer Khan gained access to sensitive uranium ultra centrifuge enrichment technology from his work at the Physics Dynamic Research Laboratory (also known as FDO), an engineering firm based in Amsterdam and a subcontractor to Urenco the UK-Dutch-German uranium enrichment consortium, specializing in the manufacture of nuclear equipment. As a result of security failures, as well as deliberate and unwitting help from former teachers and colleagues he went on to build a worldwide nuclear information network. From Pakistan, ultracentrifuge technology, knowledge and materials, were exported to Libya, Iran, and the People's Democratic Republic of Korea. The network used to supply these activities is global in scope, stretching from Germany to Dubai and from China to South Asia, and involves numerous middlemen and suppliers. The disclosures of the network in 2003 with the admission by Libya of its program, was truly shocking to the IAEA, yet it had been known for years that Urenco technology had proliferated beyond Europe, For detailed background on A.Q. Khan and Urenco, See, A.Q. Khan, Urenco and the proliferation of nuclear weapons technology, the symbiotic relations between nuclear energy and nuclear weapons, Loop Boer, Henk van der Keur, Karel Koster, and Frank Slijper, WISE Amsterdam report for Greenpeace International 2004.

59 See, http://www.iaea.org/NewsCenter/News/2008/np2008.html

60 Catastrophic Climate Change: is the nuclear renaissance essential ? World Nuclear Association, which includes the WNA world nuclear century outlook, available at www.world-nuclear.org.

Addressing the IAEA General Conference,[61] ElBaradei highlighted in particular the proliferation threat from commercial uranium enrichment and plutonium reprocessing technology, access to which was now widespread, permitting,

> ***"a state with a fully developed fuel-cycle capability to 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."***

The fact that the IAEA had spent the best part of four decades in promoting the acquisition and development of the same dual use technologies and materials that were now able to provide up to 40 nations with access to nuclear weapons material was of course not acknowledged by ElBaradei. But at least there was recognition of a problem long highlighted by critics of the nuclear fuel cycle.[62]

In contrast to the debate in the 1970's, the IAEA Director gave equal weight to the threat from uranium enrichment. This was due in large part to the revelations of the Irans' multiple research efforts in enrichment technologies, the disclosures on the extent of the A.Q. Khan network, and admission by Libya of its enrichment program. The scale of Iran's ambitions to enrich uranium were only just beginning to emerge at this time.

> ***"Uranium enrichment is sophisticated and expensive, but it is not proscribed under the NPT. Most designs for civilian nuclear-power reactors require fuel that has been "low-enriched", and many research reactors operate with "high-enriched" uranium. It is not uncommon, therefore, for non-nuclear-weapon states with developed nuclear infrastructures to seek enrichment capabilities and to possess sizeable amounts of uranium that could, if desired, be enriched to weapons-grade."***[63]

In condemning the failure of the declared nuclear weapon states to meet their Article VI disarmament commitments, ElBaradei also made three recommendations to reduce proliferation threats:

- limit the processing of weapon-usable material (separated plutonium and high-enriched uranium) in civilian nuclear programmes, as well as the production of new material through reprocessing and enrichment, by agreeing to restrict these operations exclusively to facilities under multinational control;

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61 Statement by Director General to the 47th Regular Session IAEA General Conference, September 2003; these points were further explained in Towards a Safer World by IAEA Director General Dr. Mohamed ElBaradei, Op-Ed, published in The Economist 16 October 2003.

62 Special mention should be made here of the Nuclear Control Institute, and its director Paul Leventhal. For more than 25 years they sought to challenge the IAEA over its promotion of the nuclear fuel cycle and its proliferation dangers, see www.NCI.org

63 Opcit, ElBaradei, The Economist. Statement by Director General to the 47th Regular Session IAEA General Conference, September 2003; these points were further explained in Towards a Safer World by IAEA Director General Dr. Mohamed ElBaradei, Op-Ed, published in The Economist 16 October 2003.

- nuclear-energy systems should be deployed that, by design, avoid the use of materials that may be applied directly to making nuclear weapons;
- we should consider multinational approaches to the management and disposal of spent fuel and radioactive waste.

One additional point worth making is that the IAEA head was effectively saying that his Agencies nuclear safeguards system could not be relied upon to detect the diversion of nuclear weapon materials from peaceful to military use.

6. MULTINATIONAL NUCLEAR APPROACHES: PROLIFERATION OF PROPOSALS

This section describes the proposals for multinational approaches to the nuclear fuel cycle that emerged from 2005 onwards. From the IAEA Expert Study Group that looked at both the front-end of the nuclear fuel cycle – uranium and uranium enrichment and fuel supply, to back end issues – spent fuel, reprocessing and nuclear waste management and disposal. The IAEA Group recommended a range of options from limited assurances of fuel supply, including uranium fuel banks, fuel leasing, to conversion of existing national facilities to international control, to joint construction of new facilities, and international management of spent fuel. This report was followed by initiatives from Russia, Germany, the Netherlands and the UK, Japan, Austria and the United States. The content of these proposals is summarized below. Out of all the proposals, the Russia's international uranium enrichment center at Angarsk has advanced the most. In November 2009 it was approved by the IAEA Board of Governors. The IAEA also has secured international funding for a uranium fuel bank. Both of these proposals have faced criticism by developing nations as restricting the rights of nations under Article IV of the NPT.

Since Mohamed ElBaradei's call for a ***"new approach"*** to non-proliferation, there has been a flood of studies, initiatives and proposals seeking to balance a nuclear renaissance with a more effective non-proliferation regime. These will be summarized below.

6.1 The IAEA Multilateral Approaches to the Nuclear Fuel Cycle: Expert Group Report

The Expert Group Report (hereafter the Group) was submitted to the Director General in February 2005.[64] It focused on options both at the front end of the nuclear cycle – uranium enrichment; and back end - spent fuel disposal and reprocessing, as

64 See, INFCIRC/640 - 22 February 2005. The mandate of the Expert Group was three-fold: • To identify and provide an analysis of issues and options relevant to multilateral approaches to the front and back ends of the nuclear fuel cycle; • To provide an overview of the policy, legal, security, economic, institutional and technological incentives and disincentives for cooperation in multilateral arrangements for the front and back ends of the nuclear fuel cycle; and • To provide a brief review of the historical and current experiences and analyses relating to multilateral fuel cycle arrangements relevant to the work of the expert group.

well as fuel leasing and take-back (of spent fuel). The report, commissioned by ElBaradei acknowledged that the non-proliferation regime was under pressure due to a number of factors - a rise in regional arms races; the breach of safeguards agreements by non-nuclear weapon states, burgeoning clandestine nuclear supply networks and increased risk of terrorist or non-state actors acquiring nuclear materials. But in addition, the Group confirmed that,

> ***"In light of existing, new and reawakened interest in many regions of the world, the prospect of new nuclear power stations on a large scale is therefore real. A greater number of States will consider developing their own fuel cycle facilities and nuclear know-how, and will seek assurances of supply in materials, services and technologies."***

Of course what was not stated was that these newly threatening nuclear states had been actively encouraged into pursuing nuclear power by the very same IAEA that was now concerned about the proliferation implications.[65] It was the prospect of nuclear power plant growth, matched with proliferation concerns that drove the multilateral debate in the immediate post-war period, and through the 1970's.

As in the 1970's, the IAEA report confirmed that two primary deciding factors dominate all assessments of multilateral nuclear approaches, namely "***Assurance of non-proliferation"*** and ***"Assurance of supply and services".***

In the case of the non-proliferation value of a multilateral approach, the report identified risks including the diversion of materials from MNAs but these would be reduced, they concluded, through the presence of a multinational team. Other issues considered were the theft of fissile materials, the diffusion of proscribed or sensitive technologies from MNAs to unauthorised entities, the development of clandestine parallel programmes and the breakout scenario. The latter refers to the case of the host country "breaking out", for example, by expelling multinational staff, withdrawing from the NPT (and thereby terminating its safeguards agreement), and operating the multilateral facility without international control.[66]

The Group in assessing the "assurance of supply" value of a multilateral arrangement measured such issues as the guarantees provided by suppliers, governments and international organisations; the economic benefits that would be gained by countries participating in multilateral arrangements, and the better political and public acceptance for such nuclear projects. As the Group stated,

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65 The IAEA's promotion of nuclear programs is indeed global - technical training, workshops and conferences, and direct intervention in drafting energy policy documents for developing and newly industrialising nations. Despite ElBaradeiBaradei's warnings, the IAEA has for decades also promoted the development of nuclear energy programs based on widespread and largescale plutonium production and use, including Generation IV – largely breeder design – programs such as in INPRO.

66 These had also been identified in earlier assessments of MNAs – see for example, International Cooperation in Nuclear Fuel Services: European and American approaches, H. Menderhausen, Rand Corporation Report, P-6308, 1978, The Rand Corporation, Santa Monica, California, United States.

> ***"One of the most critical steps is to devise effective mechanisms for assurances of supply of material and services, which are commercially competitive, free of monopolies and free of political constraints. Effective assurances of supply would have to include back-up sources of supply in the event that an MNA supplier is unable to provide the required material or services."***

The Group identified a range of multinational options from the use of existing markets to complete ownership of fuel cycle facilities:

Type I: Assurances of services not involving ownership of facilities:

a) Suppliers provide additional assurances of supply – private fuel bank
b) International consortium of governments – intergovernmental fuel bank
c) IAEA-related arrangements – variation on the above

Type II: Conversion of existing national facilities to multinational ones

Type III: Construction of new joint facilities

The Group assessed the advantages and disadvantages of MNAs for sensitive nuclear technologies and spent fuel options. A variety of options for how MNAs would be established and how they would function were identified. These were weighted against the non-MNA option that is national control under existing IAEA safeguards. A brief summary of these assessments follows.

Uranium enrichment – while recognizing that the existing market based approach adequately served existing customers, the Group believed that in one option suppliers could provide additional assurances of supply. This would correspond to enrichment plant operators, individually or collectively, guaranteeing to provide enrichment capacity to a State whose government had in turn agreed to forego building its own capacity, but which then found itself denied service by its intended enrichment provider for unspecified reasons. A second approach would see a group of governments provide guarantee of supply, ***"the arrangement would be a kind of "intergovernmental fuel bank", e.g. a contract under which a government would buy guaranteed capacity under specified circumstances."***

The Group also considered the role of the IAEA. The Agency would function as a kind of ***"guarantor"*** of supply to States in good standing and that were willing to accept the requisite conditionality. This would mean a commitment by a state to not construct its own enrichment plant, and in the case of a non-nuclear weapon state, it would agree to sign up to the IAEA enhanced safeguards arrangement, the Additional

Protocol.[67]

The Group identified two existing uranium enrichment partnerships that provide possible models for future joint facility MNAs. Specifically the Dutch/German/UK uranium enrichment partnership, Urenco, and the French EURODIF project.[68] In both cases, according to the IAEA, proliferation risks were reduced by the existence of these two entities.[69]

Plutonium reprocessing – the Group assessed that the existing capacity of facilities worldwide would meet any future demand over the next two decades. Consequently, options for future MNA application were restricted to some form of IAEA role in supervising an international consortium, or converting an existing facility to international ownership and management.

Spent fuel disposal – The Group stated that at present there is no international market for spent fuel disposal services, as all undertakings are strictly national. Consequently, ***"the final disposal of spent fuel is thus a candidate for multilateral approaches"*** as it offers major economic benefits and substantial non-proliferation benefits according to the Group. National solutions will remain a first priority in many countries but that ***"others with smaller civilian nuclear programmes, a dual-track approach is needed in which both national and international solutions are pursued. Small countries should keep options open (national, regional or international)"***

Spent fuel storage – the Group confirmed that with the exception of Russian take back of spent fuel from client states, there is currently no international market for services in this area, and that it should be considered a candidate for a multilateral approach.

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67 The Additional Protocol emerged after the disclosures of Iraq's nuclear weapons program and the ease with which Iraq had evaded detection by the IAEA.

68 Based on the Treaty of Almelo, Urenco owns and operates gas centrifuge enrichment facilities in the three participating States, helps to coordinate research and development (at first jointly, then individually, and then collectively once again), assures equal access to developments in centrifuge technology by any of the members, and executes contracts for the sale of services to third countries with the unanimous agreement of the participants; In the case of EURODIF involved five participating countries - France, Italy, Spain, Belgium and Iran - but only one enrichment facility, located in France. Unlike Urenco, which is oriented towards an external market, EURODIF was intended to serve the domestic fuel requirements of its members. The level of investment of each member corresponded to its percentage share of the product, and sensitive barrier technology was held by only one member: France. Thus, while excluding the transfer or sharing of sensitive technology, EURODIF did provide European participants with an assurance of supply, and an equity share in a production enterprise utilising proven advanced technology. Unlike Urenco, EURODIF has never been a manufacturer of enrichment equipment.

69 The reality has proved very different, with Urenco being the source of centrifuge technology for Pakistan, Iran, North Korea, Libya, and it is suspected Brazil. As Mycle Schneider points out, in the case of Eurodif, it was established in 1975, with member nations including Iran. Iran has not received enriched uranium from the Eurodif plants, but did receive an income transferred through SODIF (Atomic Energy Commission, CEA France and the Iran Atomic Energy Organization. In 2005 Iran received 7million Euros from uranium enrichment operations in France, see, The Permanent Nth Country Experiment Nuclear Weapons Proliferation in a Rapidly Changing World, Mycle Schneider, report for the European Greens/European Free Alliance, Paris, 24 March 2007, available at http://www.greens-efa.org/cms/topics/dokbin/174/174257.the_permanent_nth_country_experiment_nuc@fr.pdf

Fuel-leasing/Fuel take-back – as the Group explained this could be an option whereby a government would issue an export license to a domestic fuel supplier, with the agreement that upon discharge from a reactor and the required period of cooling in the customer country, the spent fuel would be returned, either to the country of origin, or through an IAEA-brokered arrangement to a third party multinational or regional fuel cycle center.

The IAEA Expert Group, concludes that the potential benefits of MNAs for the non-proliferation regime are both

> ***"symbolic and practical...as a confidence-building measure, multilateral approaches can provide enhanced assurance to the partners and to the international community that the most sensitive parts of the civilian nuclear fuel cycle are less vulnerable to misuse for weapon purposes,"***

and that they also reduce the number of sites where sensitive facilities are operated, thereby curbing proliferation risks, and diminishing the number of locations subject to potential thefts of sensitive material. And finally, these approaches can even help in creating

> ***"a better acceptance for the continued use of nuclear power and for nuclear applications."***

Textbox 2: IAEA Expert Working Group – five possible approaches

IAEA Expert Working Group – five possible approaches

The objective of increasing non-proliferation assurances associated with the civilian nuclear fuel cycle, while preserving assurances of supply and services around the world could be achieved through a set of gradually introduced Multilateral Nuclear Approaches (MNA):

1. Reinforcing **existing commercial market mechanisms** on a case-by-case basis through long-term contracts and transparent suppliers' arrangements with government backing. Examples would be: fuel leasing and fuel take-back offers, commercial offers to store and dispose of spent fuel, as well as commercial fuel banks.

2. Developing and implementing **international supply guarantees** with IAEA participation. Different models should be investigated, notably with the **IAEA as guarantor** of service supplies, e.g. as administrator of a fuel bank.

3. Promoting voluntary conversion of **existing facilities to MNAs**, and pursuing them as **confidence-building measures**, with the participation of NPT non-nuclear weapon States and nuclear-weapon States, and non-NPT States.

4. Creating, through voluntary agreements and contracts, **multinational, and in particular regional, MNAs for new facilities** based on joint ownership, drawing rights or co-management for front-end and back-end nuclear facilities, such as uranium enrichment; fuel reprocessing; disposal and storage of spent fuel (and combinations thereof). Integrated nuclear power parks would also serve this objective.

5. The scenario of a further expansion of nuclear energy around the world might call for the development of a **nuclear fuel cycle with stronger multilateral arrangements** – by region or by continent - **and for broader cooperation**, involving the IAEA and the international community.

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6.2 IAEA NTI Fuel bank

One consequence of the IAEA Director's initiative on Multinational Approaches to the nuclear fuel cycle was the announcement of a fund to establish an IAEA managed nuclear fuel bank. An initial pledge of US$50 million was made in September 2006 by the Nuclear Threat Initiative (NTI),[70] with a condition that a further US$ 100 million should be pledged by IAEA member states. The uranium assigned to the bank would originate from Russian stocks of highly enriched uranium, declared excess from its military stockpile and down-blended (mixed with depleted and low enriched uranium). The uranium would be stored in the host country, which it is believed would be at the Ulba Metallurgical Plant in Ust Kamenogorsk, Kazakhstan.[71] The fuel bank was to act as last-resort fuel reserve for nations that have no indigenous enrichment facilities.

Additional pledges to the IAEA fuel bank concept were made by the U.S., the European Union, Norway, the United Arab Emirates and Kuwait. The latter's pledge of US$ 10 million in March 2009 secured the target condition of US$100 million.[72] Along with Russia's proposal the IAEA Fuel Bank was discussed at the June 2009 IAEA Board of Governors meeting without agreement (see below). The proposals latest expiration date is September 2010 by which time the IAEA Board is required to approve it or the NTI pledge expires. However the deadline has been extended twice before.

6.3 Russian proposal

In January 2006, at a speech in St Petersburg, Russian President Vladmir Putin announced the creation of a **Global Nuclear Power Infrastructure (GNPI)** intended to establish a network of international nuclear fuel cycle centres under IAEA safeguards. This was followed in June 2007, with a proposal to the IAEA that detailed the "Establishment, structure and operation of the **International Uranium Enrichment Centre (IUEC)**", to be located at the Angarsk Electrolysis Chemical Complex (AECC).[73] The main function of the IUEC was to provide participating organizations or states with guaranteed access to uranium enrichment capabilities, on the basis that they would not develop domestic uranium enrichment capabilities on their territory. The uranium enrichment technology would be retained by Russia with no transfer to participating organizations or states. A joint advisory committee would be established with IAEA participation. The intention in the first instance would be to build up a stockpile of enriched uranium sufficient for one reactor – around 120

70 The NTI is a Washington DC based arms control think tank, backed by leading politicians such as former US Senator Sam Nunn. The initial 50 million was made by NTI supporter Warren Buffet.

71 See, Intenational Fuel Bank – helping world peace, BBC, January 8th 2010, www.bbc.co.uk/1/hi/8445539.stm

72 The U.S. pledge was US$50 million; Norway US$5 million; the EU US$25 million; and UAE US$10 million.

73 See, Communication received from the Resident Representative of the Russian Federation to the IAEA on the Establishment, Structure and Operation of the International Uranium Enrichment Centre INFCIRC/708 8 June 2007. The venture as of 2009 had two shareholders, Russia's Tenex and Kazakhstans, Kazatomprom. Armenia has also signed up to the venture.

metric tonnes.

The Russian proposal was discussed at the June 2009 IAEA Board meeting, along with the IAEA/NTI fuel bank proposal, and a proposal from the German government (see below). There was no consensus of support at the meeting and reports of a formal objection to the proposals. According to the official summary of the meeting made available to Platts, ***"several members"*** of the board expressed a variety of reservations and objections related to the proposals.[74]

The summary reflected suspicions on the part of these IAEA Board members that the mechanisms for ***"reliable assurances of nuclear fuel supply"*** would be used to coerce states into renouncing their rights under international agreements to nuclear technology, including fuel cycle technology. The objections to the proposals came from non-nuclear weapon states within the Group of 77 nations (G77). These states have traditionally called for non-discrimination in access to nuclear technology as required under Article IV of the NPT.

Despite the opposition of G77 nations[75], the 35-member nation IAEA Board approved the Russian proposal at a meeting on November 20th 2009. Twenty-three nations voted for the proposal, with eight against.[76] The initiative was to be fully funded by the Russian Federation, and according to out-going IAEA Director, ElBaradei,

> ***"would guarantee the supply of [low-enriched uranium] through the agency for eligible member states, in accordance with predetermined criteria to be approved by the board. It would complement the proposed agency LEU bank, if and when approved, by making more material available to the IAEA."***[77]

On March 29th 2010, the IAEA newly appointed IAEA Director General Yukiya Amano and the Director general of Rosatom, Sergey Kirienko, signed an agreement that would establish the 120-ton fuel reserve to be located at Angarsk. The IAEA has estimated the value of this reserve at US$250 million, with the first 40 tonnes to be established by the end of 2010. The reserve will be co-located at Angarsk, but will be segregated from the rest of the Angarsk site. Whereas the IAEA material will be under safeguards, Angarsk remains outside safeguards. The material will remain the property of Rosatom, until called upon by the IAEA, at which point the material will

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74 IAEA fails to endorse fuel bank proposals, continues fine-tuning, NuclearFuel July 27, 2009.

75 The Group of 77 is the largest intergovernmental organization of developing states in the United Nations with 130 members. It provides the means for the countries of the South to articulate and promote their collective economic interests and enhance their joint negotiating capacity on all major international economic issues within the United Nations system, and promote South-South cooperation for development. On nuclear matters the G77 has for many years been critical of the nuclear weapons states for not meeting their disarmament obligations, while also demanding the right to access to nuclear technology for peaceful purposes. They led the opposition to indefinite extension of the NPT in 1995, see, http://www.g77.org/doc/

76 See, IAEA ready for LEU fuel bank after pact signed with Rosatom, Anne MacLachlan, Nuclear Fuel, April 5th 2010.

77 IAEA Board Backs Russian Fuel Bank Proposal, Deutsche Presse Agentur, November 30th 2009, www.globalsecuritynewswire.org/gsn/nw_20091130_7814.php

be transported by rail to St Petersburg. It will then become the property of the IAEA and then immediately transferred to the ownership of the final recipient, before onward shipment. While the IAEA value of US$250 million is based upon current uranium spot market price, at the time of delivery the Russian government would receive payment on the basis of the spot price at that time.

Russia's role in MNAs has to be seen in the context of its wider domestic and global nuclear power strategy. The MNAs provides a non-proliferation fig leaf to a strategy that will lead to serious proliferation, as well as environmental consequences. See Appendix I.

6.4 German proposal

In May 2007 the German government submitted a proposal to the IAEA for the establishment of a new uranium enrichment plant to be operated as multinational facility, by a commercial company but under IAEA auspices.[78] The intention of the **Multilateral Enrichment Sanctuary Project (MESP)** as proposed by the German government would be for the new facility to be located in a state not yet operating a uranium enrichment plant. The enrichment technology would not be transferred to the IAEA but remain as a "black box" within the control of the supplier. The enriched uranium would be provided under commercial supply contracts. Reflecting the sensitivity of states-rights under the NPT article IV, the proposal did not set the condition that those states receiving enriched uranium would be required to not develop domestic uranium enrichment capacity. The German proposal was discussed at the June 2009 IAEA Board meeting, with some members expressing the view that the IAEA should not administer a commercial nuclear fuel or enrichment company.

Textbox 3: Further proposals for multinational/multilateral control of the nuclear fuel cycle

Further proposals for multinational/multilateral control of the nuclear fuel cycle

The U.S. **Global Nuclear Energy Partnership (GNEP)** launched by President GW Bush in February 2006 had a dual function of restricting the number of states with access to uranium enrichment and plutonium reprocessing, while also establishing a global cradle to grave nuclear infrastructure. Fresh enriched uranium fuel would be provided to states signed up to the non-proliferation objectives of GNEP. The spent fuel discharged from the reactors would be shipped to regional fuel cycle Centres where it would be reprocessed. The resultant separated plutonium would be used to manufacture Mixed Oxide fuel for use in light water reactors and Generation IV breeder reactors. These would be only built in states designated as trustworthy in non-proliferation terms. GNEP was controversial from its launch. The Obama administration has officially terminated the domestic arm of GNEP, though the international program remains in place – and its future scale remains unclear – the administration is committed to supporting the multinational approach to the nuclear fuel cycle.[79]

78 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, INFCIRC/704 4 May 2007; in 2006, Germany, together with the UK and the Netherlands had submitted to the IAEA a document supporting the multinational approach to the nuclear fuel cycle, see, Communication received from the Resident Representatives of Germany, the Netherlands and the United Kingdom to the Agency concerning multilateral cooperation on energy security in support of Article IV of the Treaty on the Non-Proliferation of Nuclear Weapons, **INFCIRC/713,** 17 September 2007.

79 See, IAEA International Ministerial Conference on Nuclear Energy, Beijing speech of US Ambassador to China Gregory Schulte on April 20 2009, as reported at www.neimagazine.com/story.asp?storyCode=2052785

Six country proposal – "In June 2006, France, Germany, the Netherlands, the Russian Federation, the United Kingdom and the United States circulated a proposal on a concept for a multilateral mechanism for reliable access to nuclear fuel. This so-called **"six-country proposal"** called for a standing multilateral mechanism at the IAEA. This mechanism could only be only be used in the event of a disruption in services that (1) occurred for other than non-proliferation reasons; and (2) could not be restored through normal market processes. The prospective recipient would need to be in good standing with its safeguards agreements, have adhered to nuclear safety standards and crucially, have chosen not to pursue sensitive fuel cycle activities."[80]

Japan's Standby arrangement for assurance of fuel supply

In September 2006, Japan circulated a proposal called the **"IAEA Standby Arrangements System for the Assurance of Fuel Supply."**[81] Potential supplier States could register their nuclear fuel supply capacity in terms of uranium ore capacity; uranium reserve capacity; uranium conversion capacity; uranium enrichment capacity; and fuel fabrication capacity. Thus the proposal would cover not only uranium enrichment services, but also all important activities of the front-end of the nuclear fuel cycle. While it is still supported by the Government of Japan there has been no further progress since 2006.

Austrian proposed fuel bank - The Federal Government of Austria submitted to the IAEA in May 2007 a general communication proposing that all future enrichment and reprocessing to be conducted under the auspices of an international nuclear fuel bank.[82] The first step in this process would be for all states to declare the full extent of their nuclear programs. Of all the MNA proposals this is the one that came closest to the Acheson/Lilienthal recommendations.

UK enrichment bond - Also in May 2007, the UK proposes to the IAEA and enrichment bond, which evolves into a concept for nuclear fuel assurance.[83] It would be a virtual bank, centred around pre-approval of license agreements for supply of uranium fuel. The UK stated that the concept would have minimal potential to distort the existing fuel market. The IAEA would be advisor and counter signatory. Possible presentation to IAEA Board in June 2010.[84]

7. MULTILATERAL APPROACHES AND NUCLEAR FUEL MARKET

This section describes the current operation of the international nuclear fuel market and their relationship to MNAs. The international nuclear fuel market is complex and secretive. One critical factor for all nuclear reactor operators is guaranteeing supply – so called fuel assurance. The proposals for MNAs are intended to meet this demand while also discouraging states from building new sensitive facilities, in particular uranium enrichment and plutonium reprocessing. The conclusion reached is that proposed MNAs will have no role in the nuclear fuel market other than at the margins with newly emerging nuclear states. Even then a significant number of states are reluctant to give up their rights to develop the nuclear fuel cycle. Other than for the highest growth scenarios for nuclear power, existing and planned uranium enrichment plants will be capable of meeting projected demand in the coming two decades.
The multibillion nuclear fuel market overwhelms in scale any prospects for MNAs, with doubts about the practicality of the IAEA being able to make judgements in disputes prior to approval of access to multilateral holdings.

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80 See, Assurances of Nuclear Supply and Nuclear Non-Proliferation: the outcome of the IAEA Special Event (19-21 September 2006), Fiona Simpson, www.cic.nyu.edu/internationalsecurity/wmd_article.html
81 Ibid.
82 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 INFCIRC/706 31 May 2007.
83 See, The UK-led Nuclear Fuel Assurance, Mel Draper, UK Dept. of Energy and Climate Control, March 2009.
84 See, IAEA ready for LEU fuel bank after pact signed with Rosatom, Anne MacLachlan, Nuclear Fuel, April 5th 2010.

The decades long debate on multinational arrangements for managing the nuclear fuel cycle have today (at least in diplomatic terms) reached fever point. A great deal of work, many thousands of hours and words have been expended on proposals with the stated aim of reducing the risk of nuclear proliferation while also trying to assure nuclear fuel supply. But there remain fundamental problems with the proposals. One area in particular is the relationship between the proposals and the current global uranium market. The common objectives with all the proposals are that they are intended to discourage states from developing indigenous uranium enrichment capacity and to sign up to multilateral supply. What impact will the proposals make on the global nuclear fuel market? Are they relevant for current operators? What is the future of uranium enrichment, and will the proposals affect new capacity and location? The conclusion reached is that the proposals will have minimal impact on the commercial nuclear markets, most scenarios for nuclear growth can be met with existing enrichment capacity, together with that planned, and that the vast bulk of nuclear trade will continue outside multinational fuel banks and the other concepts being proposed.

7.1 The current nuclear fuel market – uranium supply

In most cases worldwide nuclear power reactors are operated by electrical utilities, the majority of which are privately owned, one significant exception being Electricite de France. The private companies primary interest is in generating income via electricity sales, with one key factor to ensure this being guaranteed access to uranium.

Prior to enrichment, uranium is mined, processed and converted into a form suitable for enrichment. In the stages after enrichment the uranium is manufactured into fuel pellets with the final stage being fuel assembly fabrication. Each of these stages required contractual agreements between end user, the utility, and the supplier. Products or services for each front-end stage are bought and sold in separate markets. Available capacity, inventory level, and the application of trade restrictions and other national policies differ from market to market. Consequently, trends in prices may show little correlation between markets. For example, the average annual spot-market price for the restricted U.S. natural uranium market increased by 36 percent from 1995 to 1996, compared with an increase of only 6 percent in the average annual spot-market price for the restricted U.S. enrichment market.

The strategies adopted by nuclear utilities to meet their uranium demands vary from country to country. Nuclear utilities historically have favoured the maintenance of inventories in excess of immediate uranium requirements. Inventories of natural uranium are managed by utilities as part of work-in-process or "pipeline" materials required for the preparation of nuclear fuel to be loaded into the core of reactors. In addition to the pipeline category, utilities also hold strategic inventories that could be used to minimize possible disruptions in supply, as well as hedging inventories used

to take advantage of movements in uranium spot-market prices. Countries distant to uranium supply or nuclear fuel cycle services are more likely to hold strategic inventories. In contrast, some utilities in the United States, due to the presence of large-scale domestic uranium enrichment and fuel fabrication capacity, beginning in the 1980s, held only inventories of the magnitude needed in the pipeline for a particular fuel reload. Nevertheless, U.S. utilities have acquired excess inventories to hedge against a rise in prices.[85]

Securing information on the uranium procurement strategies of the nuclear industry is a challenge for those outside the nuclear industry. Very few outside the companies themselves have access to detailed documentation. However, information is available.[86] From this is it is clear to see that the multinational approach to the nuclear fuel cycle will not provide any significant contribution to the operations of the current global nuclear power industry. The scale of nuclear material flows and diversification of supply cannot be matched by any of the proposals currently on the table. An example that illustrates this is the experience of U.S. utilities currently operating the largest number of reactors in the world – see box.

Textbox 4: U.S. utility strategy for uranium procurement[87]

U.S. utility strategy for uranium procurement

In 2008, owners and operators of nuclear power plants in the U.S. purchased a total of 53 million pounds of Uranium oxide equivalent. The weighted average price was US$45.88 per pound equivalent, this was a 40 percent increase compared with the 2007 price of 32.47 per pound equivalent. Of the total, 14% was U.S. origin uranium at a weighed average price of US$59.55. The remaining 86% was foreign origin deliveries at a weighted-average price of US$43.47 per pound. Australian-origin and Canadian-origin uranium together accounted for 42 percent of the 53 million pounds. Uranium originating in Kazakhstan, Russia and Uzbekistan accounted for 33 percent and the remaining 11 percent originated from Brazil, Czech Republic, Namibia, Niger, South Africa, and the United Kingdom.

Thus, owners and operators of U.S. civilian nuclear power reactors purchased uranium for 2008 deliveries from 33 sellers, up from the 25 sellers in 2007. Owners and operators of U.S. civilian nuclear power reactors purchased uranium of several material types. Uranium concentrate was 55 percent of the deliveries in 2008; natural UF_6 was 36

percent and enriched uranium was 9 percent.

During 2008, 16 percent of the uranium was purchased under spot contracts at a weighted-average price of US$66.95 per pound. The remaining 84 percent was purchased under long-term contracts at a weighted-average price of US$41.59 per pound. Spot contracts are a one-time delivery (usually) of the entire contract to occur within one year of contract execution (signed date). Long-term contracts include those with one or more deliveries to occur after a year following the contract execution (signed date) and as such may reflect some agreements of short and medium terms as well as longer term.

In 2008, owners and operators of U.S. civilian nuclear power reactors signed a total of 86 new purchase contracts. Of these 60 were new spot contracts and 26 were new long-term contracts with deliveries of 36 million pounds from 2009 through 2018. As of the end of 2008, the maximum uranium deliveries for 2009 through 2018 under existing purchase contracts for owners and operators of U.S. civilian nuclear power reactors totalled 229 million pounds U_3O_8e. Also as of the end of 2008, unfilled uranium requirements (not under contract) for 2009 through 2018 totalled 274 million pounds U_3O_8e. These contracted deliveries and unfilled requirements combined represent the maximum anticipated

85 See, Impacts of Electric Energy Industry Restructuring on the US Nuclear Power Industry, Energy Informationl Agency, US Department of Energy, 1997.

86 The following details are taken from the Energy Information Agency, U.S. Department of Energy, 2009, www.eia.doe.gov/cneaf/nuclear/umar/umar.html

87 Ibid.

market requirements of 503 million pounds U_3O_8e over the ten year period. For the years 2009 through 2013, the maximum anticipated requirements of owners and operators of U.S. civilian nuclear power reactors is 25 million pounds U_3O_8e less than projected enrichment feed deliveries for the same period, which indicates a period of inventory drawdown.

The relevance of the U.S. experience to the multinational approach proposals can be summarised thus:

- large annual material flows – millions of pounds;
- diverse supply procurement – 33 suppliers in 2008;
- 86% purchased on long-term contracts;
- spot price fluctuation - 40% increase in spot-price for uranium oxide between 2007 and 2008
- new long term contracts covering period out to 2018;

The approach of U.S. utilities is not necessarily the same for the rest of the global nuclear industry but it is illustrative. For security of supply, utilities seek to spread the risk of disruption by multiple supplier contracts. Actual and anticipated fluctuation in the spot-price, and with uranium prices expected only to increase in the coming years, mean utilities want long-term assurance through 10 year or more contract periods. This all points to the conclusion that the MNA to the fuel cycle – fuel banks, virtual banks – will play no significant role in meeting the demands of the current global nuclear industry.

The proposals for MNAs are therefore only relevant to new markets for nuclear power.

But for those nations planning to embark on nuclear power plant operation, and on the assumption that their motivation is electricity generation (not military), why should they be expected to limit their options in terms of fuel supply? Securing diversity of supply has many advantages, not least leverage over price. Will the few multinational operations be able to offer the same security as a broad market approach? Unlikely. A number of the states announcing new nuclear programs, the UAE for example recognise the political advantage to signing up to the latest non-proliferation/nuclear energy vogue.[88] Early passage of the U.S.-UAE nuclear cooperation agreement being one. But nuclear power programs announced in 2010, are unlikely to come to fruition before 2020, if at all. What is fashionable today will almost certainly not be the same in a decade or more.

A counter argument may be made that you cannot compare the mature privatised nuclear market of the U.S. with new emerging nuclear power nations in the developing world. Many of the announced programs are likely to be state backed in

88 See, USA signs 123 Agreement with UAE, Secretary of State Rice stated that, "As expressed in the agreement we are signing today, the UAE is choosing to pursue nuclear power via the import of nuclear fuel, rather than developing expensive and proliferation-sensitive fuel cycle technologies, such as uranium enrichment and reprocessing. This is a powerful and timely model for the world and the region, and we welcome the UAE's decision." December 9th 2009, http://www.uae-embassy.org/uae/energy/nuclear-energy.

an electricity market very different from the semi-deregulated ones in OECD states. But this raises another major issue, the principal motive of states to embark on nuclear power programs, and the linkage with nuclear weapons proliferation.

7.2 The current nuclear fuel market – uranium enrichment

Currently, the world enrichment capacity is approximately 56 million SWU/year, with 22.5 million SWU/year in Gaseous Diffusion Plants and more than 33 million SWU/year in Gas Centrifuge Plants. Most capacity is concentrated in Russia, the United States, France, and the three Urenco nations (the UK, Germany and the Netherlands), with China and Japan rounding out the bulk of the capacity. The capacity to produce another 34 million SWU/year is under construction or planned (with resultant major proliferation implications) but current enrichment plants will probably continue operating as long as it is economical to do so. Its worth noting that countries that have developed small commercial nuclear power programs have not operated domestic commercial enrichment plants, with the exception of Iran, but have opted to secure services from overseas suppliers. As of today, thirty two nations have operated nuclear power plants to generate electricity, of these, 13 have built uranium enrichment plants. However, due to the proliferation of enrichment technology, 18 nations have conducted uranium enrichment operations. It is likely that any future growth of nuclear power will mirror this history (with resultant major proliferation implications) but current enrichment plants will probably continue operating as long as it is economical to do so.

Table 1: Uranium enrichment facilities worldwide[89]

State	Plant	Operator	Technology	Capacity 2008 thousand SWU/kg/yr	Increased capacity 2015 thousand SWU/kg/yr	Status
Argentina	Pilkaniyeu	CNEA	Diffusion	20,000		Standby/planned
Australia	Lucas Heights	AAEC	Centrifuge	Lab scale		Shut-down
Brazil	Resende Aramar	INB Navy	Centrifuge Centrifuge	120,000 9,000		Operating/under construction Operating
China	Heping Lanzhou Hanzhong Lanzhou Hanzhong or Lanzhou	CNNC CNNC CNNC CNNC CNNC	Diffusion Diffusion Centrifuge Centrifuge Centrifuge	400,000 500,000 500,000 500,000	500,000	Operating Shut down Operating Operating 4th phase
DPRK	?	?	Centrifuge ?	?		?
France	Tricastin George Besse II[90]	AREVA AREVA	Diffusion Centrifuge	10,800,000	? 7,500,000	Operating By 2016
Germany	Gronau	URENCO	Centrifuge	2,720,000		Operating
India	BARC/ Trombay Rattehalli	DAE IREL/DAE	Centrifuge Centrifuge	Pilot 4-10,000		 Operating
Iran	Natanz PFEP Natanz PFP QOM	AEOI AEOI AEOI	Centrifuge Centrifuge Centrifuge	Pilot 250,000 ?		Operating Operating/ under construction
Israel	Dimona Dimona	IAEC IAEC	Centrifuge Laser	? ?		Unkown Unknown
Japan	Ningjo Toge Rokkasho-mura	JNC JNFL	Centrifuge Centrifuge	250,000 1,050,000	1,500,000	Shut-down Operating
Netherlands	Almelo	URENCO	Centrifuge	4,400,000		Operating
Pakistan	KRL-Kahuta Kundian	PAEC PAEC	Centrifuge Centrifuge	15,000-20,000 ?		Operating Planned
RO K[91]	Daeduk	KAERI	Laser	?		Unknown
Russia	Angarsk Nouvoralsk Seversk Zelenogorsk	Rosatom Rosatom Rosatom Rosatom	Centrifuge Centrifuge Centrifuge Centrifuge	2,600,000 9,800,000 2,800,000 5,800,000	7,600,000	Operating Operating Operating Operating
South Africa	Z plant – Pelindaba Y-plant Valendaba	NECSA NECSA	Aero-dynamic Aero-dynamic	300,000 10,000		Shutdown/ dismantled Shutdown/ dismantled
UK	Capenhurst	Urenco	Centrifuge	5,050,000		Operating
U.S.	Oak Ridge Padukah Portsmouth Piketon Piketon Eagle Rock Silex	U.S. DOE U.S. DOE U.S. DOE USEC USEC AREVA GLE	Diffusion Diffusion Diffusion Centrifuge Centrifuge Centrifuge Laser	8,500,000 11,300,00 7,400,000 Pilot 3,800,000 3,300,000	3,800,000 3,300,000 3.5-6,000,000	Shutdown Operating Standby Under construction Planned Pre-licensing Pre-licensing

89 Sources for Uranium enrichment facilities: Profile of world uranium enrichment programs, 2009, Oak Ridge National Laboratory, ORNL/TM-2009/110; Uranium Enrichment Facilities WISE Amsterdam, http://www.wise-uranium.org/efac.html; International Panel on Fissile Materials, www.fissilematerials.org/ipfm/pages_us_en/fissile/production/production.php

90 George Besse II first cascade started in Dec 2009

91 Republic of Korea

As with natural uranium procurement, the U.S. utility example illustrates the strategy of diversification, though in the case of enrichment there are more limited suppliers – see box.

Textbox 5: U.S. utilities uranium enrichment procurement

U.S. utilities uranium enrichment procurement

In 2008, owners and operators of U.S. civilian nuclear power reactors delivered 43 million pounds U_3O_8e of natural uranium feed to U.S. and foreign enrichers.[92] Fifty-four percent of the feed was delivered to U.S. enrichment suppliers and the remaining was delivered to foreign enrichment suppliers. Thirteen million separative work units (SWU) were purchased under enrichment services contracts from 5 sellers in 2008. The average price paid by the owners and operators of U.S. civilian nuclear power reactors for the 13 million SWU was US$121.33 per SWU, a 6 percent increase compared with the 2007 average price of US$114.58 per SWU. By September 2009, the spot price for secondary SWU was being quoted as US$160.[93] In 2008, the U.S.-origin SWU share was 15 percent and foreign-origin SWU accounted for the remaining 85 percent. Russian-origin SWU was 38 percent of the total. France, Germany, Netherlands, and the United Kingdom had an aggregate share of 34 percent. Uranium in fuel assemblies loaded into U.S. civilian nuclear power reactors during 2008 contained 51 million pounds U_3O_8e, compared with 45 million pounds U_3O_8e loaded during 2007. Twelve percent of the U_3O_8e loaded in 2008 was U.S.-origin uranium, and 88 percent was foreign-origin uranium. On factor affecting the U.S. market is the supply of downblended highly enriched uranium (HEU) from dismantled Russian nuclear warheads. Currently the equivalent of 6 million SWU per year is supplied to U.S. utilities from downblended Russian HEU. This supply is due to expire in 2013, leading utilities to anticipate a supply shortfall. This is leading them to sign contracts covering the period up to 2028.[94] The proposals for MNAs are completely irrelevant in terms of meeting this demand.

92 See, Energy Information Agency, U.S. Department of Energy, 2009,www.eia.doe.gov/cneaf/nuclear/umar/umar.html

93 See, Nuclear Fuel, September 21st 2009.

94 See, Areva wants to work with USEC to boost enrichment loan guarantee, Nuclear Fuel November 16th 2009.

Chart 2: Major enrichment companies with approximate 2007 market shares and %

Major enrichment companies with approximate 2007 market shares (thousand SWU) and %

Company	Market Share	Share (%)
Atomenergoprom	14 500	31.5
US Enrichment Corporation (USEC)	11 000	23.9
AREVA	10 000	21.7
Urenco	8 500	18.5
Japan Nuclear Fuel Ltd (JNFL)	1 000	2.2
China National Nuclear Corp. (CNNC)	1 000	2.2
Total	**46 000**	**100.0**

Source: Current and Future Market Trends in Nuclear Fuel Supply, Robert Vance, Nuclear Development Division, OECD, January 2009.

As can be seen above, four principal companies largely dominate global enrichment supply.

Utility strategies for enrichment services can be summarized:

- supply dominated by several large industrial producers – but utilities still use multiple sources;
- concern over supply shortfall and enrichment prices increases - leading to pressure for long-term assurance and 18 year contracts.

The growing importance of assurance of supply is directly relevant to the prospects for MNAs to the nuclear fuel cycle. In the 1970's uncertainties over supply was a major factor in nuclear industry lack of enthusiasm for international management, which they perceived as control. The industry's priority is securing the operation of their assets. Any development that potentially impacts on security of supply will not be welcomed.

Chart 3: Approximate 2007 LWR fabrication capacities by company 2007

Approximate 2007 LWR fuel fabrication capacities by company, and % shares

Company	Capacity (tHM)	Share (%)
AREVA	3 250	31.7
Westinghouse	2 080	20.3
Global Nuclear Fuel	1 950	19.0
TVEL (Atomenergoprom)	800	7.8
Nuclear Fuel Industries (Japan)	534	5.2
Mitsubishi Nuclear Fuel (Japan)	440	4.3
Enusa (Spain)	400	3.9
Korea Nuclear Fuel	400	3.9
China National Nuclear Corp.	200	2.0
Indústrias Nucleares do Brasil	200	2.0
Total	**10 254**	**100.0**

Source: Current and Future Market Trends in Nuclear Fuel Supply, Robert Vance, Nuclear Development Division, OECD, January 2009.

7.3 Nuclear Fuel Fabrication

It is well-established practice that utilities maintain stocks of finished fuel and intermediate products down the manufacturing chain to natural uranium, while suppliers also maintain stockpiles to cover risks of supply disruption. Such stockpiling is facilitated by the low cost of nuclear fuel in relation to the costs of electricity generation and by the relatively small physical volumes involved. Most utilities follow strategies that incorporate diversity of supply and rolling procurement programmes. These strategies emphasize working with suppliers with good credentials and a track record of high reliability. In addition, many supply contracts provide flexibilities that can be exercised in the event of supply disruptions. For many in the nuclear industry, though they will not admit it, the proposals for MNAs bring back memories of the 1970's. The non-proliferation policies that emerged then, particular from President's Ford and Carter, were not welcomed by the global nuclear industry and resisted by western European states and Japan. The restrictions

they sought to place on nuclear trade, which included proposals for multinational control of sensitive nuclear facilities, and the reaction from western Europe, led to disruption in nuclear material supply. The IAEA and governments designing MNAs for the 21st century will remember the experience of the 1970's and will seek to ensure that no restrictions will be placed on nuclear industry demands. The consequence of which will be that nuclear materials, including those capable of being used for nuclear weapons, will continue to flow. MNAs are not designed to constrain nuclear trade but to facilitate it under the badge of non-proliferation.

7.4 Nuclear Fuel Costs

It is worth highlighting the cost issue in relation to the prospects for MNAs. The IAEA Fuel bank concept as of March 2009 had received pledges of US$150 million. Not a small amount of money. However, compared with the projections for nuclear power plant operation in the developing world and the resultant annual fuel costs, it is clearly very small scale. The total annual cost associated with the "burnup" of nuclear fuel resulting from the operation of the unit is based upon the amortized costs associated with the purchasing of uranium, conversion, enrichment, and fabrication services along with storage and shipment costs, and inventory (including interest) charges less any expected salvage value.

For a typical 1,000 Mwe reactor, the approximate cost of fuel for one reload (replacing one third of the core) is about $40 million, based on an 18-month refuelling cycle. The average fuel cost at a nuclear power plant in 2008 was 0.49 cents / kWh. If the World Nuclear Association, IAEA, and OECD scenarios of nuclear power growth in the developing world are accepted, the nuclear fuel market will be worth at minimum many hundreds of millions of dollars per annum. On the high-end scenarios of 1900 GW of installed capacity in developing countries by 2100, even at today's prices the annual fuel costs would be US$76 billion. On so many levels this not credible, not least the idea that this could be managed as some sort of fuel bank under IAEA auspices, and that utilities will be prepared to limit their supply to a few international suppliers.

7.5 IAEA intervention in the fuel market under MNA

The nuclear fuel market is complex and commercially sensitive. The question arises as to the ability of the IAEA to play any role in judging whether a client should receive material under a future MNA. Former IAEA official Pierre Goldschmidt has made such an observation.

> ***"Whether the Director General is in a position to make such a determination is questionable. The IAEA has no knowledge of the commercial provisions contained in nuclear fuel contracts and it is not competent to make an authoritative judgement on whether or not these provisions have been met by either party. Typically, supply contracts stipulate that such a judgement should only be made by a three-judge arbitral tribunal, a procedure that can***

take months if not years."[95]

Further the point is made that the IAEA Fuel Bank proposal is to serve as a last resort, how would the IAEA Director be able to judge whether a customer has been unable to acquire substitute low enriched uranium on the market?

8. NUCLEAR POWER EXPANSION, FUEL CYCLE DEVELOPMENTS AND PROLIFERATION

This section looks at nuclear power growth projections and the justification that MNAs will reduce the risk of nuclear proliferation. The states promoting the schemes led by the United States, Russia, Germany, the Netherlands, the UK, Japan, Kazakhstan, France together with the IAEA, acknowledge that the anticipated growth of nuclear power, in particular in states currently not operating nuclear power plants, will increase the risk of proliferation. Specifically, it is cited that some countries may opt to develop national enrichment and reprocessing capabilities. While it is rarely stated by name, the concerns of the large nuclear powers and the IAEA is that nations in the developing world will pose this new proliferation threat.

This section will therefore assess proliferation implications of the large scale expansion of nuclear power, development of fuel cycle needs, including laser enrichment, and the effect on MNAs. The greatest proliferation danger that will result from the growth of nuclear power will be the production of plutonium. As with today, the largest concentrations of this weapons material will take place in the existing nuclear states. Even one commercial Light Water Reactor will provide a state with sufficient plutonium for tens of nuclear weapons each year. And the IAEA need the non-proliferation veneer of MNAs to the fuel cycle to legitimize their plans for nuclear power expansion.

8.1 Nuclear power growth projections

The scenarios for nuclear power growth issued by such bodies as the IAEA, OECD, Nuclear Energy Agency (NEA), World Nuclear Association as well as national governments, contain wide ranging variations. As with past projections, the reliability of these in accurately predicting the future is clearly a major question. The OECD in 1975 for example was projecting that global installed nuclear capacity would reach 2480GW by the year 2000, whereas by 2008 it had reached 371GW.[96] Today the IAEA is projecting a high growth figure of 807GW of installed nuclear capacity by 2030.

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95 Assurance of Nuclear Fuel Supply: Two Reports by the IAEA Director General, Pierre Goldschmidt, Proliferation Analysis, June 9, 2009, see, http://www.carnegieendowment.org/publications/index.cfm?fa=view&id=23256

96 See, OECD 1975 forecast for installed nuclear capacity, as cited in Uranium a strategic resource, Marian Radetzki, 1981.

Analysis from Schneider, Froggatt, Thomas, Coplow, and Hazemann[97], for example, highlight major impediments to nuclear power expansion, particularly in countries identified as lucrative new markets. In their study for the German government in 2009 they summarised the current situation thus,

> ***"For practically all of the potential nuclear newcomers, it remains unlikely that fission power programs can be implemented any time soon within the required technical, political, economic framework. None of the potential new nuclear countries has proper nuclear regulations, an independent regulator, domestic maintenance capacity, and the skilled workforce in place to run a nuclear plant. It might take at least 15 years to build up the necessary regulatory framework in countries that are starting from scratch. Furthermore, few countries have sufficient grid capacity to absorb the output of a large nuclear plant, an often-overlooked constraint. This means that the economic challenge to financing a nuclear plant would be exacerbated by the very large ancillary investments required in the distribution network."***

Whatever the future for nuclear power, the proposals for MNAs are intended to facilitate this growth, and are predicated on a major increase in the number of nuclear reactors operating worldwide. A significant number of these reactors it is projected will be built in countries that to date have not operated commercial nuclear programs. As of February 2010, the IAEA was reporting that 60 nations were considering the development of nuclear power, in addition to those already doing so.[98]

8.2 The scenarios for growth

The projected growth of nuclear power is in part based upon the projected increase in electricity production worldwide. It is generally accepted that global electricity production will increase significantly during the coming decades and it is this demand for electricity that is leading to claims that nuclear power will and must play a critical role in the future energy supply of the world, particularly for the developing world. It is this prospect of many countries new to nuclear power building a nuclear infrastructure that will lead to additional proliferation risks to the ones existing today. The conclusion reached by the IAEA and others is that the nuclear non-proliferation regime must be reformed, hence the proposals for MNAs – uranium fuel banks, credits, and international fuel centres.

But the IAEA figures tell a quite different story which should lead to a substantially different approach to both planning future global electricity supply and nuclear non-

97 See, The World Nuclear Industry Status Report 2009 With Particular Emphasis on Economic Issues Mycle Schneider, Steve Thomas, Antony Froggatt, Doug Koplow, and Julie Hazemann, commissioned by the German Federal Ministry of Environment, Nature Conservation and Reactor Safety, August 2009.

98 See, Nuclear for Newcomers Workshop Looks at Managing Development of National Infrastructure for Nuclear Power February 2010, IAEA.

proliferation.[99]

In 2010 global installed nuclear capacity of 372GWe equates to 7.8% of the world's electricity. Even with a projected figure of 807GWe by 2030, installed nuclear capacity (around 800 1000MWe reactors) will provide only 9% of the world's electricity. This capacity, as for all the projections, is based upon the new construction together with a percentage of today's operating reactors continuing to operate. That remains a lot of electricity – but less than 10% of what the world in 2030 is projected to have installed.

The figures become even more revealing when the projected growth of nuclear capacity is broken down geographically. The nations that already operate nuclear plants are where the largest new capacity is projected to take place. The United States and Canada are projected to add 50% to their nuclear capacity, with up to 168GWe installed by 2030 – the equivalent of 168 1000MWe reactors. Western Europe is projected to increase by 30% - the equivalent of 158 1000MWe reactors in operation by 2030. The largest projected growth rates for nuclear power are in China, Japan and the Republic of Korea rising over 320% by 2030, from 80GWe to 259GWe – the equivalent of 259 1000MWe reactors in operation.[100] The Middle East and South Asia figures of 560% growth refer largely to plans to increase nuclear capacity in India.[101]

99 A point should be made that the projections are for installed capacity, not actual generation. The latter can be considerably less than installed capacity, and may be significant in developing countries. For example, whereas India has installed capacity of 4.1GWe as of 1st of January, its actual generation was 1.8GWe. In the case of India this was due to shortage of uranium, according to the Indian Atomic Energy Commission, see Nuclear Power to touch 6000MW next year, Business Standard, Feb 14th 2009. The industry publishes annual figures for load factors of nuclear reactors with a wide range of availability. For the purposes of this report, the total installed capacity will be used.

100 China is projecting to install 151GWe of new capacity by 2030, from its current base of 9GWe. Thus out of the increased capacity projected for the Far East of 179GWe, China will account for 84% of new reactor operation.

101 In fact the latest target of the Atomic Energy Commission of India is for 63 Gwe installed nuclear capacity by 2032, which would be in excess of all capacity for the Middle East and South Asia projected by the IAEA in 2009, see www.world-nuclear.org, of the World Nuclear Assocation, 2010.

Table 2: Estimates of total and nuclear electrical generating capacity -2020-2030

ESTIMATES OF TOTAL AND NUCLEAR ELECTRICAL GENERATING CAPACITY												
Country Group	*2008 Total Elect. GW(e)*	*2008 Nuclear GW(e)*	*2008 %*	*2010 Total Elect. GW(e)*	*2010 Nuclear GW(e)*	*2010 %*	*2020 Total Elect. GW(e)*	*2020 Nuclear GW(e)*	*2020 %*	*2030 Total Elect. GW(e)*	*2030 Nuclear GE(e)*	*2030 %*
U.S./ Canada	1282	113.3	8.8	1296 - 1314	114 - 115	8.7 – 8.8	1440 - 1545	126 – 130	8.4 – 8.8	1568 - 1807	127 - 168	8.1 – 8.3
Latin America	297	4.0	1.3	303 - 311	4	1.3	379 - 432	6.9 – 8.0	1.8 – 1.9	483 - 636	10.8 - 23	2.2 – 3.5
Western Europe	780	122.5	15.7	793	119 - 122	14.9 – 15.4	880 - 948	90 – 131	10.3 – 13.8	984 – 1171	82 - 158	8.4 – 13.5
Eastern Europe	494	47.5	9.6	498	47	9.5	587 - 602	68 - 81	11.6 – 13.4	681 - 775	83 - 121	12.2 – 15.6
Africa	118	1.8	1.5	124 – 126	1.8	1.5	162 - 201	2.8 – 4.1	1.7 – 2.1	222 - 344	6.1 – 17	2.8 – 5.0
Middle East and South Asia	364	4.2	1.2	379 - 394	7 – 10	1.9 – 2.5	538 – 639	13 - 24	2.5 – 3.8	729 - 991	20 - 56	2.7 – 5.6
South East Asia and the Pacific	170	NA	NA	189 - 193	NA	NA	249 - 283	NA	NA	318 - 411	0.0 – 5.2	0.0 - 1.3
East Asia	1157	78.3	6.8	1200 - 1222	79 – 80	6,6	1665 – 1969	138 - 165	8.3 – 8.4	2186 - 2822	183 – 259	8.4 - 9.2
World Total	4662	371.6	8.0	4782 - 4852	372 - 380	7.8	5901 – 6619	445 - 543	7.5 – 8.2	7175 - 8958	511 - 807	7.1 – 9.0

Figures from Energy, Electricity and Nuclear Power Estimates for the period up to 2030, Reference Series 1, International Atomic Energy Agency, 2009 Edition.

Rising from a small base today of less than 5GWe India is projected to rise up to 56GWe.[102] South East Asia with no nuclear power plants in operation today, are projected by 2030 to have the equivalent of five 1000MWe reactors. Africa's 1.5GWe of capacity today (located in South Africa), is projected to reach up to 17GWe - the equivalent of 17 1000Mwe reactors in operation across the continent by 2030.

The geographical distribution of projected growth in nuclear capacity becomes clearer when you understand that of today's 372 GWe globally installed capacity, 326GWe, or 87%, is concentrated in North America, Europe, Japan and the Republic

102 The IAEA projection for 2010 for South Asia and the Middle East includes 6GW of additional capacity that was planned to start operation in India in 2010, and the start up of Iran's Bushehr reactor 1Gwe reactor. India has 4.1 Gwe of installed capacity as of January 1st 2010, and Bushehr could possibly start operation mid-2010. The 2008 figure includes Pakistan's 0.46GWe capacity from its one power reactor.

of Korea. By 2030 of the projected 807GWe installed nuclear capacity, 706GWe, or 87%, is projected to be in North America, Europe, Japan, the Republic of Korea, with the addition of China. On these IAEA figures the number of nuclear reactors will have increased but in terms of geographical concentration not much will have changed.

In terms of the geography of nuclear proliferation the figures are important. The overwhelming majority of nuclear engineers, physicists and other scientists with the skills to work on peaceful energy or nuclear weapons will remain concentrated in the same states that operate nuclear power plants today. However based upon IAEA projections, there will also be thousands of trained nuclear scientists working in tens of countries that as of today have no nuclear power program, but which by 2030 will have built a few or more nuclear reactors.

The IAEA is correct to identify the threat posed by many more states operating nuclear reactors, but as their own figures show, many of these programs will play an insignificant if not irrelevant role in providing electricity to hundreds of millions of people. Nations today that are being cited as new markets for Areva, Rosatom, Westinghouse and others, will, even on the IAEA's most optimistic of scenarios, be generating between 1% and 5% of their electricity from nuclear power. But they will have as a consequence established a dual-capable nuclear infrastructure. For not much electricity in global terms, a lot of proliferation problems are being created. It is indeed a proliferation nightmare, but not the one cited by the IAEA in its promotion of multilateral approaches. Worse still, it is a situation in large part created by the IAEA itself[103], and the nuclear-export driven policies of Russia, the United States, France, Japan, the Republic of Korea and others.

8.3 Future nuclear growth and fuel cycle needs

The International Uranium Enrichment Center at Angarsk IUEC, Russia, the IAEA Fuel Bank at Ulba Metallurgical Plant in Ust Kamenogorsk, Kazakhstan, and other proposals, are being promoted as a solution to the proliferation threats posed by the development of nuclear power in tens of new countries over the coming decades. One particular focus is the possibility of a number of these new states opting to develop enrichment capacity – a capacity that could be used to produce low enriched uranium for peaceful nuclear use, and or, highly enriched uranium for nuclear weapons.

Uranium must be enriched if it is to be used in light water reactors, today's dominant reactor type. This means that the concentration of fissile uranium 235 (U235) must be increased before it can be fabricated into fuel. The natural concentration of this isotope is generally 0.7%, but to be usable in a light water reactor the U235 must be increased to around 3.5%, which then sustains a chain reaction in the reactor. Some

103 Enacting its mandate to promote nuclear power worldwide the IAEA plays and active role in influencing the energy policy of developing countries, with of course a heavy emphasis on the development of nuclear power.

93% enrichment is customary for weapons and for naval propulsion. The enrichment process is not linear, since as much separative work is needed between 0.7% and 2% as between 2 to 93%. This means that the enrichment work up to the level usable in a nuclear weapon is reduced to less than one half and the amount of uranium feed to less than 20%, when commercial enriched uranium is readily available.

Enrichment facilities under IAEA safeguards presently exist in the following countries: Argentina, Brazil, China, Germany, Iran, Japan, Netherlands, and the United Kingdom. Furthermore, enrichment facilities not under safeguards exist in France, India, China, Pakistan, the Russian Federation and the United States.

Up to 2010 thirty-two nations have operated nuclear power plants to generate electricity. Of these 13 have built uranium enrichment plants.[104] Only one of these nations, the Netherlands, developed uranium enrichment solely for peaceful energy use. In the case of both Japan and Germany, decisions were made in the 1960's to develop technologies that were both capable of providing fissile materials for peaceful use and if necessary, military use.[105] Given this history of uranium enrichment development and its linkage to military programs, it is right to view new enrichment capability as a proliferation threat.

Not surprisingly, the IAEA study on MNAs presented the history of multinational enrichment projects in rather selective fashion. As the IAEA Expert Group states,

> ***"Where an MNA would take the form of a joint facility, there are two ready-made precedents, the Anglo-Dutch-German company Urenco and the French EURODIF. The experience of Urenco, with its commercial/industrial management on the one hand and the governmental Joint Committee on the other hand, has shown that the multinational concept can be made to work successfully. Under this model, strong oversight of technology and staffing, as well as effective safeguards and proper international division of expertise can reduce the risk of proliferation and even make a unilateral breakout extremely difficult."***

Incredibly, the high praise for Urenco made by the IAEA Group fails to refer to the proliferation of Urenco advanced centrifuge's via the A.Q. Khan network. Given that this technology forms the basis of Pakistan's, North Korea's and Iran's uranium enrichment program, and that this is cited as one driver for the MNA proposals, its perhaps not by accident that the Expert Group forgot to mention it. The potential of future MNAs leaking sensitive nuclear technology and expertise is one further

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104 In addition to these 13 nations, Iran has built a uranium enrichment plant at Natanz with a planned 250,000 SWU/year capacity, but has yet to operate a nuclear power plant.

105 See, Bonn and the Bomb, German politics and the nuclear option, Matthias Küntzel, 1995; on Japan see, Thinking the Unthinkable, Frank Barnaby and Shaun Burnie, Citizens Nuclear Information Centre, Tokyo and the Oxford Research Group, July 2005, Averting the Danger of Catastrophic Climate Change: Is the Nuclear Renaissance Essential? WNA Nuclear Century Outlook, http://cnic.jp/english/publications/pdffiles/ThinkingTheUnthinkable.pdf

argument against such proposals.[106]

An IAEA presentation in 2009 shows the projected uranium enrichment capacity increase to meet the rising demand from nuclear power plants.[107]

Table 3: IAEA Fuel cycle needs scenarios

	2008	2030	2030
		Low	High
Nuclear power (GWe)	373	473	748
Natural uranium (tonnes) per annum	67,000	65-80,000	100-125,000
Conversion UF6 (tonnes U) per annum	64,000	60-75,000	95-120,000
Enrichment (million SWU) per annum	**46**	**55-70**	**85-110**
Fuel fabrication (tonnes U) per annum	12,000	11-13,000	17-20,000
MOX fabrication (tonnes HM) per annum	200	200	500

The nuclear fuel cycle and its market: an overview, Hans Forsström, Director, Division of Nuclear Fuel Cycle and Waste Technology, February 2009, www.mofa.go.jp/policy/energy/iaea/seminar0902/nfc.pdf

106 See, for example Internationalization of the Nuclear Fuel Cycle: Goals, Strategies, and Challenges, U. S. Committee on the Internationalization of the Civilian Nuclear Fuel Cycle; Committee on International Security and Arms Control, Policy and Global Affairs; Nuclear and Radiation Studies Board Division on Earth and Life Sciences, National Academy of Sciences and National Research Council of the National Academies; Russian Committee on the Internationalization of the Civilian Nuclear Fuel Cycle Russian Academy of Sciences, 2008, www.nap.edu/catalog/12477.html.

107 One important factor to understand is the relationship between the so-called tails assay, natural uranium demand, and enrichment capacity. As stated earlier the enrichment process is measured in terms of separative works units, or SWUs. The quantity of natural uranium required to obtain a unit of enriched uranium depends on the amount of U235 discarded in the enrichment tails (waste). The higher the U235 content in the tails (referred to as tails assay) the larger the amount of natural uranium required for a given amount of enriched material. During the 1970's enriched uranium from the United States was supplied to the world market on the basis of a tails assay of 0.2% (U235). The lower the tails assay, the more U235 is removed from the tails, the more enrichment work is required. The requirement of SWUs rises geometrically for each arithmetic decline in the tails assay. For example, at a tails assay of 0.2%, 1Ib of natural uranium will require 0.3 SWUs to obtain 0.15Ibs of 3% enriched uranium. If the tails assay is raised to 0.3% the natural uranium requirement will rise by 20%, but the amount of SWU requirement will decrease by 20%. Factors such as natural uranium supply and price, and enrichment capacity and price will all play a role in determining the operational characteristics of enrichment plants. Urenco is understood to be running its plants on a tails assay of 0.25%, in contrast to Russian plants which are operating at 0.15% - one explanation is Russia's large scale enrichment capacity relative to its domestic uranium reserves and dependence on imports. See, The Global Uranium Outlook 2008/9 a buying opportunity? Maximilian Layton, The Macquarie Group, Presentation for WNA Symposium September 2008 .

A significant factor emerges in the scenarios for nuclear power growth and current and planned enrichment capacity. Taking the nuclear industries own figures, while they acknowledge there will be an increase in demand for uranium enrichment, capacity will likely meet demand for the foreseeable future. In total, current capacity and planned/under construction capacity of uranium enrichment is 90 million SWU. On the IAEA low growth scenario, demand for enrichment reaches 70 million SWU by 2030.[108] Only under the high growth scenario range of 85-110 million SWU does today's current and planned capacity not meet demand, but almost certainly if demand were to increase to the extent envisaged in this high growth scenario, extra capacity would be built. And almost certainly it would be built in the nations currently operating large-scale commercial uranium enrichment plants.

If correct, the implications of this are quite profound for the proposals for MNAs. The majority of new nuclear nations will not develop uranium enrichment to provide assurance of supply. They will secure their uranium needs on the international market. For reasons other than commercial considerations, a few nations will opt to develop domestic enrichment capacity.[109] This would be a decade or longer process.

8.4 Laser enrichment and its impact on non-proliferation

One area of uranium enrichment proliferation, which receives little attention, is the commercial deployment of laser technology.[110] It is a particular proliferation risk beyond existing enrichment technologies due to its modular, relatively simple approach and that it could be built and operated on a small scale, and potentially low cost. There is no effective safeguards system yet developed for such a facility. As a consequence the development of commercial laser enrichment will directly undermine efforts to restrict enrichment technology to a relatively few states, including proposals for MNAs to the fuel cycle.

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108 The World Nuclear Association issued similar projections in 2009, whereby on the high end of global nuclear power projections enrichment demand would grow to 66,535,000 SWU in 2020 and 79,031,000 SWU in 2030, under its reference scenario. In the upper-case scenario, those figures are 77,651,000 SWU in 2020 and 105,715,000 SWU in 2030, see World Nuclear Fuel report 2009, World Nuclear Association.

109 However, one analysis suggests that once a nation has installed 10GW of capacity it would make economic sense for them to consider uranium enrichment. see, Stemming the Spread of Enrichment Technology Fuel-Supply Guarantees and the Development of Objective Criteria for Restricting Enrichment, Babur Habib Sunil Jain Richard Johnson Ilan Jonas R. Scott Kemp Andrew Kovacs David Malkin Darya Nachinkina Bart Szewczyk Pei Tsai, paper prepared for Princeton University's Woodrow Wilson School of Public and International Affairs Fall 2005 Workshop on Stemming the Proliferation of Enrichment Plants. http://wws.princeton.edu/research/ final_reports/f05wws591f.pdf

110 The process consists of adjusting tuneable dye lasers to extremely fine frequencies (corresponding to absorption frequencies characteristic of the isotope in question), which can then excite one isotope of an element without exciting other isotopes. This is possible due to the difference in atomic weight between two isotopes of the same element. The excited isotope can then be ionized and separated by any of several methods: chemical, electrical, or magnetic.

8.5 U.S./Japan/Canadian uranium laser enrichment facility

While international attention focuses on the development of uranium enrichment technology in Iran and its possible use in nuclear weapons development, comparatively little attention has been focused on the development of the world's first commercial laser enrichment plant. After decades of stop-start research and development,[111] a first of its kind commercial laser enrichment plant is under development in North Carolina, U.S. The new Global Laser Enrichment Commercial Facility or GLE-CF, is majority owned by General Electric of the United States, together with Toshiba of Japan and Cameco of Canada,[112] The GLE-CF will have a nominal capacity of 6 million SWU per year and is currently going through pre-licensing with the Nuclear Regulatory Commission. Construction of the plant could come as early as 2012.

On one level, the U.S./Japanese/Canadian multinational fuel cycle project now underway in North Carolina fulfils the criteria for international cooperation in developing sensitive parts of the nuclear fuel cycle. However, due to the nature of laser enrichment, the development of the GLE-CF directly threatens efforts to increase enrichment technology proliferation.[113]

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111 Laser enrichment research began during the 1960s in the laboratories of a number of countries: for the United States, the Lawrence Livermore and Los Alamos Scientific Laboratories of the University of California, the Oak. Ridge National Laboratory, Sandia Laboratories at Albuquerque (under AT&T's Western Electric Company), Exxon Nuclear, and KMS Industries of Ann Arbor: in Russia, the Lebedev Physics Institute; the Max Planck Institute for Plasma Physics in West Germany; the Limeil Laboratory in France; and government-sponsored research in Israel, among other, see Laser Isotope Enrichment a new dimension to the nth country problem?, Robert L Bledsoe, Air University Review, March-April 1978.

More than 20 countries have researched laser enrichment technology including Argentina, Australia, Brazil, China, France, Germany, India, Iraq, Iran, Israel, Italy, Japan, the Netherlands, Pakistan, the Republic of Korea, Romania, Russia, South Africa, Spain, Sweden, Switzerland, the United ed Kingdom, the United States, and Yugoslavia, See, Laser Enrichment: Separation Anxiety, Charles D. Ferguson, Adjunct Senior Fellow for Science and Technology Jack Boureston, Managing Director, FirstWatch International March/April 2005 Bulletin of Atomic Scientists http://www.cfr.org/publication/7876/laser_enrichment.html. In the case of the U.S. their AVLIS program after US$2 billion of investment was abandoned in June 1999. In October 2001, the Japanese government abandoned its funding of laser enrichment research after spending more than 50 billion yen (AU$784.6 million). The project, which had run since 1980, had also received some 15 billion yen from private industry investment, see, The Japan Times Online, "Long, costly effort to enrich uranium with laser tech will now be scrapped", The Japan Times, October 4 2001, http://www.japantimes.co.jp/cgi-bin/getarticle.pl5?nn20011004c2.htm**.** In January 2004, the French Atomic Energy Commission ended a 20-year laser enrichment project. Independent of auditors appointed by the French Government to investigate the project called it a "risky bet" that had benefited from generous financing long after its inappropriateness had become evident.95 It was estimated that 1.1 billion euros (AU$1.84 billion) was spent on the project. The French company COGEMA which had also provided funding for the project, made the decision in 2004 to replace an aging enrichment plant with centrifuge technology, and not laser enrichment, see, "CEA says Silva demo shows laser enrichment has a future", Anne MacLachlan, Nuclear Fuel**,** January 19th, 2004., see Secrets, lies and uranium enrichment, The classified Silex project at Lucas Heights, James Courtney Greenpeace Australia, November 2004.

112 General Electric, through its wholly owned and majority owned subsidiaries, has a 51% indirect interest in GLE. GLE's minority owners Hitachi and Cameco have indirect interests of 25% and 24%, respectively, see, notice of receipt of application for license; notice of consideration of issuance of license; notice of hearing and commission order; and order imposing procedures for access to sensitive unclassified non-safeguards information and safeguards, in the matter of) GE-Hitachi global laser enrichment llc) Docket No. 70-7016) (GLE Commercial Facility)), 2010/01/07- Commission Order (CLI-10-04) GE-Hitachi Global Laser Enrichment, LLC (GLE Commercial Facility). The total investment is in the region from the three partners is in excess of US$2 billion.

113 The threat posed by the plant has been described recently in Stop Laser Uranium Enrichment," Francis Slakey

The GLE-CF is based upon technology developed originally by the Australian government, then transferred to Silex Systems Limited of Australia with continued technical, personnel and financial support from the Australian Government's Nuclear Science and Technology Organization, ANSTO,[114] and nuclear material support from the Australian Safeguards and Non-proliferation Office, ASNO. Silex Sytems Ltd entered into an agreement with United States Enrichment Corporation USEC in 1996, which ran until 2003.[115] Underscoring the proliferation hazard of the technology was the decision made by the U.S. Department of Energy to classify the Silex process, "Restricted Data", RD – a classification that usually relates to the design of nuclear weapons, or the use or acquisition of nuclear material suitable for their construction. It was the first time in history that privately held technology was given this classification.

The Silex arrangement with USEC required the drafting of a new bilateral agreement between Australia and the U.S., because existing agreements specifically banned the transfer of weapons related technology.[116]

8.6 Laser enrichment proliferation hazards

Laser enrichment has long been recognised as a major proliferation threat due to the simplicity and size of the technology. When compared with centrifuge and diffusion plants, a molecular laser facility capable of producing several bombs per year, can be the size of a small warehouse.[117] The proliferation threat posed by the technology is however neither a concern of the original developer Silex Systems nor GE-Hitachi-Cameco. The technology was promoted by Silex Systems Ltd, as:

> ***"a extremely low energy process; based on relatively simple and practical separation modules;. a modular technology providing versatility in deployment; and expected to have significantly lower overall power consumption and capital costs."***[118]

These are precisely the identified characteristics that make laser enrichment such a

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and Linda R. Cohen, "Nature 464 (4 March 2010): 32-33 (doi:10.1038/464032a).

114 See, *US Department of Energy, Federal Register 66, June 26, 2001, p 33954. Department of Foreign Affairs and Trade, Agreement for Cooperation with the United States of America concerning Technology for the Separation of Isotopes of Uranium by Laser Excitation, Canberra, May 2000, Article 3 (1) a,b,c.* ANTSO originally developed the laser enrichment technology, and claims that it sold it to Silex Systems Ltd in 1994, however it continued to provide "contract staff, equipment and radioactive materials. Silex leased more than 2000 square metres of space at Lucas Heights and has unspecified access to ANSTO technology and information." In addition, "ANSTO and the Australian Safeguards and Non-proliferation Office (ASNO) have assisted Silex Systems with the importation and storage of uranium hexafluoride (UF6) – a radioactive gas used in the uranium enrichment process." Opcit, Secrets, lies and uranium enrichment.

115 A total of 29 million Australian dollars were invested in the project by USEC, Opcit, Secrets, lies and uranium enrichment.

116 Opcit, Secrets and lies and uranium enrichment, Known as the Silex Agreement, the 'Agreement for Cooperation with the United States of America concerning Technology for the Separation of isotopes of Uranium by Laser Excitation' provided for the transfer of Restricted Data, sensitive nuclear technology, sensitive nuclear facilities, and major critical components of such facilities.

117 See, "Uranium Enrichment and Nuclear Weapon Proliferation", p.24, Allan S. Krass, Peter Boskma, Boelie Elzen, Wim A. Smit, Stockholm International Peace Research Institute, Taylor and Francis Ltd, London, 1983.

118 See, Silex Systems Limited, Annual Report, 2000, p 6.

proliferation risk.

The U.S. Office of Technology Assessment (OTA) in a 1977 report highlighted the fewer number of stages required to enrich uranium compared with gaseous diffusion or centrifuge enrichment.[119] The report also expressed the concern that the sale of laser enrichment technology by commercial entities could hasten the proliferation of the technology. A 1981 declassified U.S. Central Intelligence Agency report warned that the laser enrichment process was simple, plants small and a tenth of the cost of gaseous diffusion enrichment, and that,

> ***"any country might acquire the necessary technology to set up a garage sized plant to produce weapon grade uranium anywhere in the world"*** [120]

The growth of LWR reactor use, in particular the supply of low-enriched uranium, would also provide an enormous feedstock for laser enrichment to produce weapons grade uranium. A state with access to fresh LWR fuel assemblies could remove the ceramic pellets from fuel rods, crush and fluorinate them to obtain low enriched UF6. In conventional centrifuge or diffusion plants, one fifth of the effort is required to enrich 3.5% low enriched uranium to HEU.

A further proliferation issue with deployment of laser technology is its application to plutonium. States with access to such technology could use it to separate plutonium isotopes to remove the heavier isotopes of plutonium, specifically Pu240 and Pu241 from reactor-grade plutonium, to produce weapons-grade Pu239.[121] Use of laser technology to concentrate plutonium, would require access to spent fuel from a nuclear reactor and reprocessing technologies (to produce and extract the plutonium). Given the projected growth of nuclear power, and the proliferation of spent fuel, together with widespread knowledge of reprocessing techniques, the proliferation threat from laser enrichment goes beyond uranium.

> ***"The (laser) technology could be used to clean up plutonium obtained from commercial reactor fuel to weapon specification"***
> *Charles Gilbert, Deputy Assistant Secretary, Nuclear Materials section U.S. DOE.*[122]

The application of laser separation of plutonium for military purposes was clearly understood by the U.S. Department of Energy (DOE). The DOE allocated tens of millions in the early 1980's into researching laser technology to produce weapons

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119 Emilio Q. Daddario, Nuclear Proliferation and Safeguards, Office of Technology Assessment, US Congress, Washington, June 1977, Woodrow Wilson School of Public and International Affairs website,http://www.wws.princeton.edu/cgi-bin/byteserv.prl/~ota/disk3/1977/7705/7705.PDF

120 See, Uranium Enrichment, Threat of Nuclear Proliferation Increasing, CIA, Uranium Enrichment, Threat of Nuclear Proliferation Increasing, CIA website, http://www.cia.gov

121 From a weapons point of view it would not be necessary given the utility of reactor grade plutonium as a weapons material.

122 See, Laser Isotope Separation: the plutonium connection, George Palmer and Dan I Bolef, Bulletin of Atomic Scientists, March 1984.

material from commercial reactor spent fuel. The view from President Reagan's administration was that many more nuclear warheads needed to be produced and insufficient plutonium could be produced in the military production reactors at the DOE facilities at Savannah River and Hanford. Spent fuel produced in the commercial reactor program would provide the reactor-grade plutonium for nuclear weapons.

Alerted to the dangers in U.S. DOE plans by Paul Leventhal of the Nuclear Control Institute and Tom Cochran of the Natural Resources Defence Council NRDC, members of Congress passed the Hart-Simpson-Mitchell amendment to the 1983 Nuclear Regulatory Commission Authorization Act which forbade the use of commercial nuclear spent fuel to obtain plutonium for weapon production.[123]

While U.S. plans to use laser technology for fissile material separation were blocked by Congress, other states have developed the technology for weapons purposes. The whistleblower and former Israeli nuclear technician Mordechai Vanunu disclosed in 1986 that in addition to using centrifuge uranium enrichment, from 1981 it began laser enrichment at the Dimona nuclear complex, and was scaling up production in 1985 shortly before Vanunu fled the country.[124] The Republic of Korea also developed laser enrichment technology to produce small quantities of highly enriched uranium. These experiments were conducted at the Daeduk nuclear research centre which as well as being the centre of civil nuclear research had also played a key role in the country's nuclear weapons program. Though Daeduk was routinely inspected by the IAEA, the enrichment of uranium to 77% U235 went undetected.[125]
In more recent years the laser enrichment program of Iran has generated considerable interest. The Shah initiated uranium laser research in 1976.[126] By 2003 disclosures from an Iranian resistance organization prompted the IAEA, which had been unaware of Iran's research, to enquire as to the extent of laser enrichment. The Atomic Energy Organization of Iran (AEOI) denied that its laser research was related to uranium

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123 See, http://www.nci.org/new/nci-reports3.htm#Legislative, see testimony of Thomas B Cochran, Oversight Hearing, Military Plutonium from Commercial Spent fuel Subcommittee on Oversight and Investigations of the Committee on Interior and Insular Affairs, U.S. House of Representatives, Oct. 1st 1981, Serial No.97-17 pp25-26, as cited in Laser Isotope Separation: the plutonium connection, George Palmer and Dan I Bolef, Bulletin of Atomic Scientists, March 1984.

124 The details of Israel's nuclear program, including laser enrichment, were disclosed to Frank Barnaby in 1986. See, Revealed: The secrets of Israel's nuclear arsenal, The Sunday Times, October 5th 1986; and Opcit, The Invisible Bomb.

125 In 2004, the Republic of Korea disclosed as part of its Additional Protocol declaration to the IAEA that in 2000 government scientists had performed unauthorized enrichment of uranium during a larger project of enriching stable isotopes with an AVLIS process.. The experiments produced about 200 milligrams of uranium enriched up to 77% U235. As reported by Mark Hibbs, "77% U-235 was peak enrichment reported to IAEA by South Korea." Nuclear Fuel 27th September 2004.

126 The IAEA reported in 2006 that "In addition to the 1976 contract for the laser enrichment pilot plant, concluded with a US company, Iran has reported the conclusion of the following contracts related to laser enrichment (GOV/2004/60, Annex, para. 30): 1975 – for the establishment of a laboratory to study the spectroscopic behaviour of uranium metal (Germany); 1991 – for the establishment of a Laser Spectroscopy Laboratory and a Comprehensive Separation Laboratory (China); 1998 – to obtain information related to laser enrichment, and the supply of relevant equipment (Russian Federation).", see, Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions 1737 (2006) and 1747 (2007) in the Islamic Republic of Iran Report by the Director General, available *at* http://www.globalsecurity.org/wmd/library/report/2007 /iran_iaea_gov2007-58_071115.htm

enrichment. This changed in 2005 when it admitted that a pilot laser uranium enrichment plant had been established at Lashkar Ab'ad in 2000, and that experiments had been conducted in 2002 and 2003 using imported natural uranium metal. This importation had not been reported to the IAEA. The IAEA declared that the plant would have been capable of producing HEU once the plant was fully operational. It was reported at the time that Iran had acquired laser technology from the United States, China, South Africa, Germany and Russia and others.[127] In 2006 it was reported that laser enrichment work had resumed at Lashkar Ab'ad.[128]

This brief description of some laser enrichment programs highlights the proliferation role played by such technology. Bringing the issue back to the proposed GE-Hitachi-Cameco plant its worth concluding that the imported Silex technology for the plant had its origins in Australia's research into nuclear weapons development which ran from the mid-1960's to the early 1970's.[129] Not content with indigenous development of Silex, technical assistance was contracted in the late 1990's to South African scientists who had worked on the apartheid era MLIS.[130] The MLIS program had been developed to provide enriched uranium for South Africa's nuclear program – which at the time was both military and civil. On two occasions in the 1990's South Africa had also contracted with Iran to assist it with laser enrichment technology.[131] No restrictions were placed on technology transfer between South Africa and Australia.[132]
This international background to the Silex technology was highlighted recently when a nuclear industry executive observed that,

> ***"For instance, the lasers used in SILEX did not originate in the United States and did not originate in Australia where SILEX was developed. It originated elsewhere."***[133]

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127 See, Lashkar Ab'ad - Laser enrichment, available at http://www.isisnucleariran.org/sites/detail/lashkar-abad-laser-enrichment/

128 See, Opposition: Iran Using Laser Enrichment, Edith M. Lederer, Associated Press September 14, 2006, available at www.washingtonpost.com/wp-dyn/content/article/2006/09/14/AR2006091401533.html

129 See, Alice Cawte, Atomic Australia 1944-1990, NSW University Press, Kensington, 1992, p112, opcit Secrets, Lies and Uranium Enrichment.

130 See, "Laser Development Contract Signed" Goldsworthy. M, Australian Stock exchange, Document No:161933., Jun 23rd 1998, http://www.asx.com.au/asx/statistics/showSignalgDetail.do issuerId=3900&announcementId=343025, and also, "Nuclear and missile related trade and developments for selected countries", M. Barletta, C. Bowen, K. Jamison, and G. Kampani, The Non-proliferation Review, November 1997-February 1998, Monterey CA.

131 See, Focusing on Iran's Laser Enrichment Program, Charles D. Ferguson and Jack Boureston FirstWatch International June 17, 2004

132 The South African connection should also be seen in the context of that country's collaboration with Israel's nuclear weapons program, See, The Invisble Bomb, Frank Barnaby, I.B.Tauris, London, 1989. Never one to miss out on developing technology with proliferation implications, French state nuclear company Cogema had opened negotiations with South Africa in 1993 for coooperation in the MLIS program. This was formalised in 1996 with a formal cooperation agreement, See, "RF (Pik) Botha, Minister of Mineral and Energy Affairs: co-operation agreements between South Africa and France of the industrialisation of the molecular laser isotope separation (mlis) technology for the commercial enrichment of uranium, Media release, February 29th 1996.

133 See comments by Jack Edlow, President of Edlow International, speaking at Proliferation Consequences of Laser Enrichment, This transcript was prepared by Richard Sabatini of the James Martin Center for Nonproliferation Studies, seminar held at George Washington University, Washington, DC October 26th, 2009.

He did not disclose where he thought it did originate.

Given this track record of laser enrichment technology, the looming threat of the GLE has prompted a debate within the U.S. non-proliferation community. A request[134] by Tom Clements of Friends of the Earth for the NRC to conduct a Nuclear Non-proliferation Impact Assessment, NNIA, led the NRC to state that such an assessment is outside the scope of the NRC.[135]

> ***"Could this be the next A.Q. Khan black market in the making?"***[136]
> Charles Ferguson, 2009

The answer is it could be.

8.7 Laser enrichment impact on MNAs

The proposals for MNAs to the nuclear fuel cycle are justified on the basis that enrichment technology could proliferate to states planning to develop commercial nuclear power programs. Yet several of the states most actively warning of the danger of nuclear proliferation and leading efforts to establish new mechanisms for managing the nuclear fuel cycle are the ones which have spent years and allocated billions of dollars researching and developing laser enrichment technology.

For decades laser enrichment technology has been plagued with problems due to technicalities and commercial viability. It now appears poised for deployment. Many of the technical challenges of laser enrichment appear have been overcome as a direct result of the research programs operated by the U.S. Department of Energy, and their counterparts in Australia, Japan, France, Russia, India and beyond.

However, the history of laser enrichment is one of false promises and the Silex GLE-CE remains today only a blueprint.[137] If built however it will have profound implications across a spectrum of non-proliferation issues further marginalising any

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134 ***"given proliferation concerns, I request that a Nuclear-Nonproliferation Impact Assessment be prepared by the NRC on the laser enrichment technology. While this could be prepared in parallel with the EIS, it is imperative that such an assessment be prepared by the U.S. Government before this technology is deployed. Such an assessment should provide an opportunity for the public to provide input and comment."*** Tom Clements, Nuclear Campaign Coordinator, Southeastern Office, Columbia, South Carolina, Friends of the Earth, to Ms. Annette L. Vietti-Cook Secretary of the Commission, NRC, January 20th 2010.

135 See, Request to prepare nuclear nonproliferation impact assessment for laser enrichment technology, Michael F. Weber, Director office of Nuclear Material Safety and Safeguards docket no.: 70-7016, U.S. Nuclear Regulatory Commission, Washington DC. response to Tom Clements, Nuclear Campaign Coordinator, Southeastern Office, Columbia South Carolina, Friends of the Earth U.S., March 15th , 2010.

136 Charles Ferguson, Phillip D. Reed Senior Fellow for Science and Technology, the Council on Foreign Relations, speaking at the Proliferation Consequences of Laser Enrichment seminar, held at George Washington University, Washington, DC October 26th, 2009.

137 As indicated earlier, USEC after investing in the technology, withdrew seeing no prospects for its successful deployment and opted to develop centrifuge plants, See, "US Enrichment Corp. shuts down AVLIS", Vincent Kiernan, Laser Focus World, August 1999.

role for MNAs to the nuclear fuel cycle.

One major impediment to the proliferation of enrichment technology historically has been the scale of plant required. Gaseous diffusion plants built for producing highly enriched uranium for nuclear weapons are enormous structures requiring huge energy supply. The displacement of diffusion technology with gas centrifuge facilities has been due in part to the economy of scale, and the much-reduced electricity required. For any nation deploying either of these technologies it requires large financial investment, is technically challenging, and reliant on components engineered to exceedingly high standards. These factors have limited the acquisition of enrichment plants and therefore slowed the proliferation of nuclear weapons. To some extent these factors have been overturned with the operation of the A.Q. Khan network.

That said, if the claims of Silex are proven with the successful operation of the GE-Hitachi-Cameco plant, the probability of widespread take up of laser enrichment would increase considerably. For those states considering nuclear power for the first time, their newly created nuclear engineering and scientific bureaucracies will likely make the case for researching this newly accessible enrichment technology. When it becomes more widely known within the G77 non-nuclear NPT member states that the first commercial laser enrichment plant is being built in the U.S., efforts by the Obama administration to promote multinational fuel centres with restrictions on accessing enrichment technology will be further exposed to the charge of hypocrisy.

More than 20 nations have researched uranium laser enrichment technology. Laser technology developed for non-nuclear activities in many cases is dual use in being able to enrich uranium, and its knowledge is widespread. This is not to mislead - clearly it is not a simple process to start up a laser enrichment plant. But the truly significant aspect of the GE-Hitachi-Cameco development is that it legitimises the use of such technology. A U.S. administration that sanctions such a development clearly has a credibility problem when promoting proliferation restraint worldwide.

The duplicity and ineffectiveness of current non-proliferation policy, is highlighted by the GE-Hitachi-Cameco facility. It is not under international scrutiny, will not be cited in U.N Security Council debates as an issue of concern. As far as these authors are aware, the IAEA has yet to issue any statement on the proliferation implications of the U.S.-Japan-Canada laser plant, nor disclose what safeguards system if any will be applied. In fact the IAEA has actively promoted the benefits of laser enrichment technology[138] – despite awareness in non-proliferation circles that such technology if it was acquired by a non-nuclear state could halve the time necessary for that state to

138 The IAEA in 1999 reported that "The commercial application of the laser enrichment technology (for example AVLIS) could lead to much smaller enrichment plants for a given separation efficiency. It also has the potential to lead to significantly lower arisings of both operational and ultimately decommissioning waste in the enrichment phase", see, IAEA-TECDOC-1115 Minimization of waste from uranium purification, enrichment and fuel fabrication IAEA, Vienna, October, 1999. http://www-pub.iaea.org/MTCD/publications/PDF/te_1115_prn.pdf

develop a nuclear warhead.[139] This indeed is a further illustration that the IAEA whose raison d'être is the promotion of nuclear power is perhaps not best placed to make recommendations on what makes effective nuclear non-proliferation policy.

8.8 MNAs prompt declarations to enrich

Large scale uranium enrichment is likely to remain concentrated in six nations (U.S., Russian Federation, France, the Netherlands, UK and Germany), with smaller additional capacity in China, India, Pakistan, Japan, Iran, Brazil, and new capacity possibly in Argentina, and South Africa.[140] With the exception of Argentina, Brazil, South Africa and Iran, all of these states are either nuclear weapons states, or covered by a nuclear security guarantee (nuclear umbrella).

One unintended consequence of the declarations on the need to control enrichment and reprocessing technologies in the mid-2000's, in particular the U.S. GNEP, was that a number of states shortly thereafter announced their intentions to consider enrichment programs. Wanting to avoid being excluded from a future advanced nuclear fuel cycle club, South Africa, Argentina, Brazil and Australia, to varying degrees, indicated that they would be considering developing new or expanded enrichment programs. As consultants at the DOE Oak Ridge National Laboratory indicated in their report to the U.S. Department of Energy,

> ***"Plans for small enrichment programs by states such as Iran, Brazil, Argentina, South Africa, and Australia may be partially based on the desire to be considered among these "supplier" countries if such a distinction ever becomes official.".***[141]

Pronouncements on multinational control over the nuclear fuel cycle were of course not the only trigger for these states asserting their right under Article IV of the NPT to develop uranium enrichment. But these states were putting down a marker for a possible future where only a select group of nations are permitted to have advanced, sensitive nuclear fuel cycle technologies. The IAEA indication of 60 nations being interested in developing nuclear power for the first time, would suggest that at least a few of these will take up the option to develop such technologies. Which brings

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139 See, see Laser Isotope Enrichment *a new dimension to the nth country problem?, Robert L Bledsoe, Air University Review, March-April 1978.*

140 The position of Australia is also worth a note. During the 1970-1980s, the Australian Atomic Energy Commission (AAEC), had a gas centrifuge research and development program. Bench-top cascade operation was achieved at the Lucas Heights Science and Technology Centre, but the program was terminated in 1983 with no pilot plant built.53 When the centrifuge program was terminated, Australia decided to deny the IAEA access to the dismantled centrifuge components, on the basis of protecting proprietary technology. All blueprints, scientific reports, and components relating to the centrifuge program remain securely stored at Lucas Heights. However, the technology and expertise for centrifuge enrichment is still present. The Australian government is said to be considering re-launching a uranium enrichment program in the country for the purpose of "value-adding" to its current uranium exports, but no actions have been taken at this point.

141 See, Profile of World Uranium Enrichment Programs – 2007, M. D. Laughter Nuclear Science and Technology Division OAK RIDGE NATIONAL LABORATORY, UT-BATTELLE, LLC, ORNL/TM-2007/193, prepared for the USDOE under contract DE-AC05-00OR22725, November 2007.

the issue around to the fundamental proliferation threat posed by the expansion of nuclear power, of which uranium enrichment is but a part.

8.9 Nuclear power growth, spent fuel and plutonium proliferation

The IAEA projection of nuclear power expansion makes the growth of spent fuel and plutonium clear.

Table 4: IAEA Fuel cycle needs scenarios

	2008	2030	2030
		Low	High
Nuclear power (GWe)	373	473	748
Spent fuel discharged (tHM) per annum	**12,000**	**11-13,000**	**18-21,000**
Spent fuel reprocessing tHM per anum	1,500	1-2,000	4-6,000

The nuclear fuel cycle and its market: an overview, Hans Forsström, Director, Division of Nuclear Fuel Cycle and Waste Technology, February 2009, www.mofa.go.jp/policy/energy/iaea/seminar0902/nfc.pdf

Whereas in 2010, around 12,000 tonnes of spent fuel is discharged annually, by 2030 on the IAEA's high growth projection of 748GW (the equivalent of 738 1000MWe LWRs), up to 21,000 tonnes of spent fuel will be discharged annually. This would bring the total spent fuel discharged by 2030 to around 750,000 tonnes. The plutonium content would be around 7.5 million kilograms of plutonium, sufficient to manufacture 1.5 million nuclear weapons.

This is the proliferation problem that those promoting the MNAs to the nuclear fuel cycle and the global expansion of nuclear power (they tend to be the same bodies) would prefer no-one notice.

8.10 Geography of proliferation and the inadequacies of MNAs

> ***"...working with the IAEA and ongoing international efforts to explore non-discriminatory fuel leasing and fuel services approaches. It's hard to think of more inoffensive and ineffectual advice."***
> former NRC Commissioner Victor Gillinsky[142]

While the focus of MNAs has been on the front-end of the fuel cycle through uranium banks and bonds, it is clear on the basis of the IAEA's projected nuclear power growth, that many more nations will be acquiring stocks of spent fuel containing plutonium. However, as with today, the states promoting new approaches

142 A call to resist the nuclear revival, Victor Gillinsky, Bulletin of Atomic Scientists, 27th January 2009 http://www.thebulletin.org/web-edition/op-eds/call-to-resist-the-nuclear-revival

to managing the nuclear fuel cycle – the United States, Russia and nations in western Europe and Japan, will continue to accumulate the largest share of nuclear reactor spent fuel and plutonium. Again, while the proliferation debate is centred on the threat from new states acquiring access to fissile materials, the same states leading the charge to a new framework for non-proliferation are the ones today with the largest stockpiles of weapon-usable plutonium. Not surprisingly, the majority of nations party to the NPT does not welcome this selective and discriminatory approach to nuclear non-proliferation.

Table 5: Nuclear power growth, spent fuel volumes and nuclear weapons potential

Country/Region	Projected installed nuclear capacity Gwe in 2030	Annual spent fuel discharged t/Heavy Metal in 2030	Annual nuclear weapons potential from discharged plutonium
U.S./Canada	127-168	3810-5040	762-1008
Latin America	10.8-23	324-690	65-138
Western Europe	82-158	2460-4740	492-948
Eastern Europe	83-121	2490-3630	498-726
Africa	6.1-17	183-570	37-114
Middle East and South Asia	20-56	600-1680	120-336
South-East Asia and the Pacific	00.5.2	Up to 156	31
East Asia	183-259	5490-7770	1098-1554

Notes: The plutonium content of 1% is based upon LWR low-enriched uranium spent fuel. The weapons equivalent figure is based upon 5kg plutonium required for each weapon.[143]

As the projections show, in future the largest stocks of plutonium will be accumulated in the East Asia, specifically Japan, the Republic of Korea and China. Given history, unresolved disputes, and that one of these states is a nuclear weapon state, the prospects for nuclear proliferation in the region are not good.[144] While the large spent fuel problem that today exists in the traditional nuclear states within the OECD, in the future with the expansion of nuclear power, they will be joined by states in the Middle East, Africa, South-East Asia. The LWRs that are being promoted as viable energy solutions to the developing world, may not provide them with much in the way of electricity by they will provide them with plutonium in quantities sufficient for hundreds and eventually thousands of nuclear weapons.

143 The critical mass of a bare sphere of typical reactor-grade plutonium is about 13 kg compared with about 10 kg for weapon-grade plutonium. Both alpha-phase metal density of 19.6 grams per cubic centimetre. The use of a reflector a few inches thick (of say uranium) would reduce the critical mass by at least a factor of two, to say 5 or 6kg. Fast implosion technology would reduce it more.

144 See, for example, Japan the Nuclear State, Professor Gavan McCormack, Japan Focus, http://www.japanfocus.org/-David-McNeill/2488, also "Proliferation Report: sensitive nuclear technology and plutonium technologies in the Republic of Korea and Japan, international collaboration and the need for a comprehensive fissile material treaty', Shaun Burnie, Greenpeace International, paper presented to the International Conference on Proliferation Challenges in East Asia, National Assembly, Seoul, 28 April 2005, www.greenpeace.org/international/press/ reports/Proliferation-Korea-Japan

Of course one consequence of new nuclear states is that within a number of years they will be confronted with what to do with highly radioactive spent fuel. While storage options at reactor sites remains the least controversial, they will also be targeted by international nuclear fuel cycle companies offering terms for removal of the spent fuel to reprocessing sites. AREVA of France and Rosatom of Russia will likely lead this charge, based upon past experience. As utilities in Europe and Japan have found, removal of spent fuel from reactors sites has the attraction of reducing public opposition concerned as they are with nuclear waste sites. The GNEP concept as promoted by the Bush administration envisaged a fuel leasing scheme, whereby the spent fuel would be removed for reprocessing, with the resultant plutonium fuelling Generation IV fast breeder reactors in 'advanced' nuclear states. The obstacles to such schemes are considerable, not least the poor history of breeder programs. The most likely scenario is most spent fuel will remain in country which of course is a proliferation issue due to the plutonium content. AREVA, Rosatom and others are only likely to secure contracts for a percentage of the spent fuel, but that of course will lead to further proliferation consequences as they reprocess the plutonium, and in some cases supply plutonium MOX fuel back to the client states. MNAs will not be able to resolve these issues.

The ambition of the nuclear industry is of course to continue expansion throughout the coming century. The World Nuclear Association projects total installed nuclear capacity of between 2,050GWe and 11,050GWe by 2100, of which nations new to nuclear power will acquire between 323GWe and 1900GWe.[145] While wholly implausible on so many levels, the fact that WNA, representing the largest nuclear corporations on the planet is promoting a world with annual discharges of over 3.3 million kilograms of plutonium every year, sufficient for 660,000 nuclear weapons highlights that non-proliferation is not seriously considered by the nuclear industry.[146]

The proposals for MNAs are directed towards new nuclear nations. Yet the proliferation threats posed by fissile materials today exist in states and regions that will not be affected by any of the MNAs currently on the table. The MNA proposals have nothing to contribute to the proliferation dynamic currently underway in South Asia and North-east Asia. Yet the largest growth projected in nuclear power, spent fuel and plutonium production are in East Asia together with India. These programs

145 The demand for uranium enrichment services would of course also dramatically increase. A world with 11,000GW of nuclear capacity – that is 11,000 1GWE reactors – would require enrichment capacity of over 1 billion SWU based upon today's technology, and 110,000 SWU required to fuel 1GWe reactor. This compares with today's enrichment capacity of 46 million SWU.

146 The World Nuclear Associations membership ranges from nuclear fuel cycle companies such as Areva of France, TVEL of Russia, KazAtomProm of Kazakhstan, Rio Tinto, to utilities such as EoN of Germany, EDF, Chubu Electric of Japan, Vattenfall of Sweden, and ESKOM of South Africa, to financial institutions such as Deutsche Bank, to national nuclear bodies such as the Israel Atomic Energy Commission, Korea Atomic Energy Commission, and the Atomic Energy Organization of Iran, for full listing of membership see, www,world muclear.org/About/members_list.aspx. The Atomic Energy Commission of France projects that by 2050, as much as 10,000 tonnes of plutonium will be in stockpiled spent fuel, see, J. Bouchard Commissariat à l'énergie atomique, Gif-Sur-Yvette, France presentation at The Management of spent fuel from nuclear power reactors proceedings of an international conference on management of spent fuel from nuclear power reactors organized by the International Atomic Energy Agency, Vienna 2007.

may not develop as envisaged, but the problems already exist. The MNAs will have no impact, but the proliferation dangers are already real today. Little wonder that developing nations in the Middle East, Africa and Latin America question the focus on their possible future nuclear programs as presenting a proliferation challenge.

9. MULTINATIONAL NUCLEAR APPROACHES AND THE NPT

The MNA proposals that emerged in recent years have created considerable debate within the context of the NPT, and in particular the rights of states to access peaceful nuclear technology as mandated in Article IV of the Treaty. The 2010 NPT Review Conference in New York could provide further evidence that MNAs are not universally supported by NPT states. This section will assess the MNAs and the position of NPT parties, the motives of the different states and groups of states, and how effective any of this will be in reducing proliferation dangers. The May 2010 Conference is the first to be held since the conclusion of the U.S. India Nuclear Cooperation Agreement.[147] Characterized as the end of the current non-proliferation regime, the Agreement will boost India's nuclear weapons potential, permit it access to the world's commercial nuclear market and increase nuclear proliferation in South Asia. For good reason many NPT states see this as a glaring demonstration of the duplicity of the major nuclear powers. By simultaneously opening up nuclear trade with a nuclear weapon state outside the NPT, while promoting MNAs on non-proliferation grounds, the IAEA, U.S., Russia, and other large nuclear states will be judged by many NPT states as retaining little credibility. That said, there are signs of declining opposition to some MNAs as the promoters of such schemes, led by the IAEA, step up efforts to reassure developing nations that their rights to develop their own nuclear fuel cycle of choice will not be impeded by MNAs. This further exposes the inherent contradiction at the heart of the IAEA – promotion and ineffective non-proliferation monitoring.

9.1 NPT debate on MNAs

The NPT is founded on a bargain between states possessing nuclear weapons and those who do not. Article VI of the Treaty requires nuclear weapons states to disarm; while Article IV gives non-nuclear weapons states the right to develop peaceful nuclear energy. Articles I and II commit them to not acquire nuclear weapons, while Article III requires non-nuclear states to place their peaceful nuclear programs under IAEA safeguards. During the negotiations of the NPT during the late 1960's the question of whether a future Treaty would lead to restrictions on national

147 See, The U.S. India nuclear cooperation agreement – the end of the nuclear non-proliferation regime? A report commissioned by Greenpeace Germany, Shaun Burnie, August 28th 2008. http://www.greenpeace.de/fileadmin/gpd/user_upload/themen/frieden/The_US_India_nuclear_cooperation_agreement.pdf

nuclear programs was a major issue for both industrialised and developing nations.[148]

The consensus view of states parties to the NPT since its foundation is that as Article IV gives "***inalienable right"*** to states to participate ***"to the fullest possible exchange of equipment, materials, and scientific and technological information for the peaceful uses of nuclear energy"*** it means that there are no legal impediments to a state developing the range of nuclear fuel cycle facilities. But the rights of states under Article IV are also conditional on their undertakings under Article I and II of the Treaty.

Authoritative analysis over the years has made the case that the rights of access to nuclear technology through Article IV should not be interpreted to mean that this provides a legal right of states to develop uranium enrichment or plutonium reprocessing facilities. The Nuclear Control Institute was one of the first to make this argument. Specifically, it said that if there was no economic justification for the use of plutonium as fuel,

> ***"then the treaty, as it now exists and without need to amend it, can be interpreted to say that any production of separated, weapons-usable plutonium is a violation of Articles I and II."***[149]

A more recent case has been made that in addition to Articles I and II, the inalienable right must also be in conformity with Article III (safeguards).[150] Henry Sokolski makes the important point that,

> ***"this condition is difficult to meet. Not all nuclear activities and materials can in fact be safeguarded to prevent their diversion to make bombs...Similarly, some nuclear materials are so weapons usable (e.g., highly enriched uranium, separated plutonium or plutonium based fuels) that reliable and timely detection of their diversion to make bombs is simply not possible. This, then, raises the question: If a nuclear activity or material is so close to bomb making that it cannot be safeguarded against military***

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148 For a comprehensive overview of these debates see, The Nuclear Non-Proliferation Treaty, origin and implementation 1959-1979, Mohamed I Shaker, Oceana, 1980. The major industrial non-nuclear states were particularly concerned over the possible restrictions a future NPT would place on the development of their peaceful nuclear programs, this was one reason Japan did not ratify the NPT until 1976, six years after siging it. Another factor little discussed today is that the ruling Liberal Democratic Party included politicians who wished to retain the option of Japan developing nuclear weapons, see, Japan refused to promise NPT passage in '73 statement with U.S., Kyodo News , December 22nd 2008, http://search.japantimes.co.jp/cgi-bin/nn20081222a4.html

149 See, "The NPT and plutonium: application of NPT prohibitions to 'civilian' nuclear equipment, technology and materials associated with reprocessing and plutonium use", Eldon V.C. Greenberg, Nuclear Control Institute, Washington DC, May 1993.

150 Henry Sokolski notes that "The final statement of the 2000 NPT Review Conference refers to the need for nonweapons state members to exercise their Article IV activities in conformity with Articles I, II *and* III.",, See, "The NPT's Untapped Potential to Prevent Proliferation", Introduction Released to NPEC Book "Reviewing the Nonproliferation Treaty", Henry Sokolski, Executive Director, Nuclear Proliferation Education Centre, April 22nd 2010, http://www.npec-web.org/node/1239

diversion, is it protected as being "peaceful" under the NPT?"[151]

As noted earlier, the IAEA is unable to meet its detection goals for the diversion of nuclear material at enrichment, reprocessing, and fuel fabrication plants.

These are convincing arguments largely ignored by the nuclear non-proliferation community and NPT parties, but the position of Brazil reflects the view of all NPT parties when it states,

> ***"In spite of non-compliance (issues), the provisions of Article IV are not open to reinterpretation or revision, nor should they serve as a pretext to curtail bona fide, lawful programs of scientific or economic and social interest in developing countries."***[152]

Of course it is these rights to develop nuclear power that in the words of IAEA Director ElBaradei had given between 35-40 nations the ability to develop nuclear weapons.[153] In what was in effect a critique of the bargain, ElBaradei blamed the non-compliance of nuclear weapon states to disarm and the spread of dual use technology specifically uranium enrichment and plutonium reprocessing.

> ***"In 1970, it was assumed that relatively few countries knew how to acquire nuclear weapons. Now, with 35-40 countries in the know by some estimates, the margin of security under the current non-proliferation regime is becoming too slim for comfort. We need a new approach."***[154]

It was indeed significant that a serving IAEA Director should raise fundamental questions about the proliferation hazards of peaceful nuclear technology. To reduce these risks, ElBaradei put forward a proposal with three parts: limit commercial reprocessing and uranium enrichment; deploy proliferation resistance nuclear power that would prevent nations from diverting nuclear material to weapons production; and finally, the development of multinational facilities for the management and disposal of spent fuel and radioactive waste. The new approach was not exactly an anti-nuclear manifesto, but at least it was an acknowledgement that peaceful nuclear technology was a proliferation threat. In the years since ElBaradei's warnings the original proposal has evolved into MNAs for supply of uranium and uranium fuel, with the Russian Angarsk plant approved by the IAEA Board of Governors in November 2009, and the likely opening of an IAEA/NTI fuel bank in Kazakhstan.

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151 See, "The NPT's Untapped Potential to Prevent Proliferation", Introduction Released to NPEC Book "Reviewing the Nonproliferation Treaty", Henry Sokolski, Executive Director, Nuclear Proliferation Education Centre, April 22nd 2010, http://www.npec-web.org/node/1239

152 See, Statement by the Head of the Delegation of Brazil, Ambassador Luiz Felipe de Macedo Soares, Permanent representative of Brazil to the Conference on Disarmament, Cluster 3, Third Session of the Preparatory Committee to the 8th Review Conference of the Treaty on the Non Proliferation of Nuclear Weapons, May 8th 2009.

153 Towards a Safer World by IAEA Director General Dr. Mohamed ElBaradei, The Economist 16th October 2003

154 Ibid.

But proliferation threats have also increased. Nuclear weapons usable plutonium production has increased, with a new reprocessing plant opened at Rokkasho-mura in Japan, and new centrifuge uranium enrichment plants commissioned and under construction, including for the first time commercial laser enrichment. Proposals to expand plutonium reprocessing and fuel use have also multiplied in the intervening years with GNEP and Generation IV breeder reactors research programs.

As for the deployment of nuclear energy that is proliferation resistant called for by ElBaradei almost all new reactors commissioned since 2003, together with all nuclear power reactors under construction and the vast bulk of those planned are LWRs which produce on average 230kg of plutonium every year of operation. The nuclear industry intends that these reactors will operate for 60 years or more.

Seven years after ElBaradei´s original proposal there has not been a new approach to non-proliferation but rather an increase in proliferation risks from civil nuclear programs, which, as this paper has sought to show, will rise dramatically if nuclear power programs expand globally.

9.2 G77 NPT nations positions on MNAs

The very first NPT Review Conference in 1975 recognized that MNAs to the fuel cycle may have benefits both for the expansion of nuclear power and non-proliferation.[155] Thirty-five years later it is unlikely that there will be consensus on this issue at the May 2010 Review Conference. The developing nations that signed up to the NPT bargain have during the last 40 years asserted their right to access nuclear energy technology. The NPT Review Conferences have consistently seen states express their rights under Article IV, with many complaining that they have not benefited from nuclear technology development. The emergence of MNAs during the last five years has only compounded this sense that the large industrial nuclear powers are once again rewriting the rulebook and not complying with the NPT bargain.

For good reason the developing world looks on suspiciously at the proposals for restricting access to uranium enrichment and plutonium reprocessing. The very same states that are proposing multinational options for the nuclear fuel cycles are the same states that have operated uranium enrichment and plutonium reprocessing facilities, and planning new ones. As a consequence of these programs there has been the growth of nuclear weapons materials from less than 50 kg in 1946 to millions of kilograms today.

At the May 2009 Preparatory Committee (PrepCom) for the 2010 NPT Review Conference the position of the G77 group of nations (consisting of 129 of the 189

155 ***"regional or multinational nuclear fuel centres may be an advantageous way to satisfy, safety and economically, the needs of many states in the course of initiating or expanding nuclear power programmes, while at the same time facilitating physical protection and the application of IAEA safeguards, and contributing to the goals of the Treaty"*** Declaration of the 1975 NPT Review Conference.

signatories to the NPT) was made very clear.

> ***"The Group continues to note with concern however, that undue restrictions on exports to developing countries of material, equipment, and technology for peaceful purposes persist and stresses that such restrictions or limitations are incompatible with the provisions of the Treaty and should be removed..."***

and that,

> ***"The Group of Non-Aligned States parties to the NPT believes that the issue of Assurances of Nuclear Fuel Supply is a very complex and multi-dimensional concept with technical, legal, commercial, and economic implications. The Group is of the view that in order to reach a consensual conclusion, it is premature for this issue to be considered before undergoing extensive, comprehensive and transparent consultations. In this context, the Group rejects, in principle, any attempts aimed at discouraging certain peaceful nuclear activities on the ground of their alleged "sensitivity." Concerns related to nuclear non-proliferation shall not in any way restrict the inalienable right of all states to develop all aspects of nuclear science and technology for peaceful purposes."***[156]

Egypt made an even stronger worded statement on MNAs at the same NPT PrepCom,[157]

> ***"In this context, it is interesting to note that the strongest proponents of a restrictive interpretation of Article IV are often those who, in practice, reserve for themselves the right to continue engaging in the very activities that seem so objectionable to them when carried out by others. Such an approach is discriminatory and not only contradicts itself, but also engagements we have collectively undertaken by joining the NPT and in the context of its review cycles."***

and that,

> ***"With regard to fuel supply initiatives, one statement on Friday noted that greater supply assurances will allow states the peace of mind needed to dedicated finite resources to the infrastructure of nuclear power plants, while another considered that multilateral would allay concerns regarding the security of supply. The reality of the present fuel supply market, however, is one that has, to the delegations mind, neither troubled the peace***

156 Statement by the delegation of the Republic of Indonesia to the United Nations on behalf of the Group of Non-Aligned States Parties to the Treaty of the Non-Proliferation of Nuclear Weapons at the Third Session of the Preparatory Committee for the 2010 NPT Review Conference Cluster 3 Issues New York, 8 May 2009.

157 Comments by the delegation of Egypt cluster 3: Implementation of the provisions relating to the inalienable right to develop research, production and use of nuclear energy for peaceful purposes, NPT Prepcom 3, May 8th 2009

of mind of recipient countries, nor caused concerns that require to be allayed. This is testified to by the fact that it is the supplier countries rather than the recipient countries that are at the origin of the recent proliferation of supply initiatives."

Malaysia, another leading member state of the G77, and with plans to develop nuclear power in the coming years also made an important point at the 2009 NPT PrepCom. Specifically,

"With regard the issue of multilateral nuclear fuel assurance, Malaysia reiterates its position that any initiative to develop multilateral approaches to the nuclear fuel cycle should focus on the original aim of finding an optimum arrangement that would satisfy both the objectives of assurance of supply and services. The existing international regime based on the Nuclear Non-Proliferation Treaty (NPT), of which Malaysia is a State Party, and the IAEA NPT-type safeguards system should provide the necessary non-proliferation assurances."[158]

Of course the point is the existing non-proliferation regime, including IAEA safeguards, never have and cannot meet "necessary non-proliferation assurances". That has been the fundamental problem with nuclear power recognised in 1946 by Acheson and Lilienthal and subsequently ignored from Eisenhower's Atoms for Peace, through the foundation of the IAEA to the drafting of the NPT.

Reflecting the impact of this opposition, the International Commission on Nuclear Non-Proliferation and Disarmament, not opposed to nuclear power expansion, made the observation that,

"This lukewarm political support, coupled with the fact that most proposals deny access to multilateral fuel cycle services if the state making the request is not in good standing with IAEA safeguards (such as Iran) or are outside the NPT, limit the effectiveness of the proposals in reigning in states of proliferation concern. Proposals requiring states to forgo national facilities as a precondition of participation, such as the US HEU fuel bank, are politically unpalatable for many developing states and unlikely to succeed in limiting the spread of sensitive technologies"[159]

The fact that MNAs have not been universally welcomed is not a surprise.[160] Those

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158 See, Intervention by the representative of Malaysia on Cluster 3 Issues (Peaceful use of nuclear energy), NPT PrepCom, New York May 4-15th 2009.

159 Fuel Cycle Management, Martine Letts, International Commission on Nuclear Non-Proliferation and Disarmament. August 7th 2009.

160 Reflecting the position of many G77 nations, Jordan announcing its intention to develop nuclear power has asserted its right to develop the nuclear fuel cycle. In response to a question during a joint press conference with Minister of State for Media Affairs and Communications and Government Spokesperson Nabil Sharif JAEC Chairman Khaled Toukan said the government will not sign any agreement that is prone to compromise its rights as

promoting them are now seeking to win G77 nation support for them, even as the dispute with Iran highlights that the major states are seeking to be prescriptive in which states have access sensitive nuclear technology.

9.3 U.S. India Agreement: exposing non-proliferation discrimination and undermining MNAs

A factor that should blow a whole in the proposals for MNAs is the negotiation of the U.S. India Nuclear Cooperation Agreement in 2008.[161] Conceived in the dying days of the Clinton Administration, developed and signed during the George W. Bush presidency, and wholly endorsed by the Obama Administration, the agreement tears apart the rules of nuclear trade applied over the last forty years. While the agreement is centred on peaceful nuclear trade, it is in reality, part of a larger strategic alignment between the U.S. and India in relation to China, with potentially devastating consequences for nuclear proliferation and peace and security in the region.[162]

India as a non-NPT signatory negotiated a highly favourable agreement that will permit it to expand its domestic nuclear energy program, including importation of uranium and uranium fuel, as well as reactor technology. India understands the agreement as also permitting the importation of reprocessing and uranium enrichment technology. The Obama administration has recently given in to Indian requests to permit the reprocessing of U.S. obligated spent fuel, which will increase India's plutonium stockpile.[163] India is also permitted to keep outside safeguards its stockpiles of accumulated power reactor spent fuel and separated power reactor plutonium. Furthermore, India can choose whether any future reactors it builds will be declared military or commercial. Most significantly, by permitting India to import uranium its limited domestic uranium will be freed up to service its military program.

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enshrined in the nuclear Non-Proliferation Treaty (NPT). "Jordan will continue to demand its rights and privileges guaranteed in the NPT, and all agreements we have signed indicated this clearly," he told reporters yesterday, calling for the treaty to be applied "universally". See, Jordan will not abandon nuclear rights', April 1st 2010, Jordan Times http://www.jordantimes.com/?news=25351

161 Opcit, The U.S. India nuclear cooperation agreement – the end of the nuclear non-proliferation regime ?

162 The Pentagon's Nuclear Posture Review issued in 2001 is a critically important document setting as it does the blueprint for a Cold War Mark II, this time with China. In 2006 the Pentagon's quadrennial Defense Review Report, singled out China as the country with 'greatest potential' to challenge the U.S. militarily. In contrast, the Pentagon described India as ***"emerging as a great power and key strategic partner…(with) Shared values as long standing, multi-ethnic democracies provide the foundation for continued and increased strategic cooperation and represent an important opportunity for our two countries."***, asee, Quadrennial Defense Review Report United States Department of Defense, February 2006. s described in The U.S. India nuclear cooperation agreement – the end of the nuclear non-proliferation regime ? Opcit. ***"No one should be fooled into thinking that the US interest in India and the nuclear deal is about global warming and reducing pressure on oil…The actual rationale is to develop a strategic relationship to deal with the perceived challenges from China."*** Anuradha Chenoy, professor of international studies at the Jawaharlal Nehru University (JNU)., Indo–US nuclear deal, rises eyebrows Syed Nazakat, 20 April 2008, Sunday http://world.merinews.com. For a critically important insight into the emerging U.S./China conflict see, "Chinese Nuclear Forces and U.S. Nuclear War Planning" Hans M. Kristensen Robert S. Norris Matthew G. McKinzie, The Federation of American Scientists & the Natural Resources Defense Council November 2006

163 In agreeing to permit the reprocessing of U.S. origin spent fuel in two yet to be built reprocessing plants, the Obama administration has set less specific conditions as to when the agreement with India would be suspended. This relates for example to what would happen if India was to conduct a nuclear weapons test, see India, US completes negotiations for two reprocessing facilities, Randy Woods, Nuclear Fuel, April 5th 2010.

"This would be a sweet deal for India, but a body blow to the non-proliferation regime, so-called."
Paul Leventhal, Nuclear Control Institute, 2005.[164]

India has an expanding nuclear weapons program and is implementing a triad strategy with air, sea and ground launched nuclear forces.[165] There is no doubt that the future importation of uranium from the international market, perhaps even the Russian IUEC, will aid this nuclear weapons development. One consequence of course is that India's neighbour Pakistan has expressed its own wishes to negotiate a similar agreement with the United States, and to receive NSG approval. While unlikely in the short to medium term for a whole host of reasons, Pakistan has recently agreed with China to construct two nuclear power plants. Pakistan also views the existing disparity in stocks of weapons-usable fissile material something it needs to correct.[166] The U.S. India Agreement does nothing to de-escalate the nuclear tensions with Pakistan, quite the opposite.

The point has been made repeatedly that the U.S./India Agreement further undermines negotiations with Iran to curtail its uranium enrichment program – it, unlike India, is a member of the NPT and interprets its status as permitting access to such technology.[167]

For good reason the credibility of the nations, which approved this proliferation deal at the 2010 NPT Review should be in tatters. A special mention should be made of the position of the ElBaradei. Defending the U.S. India Agreement he stated in 2006,

"…does not add to or detract from India's nuclear weapons program,"

Apart from being fundamentally wrong, his advocacy of the Agreement took place in the same timeframe as his warnings of the dangers of nuclear weapons proliferation while offering the solution of nuclear fuel banks, and other MNAs, that would reduce proliferation risks.

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164 "Cirus reactor's role in a U.S.-India nuclear agreement" Paul Leventhal, Nuclear Control Institute Presentation to Center for Nonproliferation Studies Washington, DC December 19th, 2005.

165 One year after its 1998 nuclear tests, a draft Report of the National Security Advisory Board on Indian Nuclear Doctrine, was published, which called for a "doctrine of credible minimum nuclear deterrence" based upon a "triad of aircraft, mobile land-based missiles and sea-based assets". See, India's Nuclear Bomb, The Impact on Global Proliferation, George Perkovich, 2001 updated edition.

166 See, Playing the Nuclear Game: Pakistan and the Fissile Material Cutoff Treaty, Zia Mann and A.H. Nayyar http://www.armscontrol.org/act/2010_04/Mian

167 For example, "Many similarly see hypocrisy in rewarding India, a nuclear weapon state outside the NPT, while punishing Iran, an NPT member state that does not yet have the bomb." Sharon Squassoni, Carnegie Endowment/New Republic, August 2007.

> ***"If the [safeguards] agreement is approved today, and if an exception to the NSG directives is adopted [for India], it will be necessary to conclude that the non-proliferation regime that we know has reached its end."***
> *Government of Switzerland to IAEA Board of Governors August 1st 2008*[168]

The Nuclear Suppliers Group[169] in 2008 did indeed endorse the U.S./India Agreement when it agreed that it would be exempt from its guidelines, this despite it being clearly in contravention of the NSG own guidelines. Commercial opportunism was clearly the factor that determined the large nuclear states within the NSG, such as Australia, France, Russia, the UK, Japan, and others. The position of non-nuclear states such Ireland, Norway, New Zealand and Austria in supporting the Agreement is less easy to understand other than it being one heavy lobbying and weak diplomatic resolve. The effect of course has been to permit G77 nations to attack the discrimination within the NPT, with parties knowing full well that they will be unlikely ever to be granted the same rights as India. Its not by accident that at the 2009 NPT meeting, G77 nations expressed their opposition to MNAs in the same document as demanding a prohibition on all nuclear trade with non-NPT signatories. Specifically,

> ***"The Group remains concerned about the ability of certain States not Parties to the Treaty to obtain nuclear materials, technology and know-how to develop nuclear weapons. The Group calls for the total and complete prohibition of the transfer of all nuclear related equipment, information, material and facilities, resources or devices and the extension of assistance in the nuclear, scientific or technological fields to States non-parties to the Treaty without exception."***[170]

Worth noting of course is that amongst the G77 nations that expressed such strong views against nuclear trade with non-NPT parties were Nuclear Suppliers Group members that one year before had agreed to the U.S.-India Agreement being exempt from NSG restrictions. Specifically, Argentina, Brazil and South Africa. The reasons these states oppose MNAs is little to do with their concerns over non-proliferation and everything to do with self-interest and nuclear ambitions. All three states already operate uranium enrichment plants, or have done so in the past and have announced plans to build them. In the case of Argentina and South Africa, the announcements of

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168 See, "Some in NSG predict prolonged debate over conditions for Indian exemption" Nuclear Fuel, August 11th 2008

169 The NSG is one of two arrangements established to set guidelines for multilateral nuclear export controls, the other being the NPT Exporters Committee (Zangger Committee). The 45 NSG member governments that approved the U.S. India deal were: Argentina, Australia, Austria, Belarus, Belgium, Brazil, Bulgaria, Canada, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Kazakhstan, Republic of Korea, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, and United States. The European Commission is an observer. Iceland has subsequent to the approval of the U.S. India Agreement, become an NSG member.

170 Statement by the delegation of the Republic of Indonesia to the United Nations on behalf of the Group of Non-Aligned States Parties to the Treaty of the Non-Proliferation of Nuclear Weapons at the Third Session of the Preparatory Committee for the 2010 NPT Review Conference Cluster 3 Issues New York, 8 May 2009.

new capacity were prompted by the non-proliferation statements on restricting access to enrichment and reprocessing made by the IAEA Director, U.S. President Bush and others from 2003 onwards. Thus statements intended to warn of the dangers of proliferating sensitive nuclear technology, had the effect of pushing states to announce they wanted to be part of the nuclear club. In the case of South Africa, its two original enrichment plants which were part of its nuclear weapons and civil nuclear program, had been closed.[171] The one principle they are seeking to defend is the right as they see it under the NPT to acquire and develop peaceful nuclear technology and materials that just happen to be usable to manufacture nuclear weapons.

9.4 The IAEA MNA contradiction emerges

As mentioned earlier, the original scope of the new non-proliferation regime envisaged by ElBaradei has been severely curtailed. Further reversals on the stated non-proliferation benefits of MNA appeared at the 2009 NPT Prepcom. The presentation made by the IAEA can be seen as a clear effort to placate the G77 opposition. Explaining that there was going to be large-scale nuclear expansion in the coming decades, Tariq Rauf, who has played a central role since 2003 in developing the IAEA's thinking on MNAs, talked of the ***"new roles – new fuel cycle framework"***.[172] He explained that the MNAs would be ***"solely a back up to (the) commercial market"***, and that there would be,

> ***"no curtailment of States rights to peaceful use of nuclear energy – (it) will create additional options".***

Quoting his Director-General that,

> ***"States are free to choose their fuel options",***

and that,

> ***"no states should be required to give up their rights under the NPT regarding any parts of the nucler fuel cycle".***

The one reference to a return to the thinking behind Acheson/Lilienthal, was that

> ***"all new enrichment and reprocessing activities should be placed exclusively under multilateral control followed by conversion of all existing facilities from national to multilateral control".***

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171 It was reported that some of these states challenged the notion that uranium enrichment was a proliferation concern during negotiations at the June IAEA Board meeting, see, Talks on Fuel Bank Stalled at IAEA, Dan Horner, Oliver Meier, Arms Control Association, October 2009, available at http://www.armscontrol.org/act/2009_10/fuelBank

172 See, Possible new framework for the utilization of nuclear energy: options for assurance of supply of nuclear fuel, Tariq Rauf, IAEA presentation to Cluster 3 at the NPT PrepCom, May 8th 2009.

In explaining the IAEA fuel bank, Tariq Rauf assured NPT states that it was small, a last resort and transparent, and what it was not,

> ***"a constraint...a market alternative...and political".***

These assurances betray the inherent contradiction of the IAEA (and the NPT). To secure support for MNAs, the Agency is conceding that such schemes would not threaten states inalienable rights under the NPT to develop their nuclear fuel cycle of choice. Does the IAEA really believe that proliferation of enrichment and reprocessing can be constrained? Or even should be. As noted, the IAEA runs programs with member states for the development of Generation IV breeder reactors, which will require large scale reprocessing and the production, transportation, and use of weapons-usable plutonium. They also promote the benefits of laser enrichment. What can be said is that the IAEA is aware that the non-proliferation regime is severely damaged. International perception and reality is that the technology and materials capable of being used for peaceful or military purposes are out of control. Having spent decades trying to secure the expansion of nuclear power, the IAEA must be seen to be acting to confront proliferation threats. The MNAs have served a useful purpose in convincing commentators, governments and arms control advocates that a world of more nuclear energy will not be one with more nuclear weapons. Actual manifestation of MNAs is not the point. The point is assurance – not of supply – but of political, public and media perception that nuclear energy can be expanded with minimal proliferation dangers.

Further doubts over the real impact of MNAs on non-proliferation are underscored by Russia's IUEC. While President Putin has claimed that it will play a role in discouraging states from developing domestic enrichment, it is not clear that this will be applied rigorously. In 2007 it was stated that,

> ***"The Centre is oriented chiefly to States not developing uranium enrichment capabilities on their territory."***[173]

By 2009, Russia was stating,

> ***"We share the goal expressed by the Director General in his statement at the meeting of the IAEA Board of Governors in November 2007 "(a) that any such mechanism would be apolitical and non-discriminatory, and would be available to all States that are in compliance with their safeguards obligations; and (b) that it would not require a State to give up its rights regarding any parts of the nuclear fuel cycle".***[174]

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173 See, Communication received from the Resident Representative of the Russian Federation to the IAEA on the Establishment, Structure and Operation of the International Uranium Enrichment Centre, INFCIRC/708 Date: 8 June 2007

174 See, Principles of fuel supply guarantees and the multilateralization of fuel cycle activities Working paper submitted by Germany and the Russian Federation, Third session, NPT/CONF.2010/PC.III/WP.22 NPT PrepCom,

Similarly, the German proposed enrichment project, MESP, clearly undermines the non-proliferation justification for MNA with the declaration from the German government stating that,

> ***"the proposal does not envisage any limits on the use of nuclear technology beyond those contained in the NPT. All states retain the right to develop, construct and run their own enrichment plants in the global market."***[175]

The contradictory signals emanating from the IAEA are merely a reflection of an Agency that is mandated by statute to promote the expansion of nuclear power. Its active support of granting India's access to the global nuclear market to the direct benefit of its nuclear weapons program is but one example of its atomic schizophrenia.

9.5 Declining opposition to MNAs?

One month after the 2009 NPT PrepCom, leading non-aligned nations within the G77 opposed the two MNA proposals submitted for consideration at the June 2009 IAEA Board meeting. Argentina, Brazil, Egypt, South Africa, and India all expressed their concerns that the proposals were too restrictive, and wondered why the supplier states were promoting such schemes when there was no demand from customer countries. But it was the underlying principle of their inalienable rights to nuclear technology under Article IV that were uppermost in G77 concerns. They demanded that,

> ***"the rights of member states with regard to the establishment or expansion of their own nuclear fuel cycle capabilities would remain undiminished by the establishment of multilateral fuel supply mechanisms which would instead offer additional options for the supply of nuclear fuel,"***[176]

A formal objection was submitted to the MNA plans by the G77 nations.

However, during the following months, in addition to the IAEA's assurances that the proposed MNAs were not a threat to the nuclear ambitions of member states, as well as other unknown diplomatic assurances, something changed within the G77 states on the IAEA Board.[177] Whatever they were, by the time of the November IAEA

May 8th 2009.

175 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, INFCIRC/704 4 May 2007; in 2006, Germany, together with the UK and the Netherlands had submitted to the IAEA a document supporting the multinational approach to the nuclear fuel cycle, see, Communication received from the Resident Representatives of Germany, the Netherlands and the United Kingdom to the Agency concerning multilateral cooperation on energy security in support of Article IV of the Treaty on the Non-Proliferation of Nuclear Weapons, INFCIRC/713, 17 September 2007.

176 IAEA fails to endorse fuel bank proposals, continues fine-tuning, Ann Maclachlan, Randy Woods, Nuclear Fuel July 27th, 2009.

177 IAEA Board members for 2009/2010 which are also G77 member states are: Afghanistan, Argentina, Brazil, Burkina Faso, Cameroon, Cuba, Egypt, India, Kenya, Malaysia, Mongolia, Pakistan, Peru, South Africa, Turkey, Uruguay, and the Bolivarian Republic of Venezuela.

Board meeting opposition to the Russian IUEC had declined with it receiving endorsement by a majority of member states.[178] While endorsing the Russian proposal, the Board members stated,

> ***"Emphasizing that the inalienable rights of all Parties to the NPT to develop research, production and use of nuclear energy for peaceful purposes without discrimination provided for in Article IV of the NPT will in no way be affected by the aforementioned Russian Initiative,"***[179]

The Board did not approve the IAEA fuel bank, with the deadline for its approval by September 2010 at which point NTI's contribution is rescinded. However, unanimous approval either at the June or September Board meeting looks not possible, with some states supportive of fuel bank concepts wishing to repeat the Russian proposal and have it approved by a majority vote.[180]

The approval by the IAEA Board of the Russian IUEC took place in the last days in office of the principal driver of such schemes during recent years, IAEA Director ElBaradei. On December 1st his successor, Yukiya Amano, took office. A career diplomat from Japan, he is steeped in the nuclear policies of that country, the central element of which is the move towards a fast breeder based plutonium economy. It is therefore unlikely that Director Amano will issues general warnings of the dangers of commercial reprocessing and uranium enrichment as his predecessor has done. On the issue of MNAs, Amano will continue to support them, but almost certainly with less enthusaism than ElBaradei.[181]

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178 Approved in November 27th 2009, by 23 votes to 8, with Egypt, Turkey and Kenya abstaining, and one other not in attendance. With 35 member nations of the Board, and 17 of them from G77 countries, at least five of the G77 nations appear to have vote for the Russian proposal. One factor is the role of South Africa. With a track record in endorsing the nuclear states positions on key issues – witness its switch to support for indefinite extension of the NPT in 1995 which effectively split apart a G77 united front calling for limited extension. South Africa was reported in 2009 to be discussing with Russia the option to develop conversion and enrichment of uranium at Angarsk, see, RIA Novosti Jan. 23, 2009 as reported at http://www.wise-uranium.org/eproj.html, See, Diplomats skeptical fuel bank proposal can succeed, Randy Woods, Nuclear Fuel, March 22nd 2010.

179 See, Request by the Russian Federation regarding its Initiative to Establish a Reserve of Low Enriched Uranium (LEU) for the Supply of LEU to the IAEA for its Member States Resolution adopted by the Board of Governors on 27 November 2009. http://www.iaea.org/Publications/Documents/Board/2009/gov2009-81.pdf

180 See, Diplomats skeptical fuel bank proposal can succeed, Randy Woods, Nuclear Fuel, March 22nd 2010.

181 Dan Horner at the Arms Control Association made this point in observing the lack of MNAs in Amano's acceptance speech in September 2009, see, Talks on Fuel Bank Stalled at IAEA, Dan Horner, Oliver Meier, Arms Control Association, October 2009, available at http://www.armscontrol.org/act/2009_10/fuelBank

9.6 G10 advocacy of MNAs

The continuing efforts by states to seek to persuade the G77 nations that no restrictions are planned under MNAs is made clear by a submission from the G10 to the May 2010 Review Conference.[182] Specifically,

> ***"Assurance mechanisms, singly or in conjunction with other complementary mechanisms, should not act to distort the existing well functioning market and should address real needs, allowing for the development of peaceful uses of nuclear energy in the best safety, security and non-proliferation conditions...The Conference affirms that reliance on any such mechanism should be wholly voluntary, remaining solely a sovereign decision of the particular State, and should not act as an enforced restriction of States' activities related to the fuel cycle."***

The stated objective of ElBaradei to restrict reprocessing and uranium enrichment activities through MNAs has run into the political realities of G77 resistance. The G10 nations do remind NPT parties that such technlogies can be used for both peaceful and military purposes, and that MNAs could offer alternatives to the development of national facilities. But in reiterating the inalienable rights of NPT parties, its hard not to conclude that they may recognise the proliferation dilemma of expanding nuclear power but they are in denial as to what this will mean. The end result is that proliferation risks inherent to nuclear power are ignored, while the rhetoric of MNAs provides the non-proliferation assurances sought by politicians, the nuclear industry and the IAEA.

Sadly the view of the late Paul Leventhal that,

> ***"a nuclear industry bias still pervades all the councils addressing nonproliferation and makes dealing rigorously with the plutonium (or uranium) danger all but impossible...The nukeheads run the show,"***[183]

remains as true today as it ever has. This explains the fact that G10 nations including, Ireland, Denmark, Norway, Austria, New Zealand, with a long history of opposition to nuclear power have signed up to the rhetoric of MNAs believing that nuclear power can be expanded without major proliferation consequences. Whether their attempts to reassure G77 states will lead to broader support for MNAs remains uncertain. What it will not do is deal in any effective way with the real proliferation challenges of today or tomorrow.

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182 Articles III (3) and IV, and the sixth and seventh preambular paragraphs, especially in their relationship to article III (1), (2) and (4), and the fourth and fifth preambular paragraphs (approaches to the nuclear fuel cycle) Working paper by Australia, Austria, Canada, Denmark, Finland, Hungary, Ireland, the Netherlands, New Zealand, Norway and Sweden ("the Vienna Group of Ten"), Draft Language, 2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons 29 March 2010

183 See, Closing thoughts on non-proliferation, Nuclear Power and the spread of nuclear weapons, can we have one without the other? Ed. Paul Leventhal, Sharon Tanzer, Steve Dolley, Nuclear Control Institute, 2002.

10. CONCLUSION

This report has sought to demonstrate that expansion of Light Water reactors will lead to greater nuclear proliferation through the production of weapons-usable reactor plutonium. The ability to separate this plutonium from spent fuel in clandestine reprocessing plants within a matter of weeks would defeat any IAEA safeguards system. The same nations that are leading the charge to global nuclear power expansion are behind proposals for Multinational Approaches to the nuclear fuel cycle. The conclusion of this report is that these MNAs will play no significant role in the future nuclear fuel market. Justified on the grounds that worldwide expansion of nuclear power will increase proliferation risks, this report has made the case that they will not reduce those risks but increase them. The MNA proposals that have emerged in recent years are regularly cited as a future basis for global nuclear trade while minimizing the danger that nuclear weapons proliferation will result. The reality is that those actively promoting MNAs are not motivated by nuclear non-proliferation concerns. Instead, their interests are a combination of commercial and political: commercial because the leading promoters of MNAs are governments with ambitious nuclear export industries seeking to secure a share of the anticipated growth in the worldwide nuclear market; political because the same governments, as well as the IAEA, have decided that MNAs are one way to reassure a sceptical public that there is a solution to the nuclear power nexus of energy and weapons. An illusion is being created that with a combination of IAEA safeguards and MNAs, it will be possible for large-scale expansion of nuclear power without proliferation consequences.

Proposals for multinational approaches to the nuclear fuel cycle are as old as the nuclear age, but have never materialized. Political and economic factors have undermined these efforts since the mid-1940's. Many of these factors remain relevant today. Unfortunately, it seems that many of those supporting the MNAs have little understanding of this history. This ignorance only suits the interest of the nuclear industry and their sponsors with their ambitions to build hundreds and eventually thousands of light water reactors worldwide. The consequences of such programs, if realised, will be to provide existing nuclear states, and many new to the atom, with access to hundreds, and eventually thousands of tonnes of plutonium. The IAEA by promoting MNAs is admitting that it is incapable of safeguarding such growth. This is nothing new – they are incapable of safeguarding today's stockpiles of thousands of kilograms of plutonium, as well as plutonium reprocessing, fuel and uranium enrichment facilities.

The concept of restricting access to sensitive nuclear technology to certain nations, while others retain and develop further such technology, including such things as laser enrichment, is fundamentally flawed and unsustainable. Those states opposing MNAs within the G77 have their own interests at stake, and in most cases ensuring

non-proliferation is not one of them. Some have their own nuclear programs or plans to develop them. Understandably they resent discriminatory restrictions. To date one MNA, the Russian Angarsk International Uranium Enrichment Center, has been established. In securing its endorsement by the IAEA Board, those supporting NMA's have insisted that it will in no way remove the inalienable rights of states party to the NPT to develop their nuclear fuel cycle of choice. So we have MNA proposals and endorsement of fuel cycles that will provide atom-bomb material to multiple states.

> ***"The more countries which have the potential to make nuclear weapons, the greater the likelihood of these weapons being used in a conflict...From the point of view of proliferation it is not the power output but the number of countries involved that matters."***[184]

When Joseph Rotblat wrote these words more than 30 years ago, multinational approaches to the nuclear fuel cycle were like today high on the diplomatic agenda. Projections for nuclear growth emanating from the IAEA and nuclear industry anticipated hundreds and eventually thousands of new nuclear power plants worldwide, including in the developing world. Those same forces are still at work today, promoting nuclear expansion and multinational approaches, while the crisis in the non-proliferation regime is greater. The warning from Nobel prize winner Rotblat is even more relevant today. The proliferation threat will not be resolved by MNAs or the 2010 NPT Review, but through nuclear disarmament, a Comprehensive Fissile Material Treaty[185] and the global phase out of nuclear power. The inalienable rights of humanity are to not to have nuclear energy and weapons, but to have their long-term interests protected by their governments. Nuclear energy with or without MNAs, puts that future under severe threat.

Authors:
Frank Barnaby - frank.barnaby@btinternet.com
Shaun Burnie – burnie.shaun@gmail.com

184 Professor Joseph Rotblat, Nuclear Proliferation: arrangements for international control, Opcit Nuclear Energy and Nuclear Weapon Proliferation.

185 In 1994-5 Greenpeace International lobbied the Conference on Disarmament in Geneva to negotiate a comprehensive fissile material treaty. Due to the politics of the CD, no progress has been made since the agreement of the Shannon mandate in April 1995. In 2006, Greenpeace International presented to CD delegates a draft comprehensive treaty (originally prepared in 1997), see, http://www.greenpeace.org/international/Global/international/planet-2/report/2006/4/comprehensive-fissile-material.pdf

APPENDIX 1: MULTINATIONAL NUCLEAR APPROACHES AND RUSSIA'S NUCLEAR AMBITIONS

This appendix describes the IAEA endorsed proposal from Russia to provide uranium enrichment services from its facility at Angarsk. Rather than being driven by non-proliferation concerns, Russia is using the facility to further enable its strategy of capturing a larger share of the global nuclear market to fund expansion of its domestic nuclear program including generation IV fast breeder reactors. With ambitions to import thousands of tonnes of spent fuel for reprocessing and disposal, secure new sources of uranium, and build nuclear reactors, Russia is aiming to increase its share of global enrichment service. Russia being seen to play a constructive role in non-proliferation efforts while embarking on ever-larger proliferation of nuclear materials and technology is looking to secure greater access to the world market, through a first of its kind nuclear cooperation agreement with the United States. President Putin´s plan to create a Global Nuclear Power Infrastructure will make considerably worse an already dire situation within Russia's nuclear security and safety environment.

As we have seen, in recent years there have been numerous proposals under the banner of MNAs to the nuclear fuel cycle. All of the countries, and the IAEA, in proposing such schemes have their own agenda and track record on nuclear non-proliferation. But it is the Russian proposal for the International Uranium Enrichment Centre, IUEC, that has been endorsed by the IAEA Board of Governors, that is now hailed as potentially playing an important role in reducing proliferation dangers. It is both curious and not by accident that a proposal from a government not renowned for prioritizing non-proliferation has reached this status.

While the non-proliferation credentials of the IUEC are promoted to the fore, in the background lies a deliberate Russian strategy to increase its share of the international nuclear market. By analysing this context we will show that rather than being driven by non-proliferation concerns, the IUEC, provides international sanction for Russia's international nuclear export strategy and domestic nuclear energy growth.[186] Non-proliferation may be the declared justification, but the underlying motives are commercial – to increase its global market share and a revenue stream that drives it.[187]

By establishing better non-proliferation credentials through endorsement from the IAEA and others, Russia aims to overcome impediments to increased nuclear

186 For detailed information on Russian uranium related developments see, www.wise-uranium.org/upru.html

187 Evidence that Russia's IUEC is merely part of a nuclear expansion strategy is its offers to Armenia, Uzbekistan and Mongolia to participate in the IUEC. Each of these offers has been part of a package, which also includes joint-venture agreements for uranium mining, processing, and the option of Russia to build nuclear power plants, See, he International Uranium Enrichment Center at Angarsk: A Step Towards Assured Fuel Supply? Author: Anya Loukianova, Research Associate Newly Independent States Nonproliferation Program James Martin Center for Nonproliferation Studies October 2007; Updated November 2008 http://www.nti.org/e_research/e3_93.html

generated revenue. The most important of these is U.S. approval for a peaceful nuclear cooperation with Russia, the so-called 123 Agreement. One result of this would be Russian access to tens of thousands of tonnes of U.S obligated spent reactor fuel which it would import for storage, reprocessing and disposal. Consequently, the IUEC cannot be separated from Russia's overall nuclear policy, which rather than reducing global nuclear non-proliferation dangers will increase them.

Russia's nuclear companies

State owned ROSATOM is the overarching company that oversees the operation of the country's military and domestic nuclear program: reactors, uranium mining, conversion, enrichment and spent fuel reprocessing and waste management.[188] In 2006 a major reform of the structure of Russia's nuclear industry was launched, turning the nuclear ministry into a government run corporation.[189] Atomenergoprom runs all of Russia's civilian nuclear activities, all of whose stock is owned by ROSATOM. Sergey Kiriyenko is currently head of ROSATOM.

Uranium enrichment

The Angarsk uranium enrichment plant in Irkutsk region where the IUEC is located, is one of four enrichment facilities in the Russian Federation.[190] In total Russian enrichment capacity at present is 21 million kg SWU, with a further 5 million planned. In 2007, actual production based on market share was 14.5 million SWU.[191] Techsnabexport (TENEX)[192] is the exclusive sales representative of ROSATOM on the global market of uranium enrichment services. The company was founded in 1963 as a foreign trade agent of Soviet nuclear industry, One hundred percent of its shares are owned by Atomenergoprom. As of 2007 TENEX had secured 31% of the world market in uranium enrichment,[193] although Rosatom in 2010 was claiming it had 40% of the market.[194] It does have 40% of installed capacity worldwide. It has ambitious plans to capture a larger share of the global market, with particular focus

188 Rosatom is the successor to the Soviet-era MAPI and post-Soviet Minatom federal agencies.

189 See, Reform of russian nuclear industry takes shape,April 2006 Issue http://wmdinsights.com/I4/R3_ReformOfRussian.htm

190 The others being the Electrochemical plant at Zheleznogorsk (Krasnoyarsk Region), the Urals Electrochemical Combine at Novouralsk (Sverdlovsk Region), and the Siberian Chemical Combine at Seversk, (Tomsk Region).

191 See, Current and Future Market Trends in Nuclear Fuel Supply, Robert Vance, Nuclear Development Division, OECD, January 2009.

192 Tenex was responsible for the implementation of the 1993 Russian-American government-to-government HEU Agreement "the Megatonnes and Megawatts" on converting highly-enriched uranium (HEU) extracted from Soviet nuclear missiles into low-enriched uranium (LEU) to be used in the fresh fuel of US nuclear power plants.. The Agreement is due to expire in 2013, by which time 500 tonnes of HEU is to be downblended.

193 See, Current and Future Market Trends in Nuclear Fuel Supply, Robert Vance, Nuclear Development Division, OECD, January 2009.

194 See, www.rosatom.ru/en/. Its worth noting that EU member states are restricted to importing no more than 20% of enriched uranium from Russia, under the still secret 1994 Corfu Declaration, although new accession states such as the Czech Republic are permitted to continue existing contracts. Some operators of reactors in Central and Eastern Europe had signed lifetime contracts with Tenex, for example Paks in Hungary, see, Areva, CEZ enrichment contract covers some of Temelin's needs, Anne Maclachlan, Nuclear Fuel, November 30th 2009.

on the Republic of Korea, China, India, the U.S. In the case of Japan, Tenex has claimed it aims to secure between 20-30% of the Japanese market.[195]

Nuclear Fuel fabrication

TVEL is the exclusive supplier of nuclear fuel to all Russian NPPs, as well as to all naval, production and research reactors.[196] It also supplies fuel to 76 reactors in 14 countries, its traditional customers in the former Soviet bloc (Bulgaria, Slovakia, Hungary and the Ukraine), as well as limited amounts to EU nations. As of 2007 it had 7.8% of the global market. [197] As with Tenex, TVEL is seeking to secure longer-term contracts with customers, in part due to states in Eastern Europe looking to TVEL competitors such as Westinghouse and thus threatening TVEL's traditional monopoly of fuel supply. As part of this commercial strategy, TVEL has worked out two ideas for "interregional production facilities" and "regional plants" for fabrication of nuclear fuel on an international basis.[198] Possible locations for regional sites include India, the Czech Republic, Slovakia, Ukraine, China and even the U.S. All shares of TVEL belong to Atomenergoprom.

Putin's priority industry

Russia's pro-active role in promoting solutions to global nuclear non-proliferation challenges in recent years is directly connected to its commitment to expand its share of the global nuclear market, and, through foreign currency earnings, expand its domestic nuclear power program.

In March 2006, President Putin announced Russia's plan for the reform of the non-military activities of Rosatom at a special meeting held in the Kremlin. In a short opening statement, Putin characterized the nuclear industry as a ***"priority sector"*** of the Russian economy. Rosatom head, Kiriyenko, declared that Russia will need to add new nuclear generation capacity capable of producing 50 gigawatt's of energy, or the equivalent of two new nuclear power reactors each year.[199] With each reactor reportedly costing US$ 1.5 billion, the key to implementing these plans is funding. At the 2006 meeting, Putin rejected continued reliance on the state budget for such

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195 It may have these ambitions, but in the case of Japan for example it is unlikely to achieve it given the influence of domestic producers over utility procurement. See, TVEL Vice President V.L. Konstantinov as cited in Nuclear Fuel, July 27th 2009.

196 TVEL was founded in 1996. It combined all manufacturers of fuel assemblies and components into a holding: Mashinostroitelny Zavod (MSZ - machine engineering plant (Elektrostal, Moscow Region), Novosibirsk Chemical Concentrates Plant (Novosibirsk, Novosibirsk Region), Chepetsky Mechanical Plant (Glazov, Udmurt Republic), Moscow Composite Metal Plant, see, www.rosatom.ru/en/

197 See, Current and Future Market Trends in Nuclear Fuel Supply, Robert Vance, Nuclear Development Division, OECD, January 2009.

198 See, TVEL Vice President V.L. Konstantinov as cited in Nuclear Fuel, July 27th 2009.

199 In total, the program is to build 40 new reactors by 2030. According to Kiriyenko, VVER-1000 reactors based on current models will be constructed initially and until the larger VVER-1000+ reactor (i.e., those capable of producing more than 1,000 megawatts of electricity) becomes available. Development of the VVER-1000+ reactor is to begin in 2006. This will be followed by the development of a fourth generation of nuclear reactors, namely fast breeder reactors, see, Reform of russian nuclear industry takes shape, April 2006 Issue , http://wmdinsights.com/I4/R3_ReformOfRussian.htm

funds, and stressed that additional sources of investment are of utmost importance.[200] The need for foreign revenue to fund Russia's domestic program is highlighted further when it is understood that in 2000 the annual budget of its predecessor, Minatom, was estimated at US$3 billion to cover the operation of hundreds of nuclear facilities and tens of thousands of employees.[201]

In addition to securing reactor export orders with non-NPT states such as India, as well as China, the focus was to be made on increasing revenue stream from uranium enrichment and fuel contracts. The plan to create the IUEC to provide uranium services is also part of the vision for the restructured Russian nuclear industry. Seeking foreign nuclear sales to fund Russia's domestic program is of course not a concept invented by Putin or Kiriyenko. As the U.S. Department of Energy observed,

> ***"During his tenure as Minister, Victor Mikhailov sought to bankroll Minatom programs through the sale of nuclear technologies abroad...The Ministry will continue to aggressively promote the sale of nuclear technology abroad, often to countries with questionable non-proliferation commitments."***[202]

While the U.S. Department of Energy is hardly a paragon of virtue in terms of nuclear non-proliferation, its comments of ten years ago could equally apply today.

> ***"Depending on the states that Russia targets for sales, its drive for nuclear exports could put added pressure on global efforts to curb the proliferation of nuclear arms."***[203]

The IUEC

The International Uranium Enrichment Centre (IUEC) concept emerged out of the disclosures that Iran was developing domestic uranium enrichment. Rosatom as the supplier of the Bushehr reactor was also committed to supplying the low-enriched uranium fuel. As noted earlier, in 1995 Russia had offered to supply uranium enrichment technology to Iran, which Russia subsequently withdrew. In 2005 Russia proposed an arrangement under which Iran would end its uranium enrichment activities in return for a Russian guarantee to enrich, in Russia, all uranium needed for Iranian nuclear power plants.[204] This was rejected by Iran,

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200 See, Reform of Russian nuclear industry takes shape, April 2006 Issue, http://wmdinsights.com/ I4/R3_ReformOfRussian.htm

201 See, The Russian Federation's Ministry of Atomic Energy: Programs and Developments C. M.Johnson February 2000, Prepared for the U.S. Department of Energy under Contract DE-AC06-76RL0 1830.

202 See, The Russian Federation's Ministry of Atomic Energy: Programs and Developments C. M. Johnson February 2000, Prepared for the U.S. Department of Energy under Contract DE-AC06-76RL0 1830.

203 Reform of Russian nuclear industry takes shape, Nikolai Sokov, April 2006, Monterey Institute of International Studies for the WMD Insights project, Defense Threat Reduction Agency (DTRA), the U.S. Government. Available at http://wmdinsights.com/I4/R3_ReformOfRussian.htm

204 See, U.S.-Russian Civilian Nuclear Cooperation Agreement: Issues for Congress Mary Beth Nikitin

although it has continued to appear on the agenda during the past four years.[205] President Putin extended the Iran offer into a global non-proliferation initiative in January 2006. The proposal for Nuclear Fuel Cycle Centres would provide participating nations with full "nuclear fuel cycle services," including uranium enrichment, the fabrication of fresh nuclear fuel, and the storage and reprocessing of spent nuclear fuel. The proposals emerged in the same time frame as Putin's decision to restructure the Russian nuclear industry and expand its domestic nuclear power program through overseas sales. The seal of approval from the international non-proliferation community led by the IAEA all contributes to the legitimization of Russia's nuclear policies.

Kazakhstans nuclear expansion

Using non-proliferation initiatives to bolster expansion of nuclear trade is of course not a uniquely Russian strategy. The IUEC at Angarsk and proposals for an IAEA fuel bank at the Ulba Metallurgical Plant in Ust Kamenogorsk should be seen in the context of Kazakhstan's nuclear strategy of expansion of uranium production, increased nuclear exports, and a domestic nuclear power program.[206] Similarly, nuclear corporations worldwide have sought to secure new business with Kazakhstan. Since 2007 Kazakhstan has entered into commercial nuclear arrangements with Toshiba of Japan, Cameco of Canada, Areva of France, and the China National Nuclear Corporation.[207] These have raised alarm bells in Moscow due to Russia's dependence on Kazakhstan's uranium for fuelling its domestic reactor program, and exports.

It is Russia's need to secure nuclear supplies with Kazakhstan that part explains the tie up between the two at Angarsk. In May 2007 Kiriyenko of Rosatom and Baktykozha Izmukhambetov, Kazakhstan Minister of Energy and Mineral Resources, signed an agreement to establish the IUEC. The agreement was signed in the presence of Russian President Vladimir Putin and Kazakh President Nursultan

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Nonproliferation Foreign Affairs, Defense, and Trade Division, Congressional Research Service, Order Code RS22892 June 9, 2008.

205 In addition to offers to Iran, Russia has reportedly discussed participation in the IUEC with Belarus, Belgium, Bulgaria, Finland, Kyrgyzstan, Slovakia, Tajikistan, the Republic of Korea, Japan, China, and South Africa, see, http://www.nti.org/e_research/e3_93.html

206 In 2006, the Director of the Department of Electrical Power and Coal Industry of the Ministry of Energy and Mineral Resources of Kazakhstan announced that the government of Kazakhstan had made the decision to build a new nuclear power station, see, Oil-rich Kazakhstan chooses nuclear energy -- without raising proliferation concerns, May 2006, http://wmdinsights.com/I5/ R2_OilRichKazakhstan.htm,

207 KazAtomProm has even taken a 10% stake in Toshiba's U.S. nuclear equipment manufacturing subsidiary, Westinghouse costing US$540 million, See Toshiba announces agreement with KazatomProm, 13th August, 2007 http://www.toshiba.co.jp/about/press/2007_08/pr1301.htm. Russian commentators have argued that that deal could give Kazakhstan access to technologies that would enable it to fabricate and export finished fuel rods for Western reactors, reducing its incentive to export natural and processed uranium to Russia. See, Russian nuclear industry's domination of former Soviet enterprises encounters challenges Nikolai Sokov – Monterey Institute James Martin Center for Nonproliferation Studies for is WMD insights projectsponsored by the Advanced Systems and Concepts Office (ASCO) at the Defense Threat Reduction Agency (DTRA), October 2007.

Nazarbaev.[208]

Kazakhstan has an extensive nuclear sector, which includes 20 percent of the world's known uranium reserves; uranium mines and mills (for concentrating uranium ore); a facility for processing uranium into oxide form (for nuclear reactor fuel) and for sintering uranium oxide fuel pellets; and two research reactors.[209]

KazAtomProm, the state-controlled company that is in charge of all nuclear industry assets in Kazakhstan, plans to vastly expand production of uranium yellowcake. In 2007 alone it increased production by 36 percent to 7,200 tonnes. The country's uranium deposits are second only to Australia, and is a critical source of natural uranium for Russia. Kazakhstan supplies concentrated natural uranium, or "yellowcake," which is enriched at Russian facilities for use as reactor fuel in Russian and foreign nuclear power plants. According to Kazakh sources, Russia produces approximately 3,000 metric tonnes of yellowcake annually, but its overall annual requirements are estimated to be 9,000 metric tonnes of the material, making it dependent on yellowcake imports.[210] Moreover, Russian demand could grow to 16,000 metric tonnes of yellowcake annually by 2020, if its nuclear industry reforms, including the construction of new nuclear power plants, were to be implemented as planned. Other sources estimate current Russian demand to have already reached 16,000 tonnes. Russia's need to diversify its uranium supply has led to the proposed agreement with Australia for uranium imports, and an offer from Putin for Australia to become a partner in the IUEC.[211]

The proposal for an IAEA fuel bank at Ulba Metallurgical Plant (UMP) is not the only development planned for the site. It was announced in July 2007 that four new facilities at a total cost of $848 million would be established at UMP. These were a joint venture with Cameco of Canada, to produce uranium hexafluoride (UF6, the form of uranium used in the uranium enrichment process) and the production of enriched uranium fuel pellets for Western nuclear reactors.

Kazakhstans competition with Russia for nuclear exports will increase over the

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208 See, Russia and Kazakhstan Will Enrich Uranium Together], Finmarket.Ru, May 10th 2007; as cited in Russia and Kazakhstan establish a joint venture for uranium enrichment, June 2007, Nikolai Sokov - Monterey Institute Center for Nonproliferation Studies for **WMD Insights project** is sponsored by the Advanced Systems and Concepts Office (ASCO) at the Defense Threat Reduction Agency (DTRA).

209 Opcit, Oil-rich Kazakhstan chooses nuclear energy -- without raising proliferation concern.

210 Russia's state uranium miner, Atomredmetzoloto (ARMZ) plans to invest 203.6 billion roubles ($7.4 billion) by 2015 to fund an expansion plan as demand from the nuclear power sector grows, the company, which produces uranium in Russia and Kazakhstan, planned to increase output of the metal to 4,300 tonnes in 2009, from 3,880 in 2008. ARMZ produced 3,527 tonnes in 2007, of which 3,413 tonnes was produced in Russia, Reuters Nov. 26, 2008., see, www.wise-uranium.org/upru.html

211 See, Russian nuclear industry's domination of former Soviet enterprises encounters challenges Nikolai Sokov – Monterey Institute James Martin Center for Nonproliferation Studies for **WMD Insights project** is sponsored by the Advanced Systems and Concepts Office (ASCO) at the Defense Threat Reduction Agency (DTRA), October 2007.

coming years, not least as KazAtomProm moves away from primary nuclear exports – uranium yellowcake – to high-end uranium products by 2014. At the same time new joint ventures with Russia, such as a mining project for the development of Kazakhstan's Budennovski uranium deposits, which could produce up to 4,000 tonnes each year, ensure that nuclear trade will continue.

This short description of some aspects of Kazakstan's nuclear program, does not include the many environmental, human health, safety and security issues that have arisen as a result of past-Soviet and current operations.[212] Rather than non-proliferation being the driving factor, the establishment of an IAEA sanctioned uranium fuel bank in Kazakhstan, as with the IUEC in Russia, is a tool for increasing global nuclear exports with resultant consequences for non-proliferation.

U.S.-Russia Peaceful Cooperation Agreement

Just as the IUEC was linked to international concern over Iran's nuclear program, so to was the U.S. offer of a peaceful nuclear cooperation agreement with Russia. The original offer of an agreement came during the Clinton administration, if Russia in turn terminated nuclear assistance to Iran.[213] In July 2006, Russian President Vladimir Putin and U.S. President George W. Bush announced their two countries would shortly open negotiations on a formal agreement permitting cooperation in the peaceful uses of nuclear energy.[214] On May 6th 2008, both country's signed a nuclear cooperation agreement, which President Bush submitted to the U.S. Congress on May 13th, but the agreement was withdrawn from congressional consideration by President Bush on September 8th, 2008, in response to Russia's military actions in Georgia.[215]

The Obama administration in spite of all the negative consequences remains supportive of concluding an agreement,[216] and in May 2010 it was resubmitted to the

212 Commenting on the announcement of a deal between KazAtomProm and Westinghouse, an environmental justice organization summarized the situation in the country as follows, "Kazakhstan should not be encouraged to develop a new nuclear industry. There is a deep culture of corruption and violence in Kazakhstan, and if there are any standards at all for sharing nuclear technologies, Kazakhstan would fail. The police and other security forces are poorly paid and poorly trained. The borders are not secure. There has been a long history of reports of smuggling of narcotics and nuclear materials in Kazakhstan, even including links to the Khan network that sold nuclear secrets to North Korea, Iran and Libya", see, Keo online, 13 August 2007 http://keionline.org/content/view/121/1.

213 No date is given for when this offer was made. Russia was reported to have viewed with interest, but did not agree to terminate nuclear assistance to Iran. The source for this reference is The U.S.-Russia Civil Nuclear Agreement : Framework for Cooperation, Robert Einhorn Rose Gottemoeller Fred McGoldrick Daniel Poneman Jon Wolfsthal, Center for Strategic and International Studies, CSIS, May 2008.

214 President Bush and Russian President Putin Participate in Press Availability," July 15, 2006, Office of the Press Secretary, The White House website, www.whitehouse.gov/news/releases/2006/07/20060715-1.html.

215 U.S.-Russian Civilian Nuclear Cooperation Agreement: Issues for Congress Mary Beth Nikitin Nonproliferation Foreign Affairs, Defense, and Trade Division Order Code RL34655, September 9, 2008.

216 See, The White House, Office of the Press Secretary, Joint Statement by President Barack Obama of the United States of America and President Dmitry Medvedev of the Russian Federation on Nuclear Cooperation, July 6th 2009, http://www.whitehouse.gov/the_press_office/Joint-Statement-by-President-Barack-Obama-of-the-United-States-of-America-and-President-Dmitry-Medvedev-of-the-Russian-Federation-on-Nuclear-Cooperation.

U.S. Congress.[217]

A U.S. Russia peaceful nuclear cooperation agreement is required to comply with Section 123 of the U.S. Atomic Energy Act before bilateral civilian nuclear cooperation can take place.[218]

Securing a peaceful cooperation agreement with the United States is vital for Russia in terms of securing greater access to the U.S. nuclear market and worldwide and as a result increasing foreign currency earnings. Two target areas in particular would become available to Russia should an agreement be made – uranium fuel supply to the U.S. nuclear sector; and global spent fuel stocks.

In terms of the uranium market, the United States imposed anti-dumping sanctions against Russia in the 1990s, when Russia and other former Soviet Republics started supplying cheap uranium to the world market. Anti dumping duties apply to nuclear materials exported by Russia to the United States, as the production of enriched uranium is subsidized in Russia, and the U.S. Department of Commerce considers its price below the fair market value. Russia can currently sell natural uranium and LEU in the United States without import duty only through the U.S. Enrichment Corporation (USEC), within the HEU-LEU Program.[219]

In terms of global spent fuel, under U.S. nuclear non-proliferation legislation countries with spent fuel discharged from their nuclear power plants and containing U.S. supplied uranium are required to seek U.S. consent for its disposition – specifically if it is to be reprocessed domestically or exported for storage, reprocessing or disposal. Through the 1990's Russia sought to secure contracts for the importation of spent fuel from clients in Asia and Europe. As much as 95% of this spent fuel is covered by so-called U.S. consents rights, requiring both U.S. approval for the exporting country and a 123 Agreement with the importing country, in this case Russia. The Russian government claimed that with the importation of 20,000 tonnes of spent fuel by 2020 would generate an income of US$21 billion. These plans were strongly opposed on environmental and non-proliferation grounds, not least on the basis that it was contrary to Russian Law.[220] But in 2001, a law was enacted permitting the importation of foreign spent fuel.[221]

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217 Obama rekindles nuclear deal with Russia, Daniel Dombey, May 12th, 2010, http://www.ft.com/cms/s/0/ed253d6e-5d5d-11df-8373-00144feab49a.html

218 See, U.S.-Russian Civilian Nuclear Cooperation Agreement, Gaukhar Mukhatzhanova, Research Assistant, Center for Nonproliferation Studies Monterey Institute of International Studies July 2006.

219 See, www.nti.org/db/nisprofs/russia/fissmat/heudeal/heudeal.htm.

220 Greenpeace Russia and EcoDefence and others have mounted sustained campaigns since the early 1990's against plans to import spent fuel for reprocessing, storage and or disposal. This included the collection of 2.5 million signatories against the plans, in 2000. According to the ROMIR polling agency survey of November 2000, 93.5 per cents of Russian citizens negatively react to the plans to import radioactive materials to Russia from other countries for storage, reprocessing, or dumping.

221 See, Philipp Bleek, "Russian Duma Passes Bill Allowing Import of Spent Fuel," Arms Control Today 31st (July/August 2001) http://www.armscontrol.org/act/2001_07-08/dumajul_aug01.asp.

The original announcement by Putin in 2006 of a plan for a Global Nuclear Power Infrastructure, of which the IUEC is the part, also includes the fuel leasing/spent fuel return option with which Russia hopes to secure tens of thousands of tonnes of spent fuel.[222]

While U.S. concerns over Iran's nuclear program may have initially prompted the offer of an agreement with Russia, it is the latter's nuclear cooperation with Iran that with justification remains an obstacle to approval of a 123 Agreement with Russia.

In January 1995, Russian Minister of Atomic Energy Viktor Mikhailov and the head of the Atomic Energy Agency of Iran, Reza Amrollahi, signed an $800 million contract calling for Russia to complete the first unit of the unfinished nuclear power station at Bushehr by installing a 1,000MW VVER-1000 light-water reactor at the site within four and a half years.[223]

But also at that time, Amrollahi and Mikhailov also signed a secret protocol to the contract under which Russia and Iran would conduct talks on a wide range of nuclear assistance beyond the power reactor. Under this protocol, Russia agreed to open negotiations on providing Iranian specialists with training at Russian nuclear research Centres, assisting Iran's efforts to mine uranium, and supplying Iran with a gas-centrifuge uranium enrichment facility. Under pressure from the United States, Russian President Yeltsin announced at his May 1995 summit meeting with President Clinton that he was cancelling the centrifuge aspect of the deal. Russian officials later denied that this aspect of the deal ever existed.[224]

Since the initial offer of an Agreement with Russia was made, U.S. legislation has been introduced that should preclude any agreement. The 2006 Iran Freedom Support Act (P.L. 109-293) gives the sense of Congress that no nuclear cooperation agreement should be entered into with a country that is assisting the nuclear program of Iran. The Iran Counter-Proliferation Act of 2007 (HR1400), passed by the House of Representatives, would prohibit any,

> ***"agreement for cooperation between the United States and the government of any country that is assisting the nuclear program of Iran or transferring advanced conventional weapons or missiles to Iran."***

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222 See, "Cradle-to–Grave Nuclear Fuel Supply Assurance Workshop: Industry's Potential Role," Workshop Report, 6 June 2007, Pacific Northwest Center for Global Security, Pacific Northwest National Laboratory, p3 available at http://pnwcgs.pnl.gov/pdfs/NuclearFuelSupplyWorkshop.pdf.

223 See, "Iran, Russia Agree On $800 Million Nuclear Plant Deal," Washington Post, 9 January 1995.

224 See, Andrew Koch and Jenette Wolf, "Iran's Nuclear Procurement Program," Nonproliferation Review, no. 5 (Fall 1997), p. 127.

In 2008 intelligence reports in the U.S. indicated that Russian entities have transferred sensitive nuclear technology to Iran. This activity was reportedly ended by high-level Russian governmental intervention and assurances were given to the highest levels of the U.S. government. The Congressional Research Service reports that information about this may have been included in the classified Nuclear Proliferation Assessment (NPAS).[225]

Even after Putin and Bush signed the U.S./Russia Agreement in 2008, reports indicated that nuclear cooperation in sensitive technology (the assumption being uranium enrichment) between Russia and Iran, although decreased since the 1990's, had not been stopped altogether.[226]

Environmental and safety issues

The focus of this report has been the non-proliferation issues around nuclear power expansion and multilateral approaches to the nuclear fuel cycle. The environmental, human health and safety consequences are not part of this study. However, it is important to make reference to the particular situation in Russia, given that it now hosts the first facility to emerge since the call to action by IAEA Director ElBaradei in 2004.

Environmental groups, academicians, and citizens in the Russian Federation have during the past few decades sought to highlight the disastrous condition of Russian nuclear facilities and their impacts on the environment.[227] International concerns over

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225 See, U.S.-Russian Civilian Nuclear Cooperation Agreement: Issues for Congress Mary Beth Nikitin Nonproliferation Foreign Affairs, Defense, and Trade Division, Congressional Research Service, Order Code RS22892 June 9, 2008, citing "Prospects for a U.S.-Russian Agreement for Peaceful Nuclear Cooperation in Congress: Robert Einhorn and Jon Wolfsthal," Remarks at the Carnegie Moscow Center, April 15, 2008, www.carnegie.ru/en/news/78128.html.

226 See the analysis of Henry Sokolski, where he notes that, **"Congressman Dingell, chair of the House Energy and Commerce Committee, formally requested that the Government Accountability Office investigate whether the Administration's Nuclear Proliferation Assessment Statement on Russia was complete or if "there is contradictory information that was omitted which could invalidate, modify, or impair the conclusions or basis for recommendation to approve the 123 agreement."6 On what basis did Mr. Dingell launch this investigation? Did he have specific information? This Committee should fin**d out.", See, The U.S.-Russia Nuclear Cooperation Agreement: The Case for Conditioning, Testimony Presented before a Hearing of The House Committee on Foreign Affairs Russia, Iran, and Nuclear Weapons: Implications of the Proposed US-Russia Agreement June 12, 2008Henry Sokolski Executive Director The Nonproliferation Policy Education Center. For the full text of Chairman Dingell's letter to the Government Accountability Office, see www.energycommerce.house.gov/Press_110/110-ltr.052208.GAO.123.ltr.pdf

227 In relation to uranium waste imports, in 2005 Greenpeace Russia filed a complaint against JSC "Tekhsnabexport" for concluding contracts with Eurodif, Urenco, Internexco and GKN which are breaching the Russian Federal law of 2001 'On Environmental Protection'. Under these contracts, a total of 106,725 tonnes of uranium waste was shipped to Russia, while only 9,742 tonnes were sent back. For example, under the contract #60111 with Eurodif (France), 13887 tonnes of depleted uranium (DU) enriched 0.3% with uranium-235 were exported to Russia. After re-enrichment, 228.8 tonnes of uranium with natural enrichment of 0.711% with uranium-235 were returned to the client company. The remaining 13658.2 tonnes with an enrichment of 0.29% uranium-235 was made the property of the Russian Federation and was put in storage. Thus, some 98% of the initially exported depleted uranium is stored as UF6 in Russia.The Russian legislation prohibits the import of foreign nuclear materials for storage. According to paragraph 3 of article 48 of the federal law of 2001 "On Environmental Protection", import of nuclear waste and foreign nuclear materials to the Russian Federation for the purpose of its

the security of the hundreds of facilities hosting nuclear materials, including plutonium and highly enriched uranium have led to many hundreds of millions of dollars in assistance in an attempt to improve security.

However, successive Russian governments have failed to prioritize environmental, safety, security and human health issues, focussing instead on securing new markets, and the expansion of existing nuclear projects. Recent evidence on the state of the Russian nuclear infrastructure by Rostekhnadzor[228] and described by the environmentalist Vladimir Slivyak, should be required reading for those at the IAEA and others supporting the IUEC at Angarsk, the uranium bank in Kazakhstan and elsewhere.

The 2007 Rostekhnadzor report covers the entire nuclear industry in Russia, including reactor safety and reprocessing. Specifically in relation to the management of uranium, including its enrichment and storage, the report is damning.

> ***"The pressing issue also remains of providing safety during long-term storage of depleted uranium hexafluoride at open storage facilities of [nuclear fuel cycle enterprises]. This problem continues to be of utmost urgency at the industry's enterprises since storing uranium hexafluoride in open storage spaces is a distinct environmental and radiation risk due to the significant amounts of the material stored and its high chemical activity."***[229]

The uranium hexafluoride referred to includes hundreds of thousands of tonnes of depleted uranium and reprocessed uranium imported from western Europe from Urenco enrichment plants in Germany, the Netherlands and the UK, and France's Areva enrichment plants at Pierrelatte and reprocessing operations at la Hague. As described by Vladimir Chouprov of Greenpeace Russia in 2005,

> ***"The uranium is stored in cylindrical steel containers, each one holding over ten tonnes. Usually sitting out in the open, the steel containers are subject to external corrosion. Pin holes and fissures arising from corrosion are initially plugged by the reaction of the UF6 with moist air and iron leached from the container steel alloy, forming hydrates of the more stable uranium tetrafluoride (UF4) which partially seals up the breach."***[230]

This was confirmed by Rostekhnadzor in 2007,

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storage or disposal is prohibited. "These contracts are thus a clear breach of the Russian law and under Russian legislation, all uranium tails should be sent back to the clients." Vladimir Chouprov, Greenpeace Russia, see, http://www.greenpeace.fr/stop-plutonium/en/dumping_russia_en.php3

228 The Russian Federal Service for Ecological, Technological, and Atomic Supervision Rostekhnadzor on safety violations in the Russian nuclear energy industry issued 2007, extracts from the report are at Vladimir Slivyaks blog Global economic slump may lay bare nuclear safety and proliferation problems on February 2nd 2009, available at www.bellona.org/weblog/Slivyak_blog/1233584230.98,

229 Ibid.

230 http://www.greenpeace.fr/stop-plutonium/en/dumping_russia_en.php3

> ***"storage of containers with depleted uranium hexafluoride in open-air storage facilities at such Russian enterprises as the Siberian Chemical Combine in Tomsk, the Angarsk Electrolysis Chemical Combine, the Zelenogorsk-based Electrochemical Plant near Krasnoyarsk, and the Ural Electrical Chemical Combine is performed "in the conditions of insufficient normative basis and a significant degree of risk of containers losing impermeability."***[231]

Disregard for environmental impacts of fuel cycle operations in Russia are well known, but Rostekhnadzor confirms it.

> ***"A number of [nuclear fuel cycle enterprises] under the agency's purview that operate sites of application of atomic energy do not have state environmental impact assessments [licensing] them to perform the types of activities they are carrying out."***[232]

While President Putin was proposing the establishment of the International Uranium Enrichment Center at Angarsk, Rostekhnadzor notes that,

> ***"already in 2007, these same officials moved to "cut back on the personnel […] responsible for the control over, and enforcement of, safety at [sites of the nuclear fuel cycle]."***[233]

The situation in Russia is undoubtedly much worse than that described by Rostekhnadzor, which after all is a Russian government agency. Plans to expand Russia's nuclear program, including increased uranium enrichment, are being made while an environmental, safety and security crisis continues. While non-proliferation considerations may be the stated priority of the IAEA and Western governments, arms control specialists and commentators, the shocking reality of how Russia mismanages its nuclear infrastructure exposes their inherent contradictions and raises profound questions as to the underlying justification for the IUEC and other such schemes. It is worth stating however, that at every stage of the uranium fuel cycle there are environmental, human health, safety and security consequences. This is not a problem unique to Russia.[234]

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231 Opcit, Vladimir Slivyaks blog
232 Ibid.
233 Ibid.
234 See Wise Amsterdam for comprehensive documents on uranium production and its impacts - www.wise-uranium.org/upru.html

APPENDIX 2: THE URANIUM SUPPLY PROBLEM AND MOVES TO THE PLUTONIUM ECONOMY

The demand for plutonium as a nuclear fuel will increase considerably as the supply of high-quality uranium decreases. According to the International Atomic Energy Agency (IAEA) and the Organisation for Economic Co-operation and Development (OECD), the known recoverable uranium resources are 4.7 million tonnes. This includes uranium ores that: are of relatively low grade (the percentage of uranium in the ore); occur at great depths; require long transport distances from mine to refinery; and are harder to mine.

The world's current nuclear-power reactors consume uranium at the rate of 68,000 tonnes a year; the uranium will, therefore, last for about 70 years. As the richest uranium ores are depleted first, the net energy extracted from uranium ore will decrease. The net energy, a measure of the quality of the uranium ore, is the energy produced per tonne of uranium fuel minus the energy used to produce the reactor fuel elements. The quality of the world's uranium resources is much more important than the quantity of these resources.

According to calculations made by Jan Willem Storm van Leeuwen, an expert on uranium resources, assuming that world nuclear capacity remains constant at 373 GW, the net energy from uranium will fall to zero by about 2070.[235] Assuming that world nuclear share remains constant at 2.2 per cent of world energy supply, given that energy demand will increase to meet the needs of a rapidly growing human population, the net energy benefit will fall to zero by about 2050. Normally, the highest quality uranium ores are mined first, because these usually generate the largest profits for the mining companies. Therefore, the average ore grade of the world uranium resources will decline over time. Within a few decades, the net energy from uranium will fall to zero. It is very unlikely that new uranium resources of high quality will be discovered in the foreseeable future.

Moves to the plutonium economy

Many political leaders, and their advisers, believe that the use of nuclear power for electricity generation is the best way to reduce the emissions of greenhouse gases and to improve the security of energy supplies. This nuclear 'renaissance' if realized will involve a massive global increase in the civil use of plutonium. The plutonium economy will inevitably involve a greatly increased risk of the spread of nuclear weapons to both countries and terrorist groups.

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235 See, Jan Willem Storm van Leeuwen, *Energy Lifecycle of Nuclear Power,* www.nuclearinfo.net/Nuclearpower/ WebHomeEnergyLifecycleOfNuclear_Power and Jan Willem Storm van Leeuwen, *Into the Unknown, fuelling civil nuclear power?*, in Frank Barnaby and James Kemp (eds.) *Secure Energy; Civil Nuclear Power, Security and Global Warming*, Oxford Research Group, London, March 2007.

Because of the shortage of uranium ores rich enough to give a positive net energy result, a new generation of nuclear-power reactor would be proposed. This will be the fourth generation (generation IV), which will include reactor designs such as the fast breeder reactor (FBR), which produces (breeds) more nuclear fuel than it uses.[236]

The early prototype reactors of the 1950s and 1960s were mainly used to obtain plutonium for nuclear weapons. The second generation was the commercial reactors constructed in the 1970s and 1980s, and the third generation includes most of the reactors being built now to replace or add to earlier ones. A blanket of uranium-238 surrounds an FBR. When the uranium-238 captures fast neutrons escaping from the reactor core, it is converted to plutonium-239, a fissile material. It is this plutonium that would be used as fuel for another FBR. But on present breeding ratios, it would require one FBR operating for many years before sufficient plutonium is produced to fuel one further FBR.

It is therefore only theory that states that a group of FBRs would eventually be self-sufficient in fuel with only a small injection of uranium. This issue aside, the breeder function of FBRs is seen by some as the solution to the coming shortage of high quality uranium. But a world of many generation IV reactors will contain an even larger amount of plutonium than that produced in LWR's. Those proposing multinational solutions to the nuclear fuel cycle - one reason being that they are the same bodies supporting the development of Generation IV breeder reactors - ignore the proliferation consequences of this threat.

Amounts of plutonium involved

Governments want nuclear power, they say, because its use will make a significant impact on global warming. Currently, nuclear power generates about 373 megawatts of electricity (MWe) or about 15 per cent of the world's electricity. Electricity demand will probably double by 2030. Between now and 2030, the United Nations predicts the world population will increase from about 6.6 billion to about 8.3 billion. By 2075, it is likely to reach more than 11 billion, about double today's world population. Electricity demand is likely to increase faster than the increase in world population.

If nuclear power were adopted with the aim of offsetting perhaps 25% of global carbon emissions, at least 3,000 gigawatts (GW) of nuclear electricity in, say, 2075 would be required. If this were to be generated by light-water reactors, it would be generating, as a by-product, approximately 600 tonnes of plutonium annually.[237] However, if this nuclear capacity is provided by FBRs, as the nuclear industry predicts, more than 4,000 tonnes of plutonium will have to be fabricated into fresh

236 See, W.J.Nuttall, *Nuclear Renaissance; Technologies and Policies for the Future of Nuclear Power*, Institute of Physics Publishing, Bristol and Philadelphia, 2005.

237 See, H.A.Feiveson, *Nuclear Power, Nuclear Proliferation, and Global Warming*, Forum on Physics and Society of the American Physical Society, January 2003.

reactor fuel each year.[238] This is enough plutonium to produce no less than a million nuclear weapons!

Large amounts of plutonium will be in global circulation if the world comes to depend on FBRs because plutonium accounts for a very large fraction of the nuclear fuel used in them. Any country that chooses to operate generation IV reactors in future will have relatively easy access to plutonium usable as the fissile material in the most efficient nuclear weapons and will have competent nuclear physicists and engineers who could design and fabricate them.

Because they could produce a nuclear force in a relatively short time – months rather than years – these countries would need to be regarded as de facto nuclear-weapon powers. It must be expected that some of them will take the political decision to become actual nuclear-weapon powers.

The separation of uranium and plutonium in MOX

The easiest way for a country clandestinely to acquire plutonium for a future nuclear-weapon programme would be to obtain commercial MOX nuclear fuel and separate the plutonium dioxide from the uranium dioxide in it. The separation of plutonium and uranium in unirradiated MOX is a very much simpler procedure than the clandestine reprocessing of spent nuclear-power reactor fuel because the concentration of plutonium is much higher in MOX than in irradiated nuclear fuel and the chemistry is much simpler as only three elements (uranium, plutonium and oxygen) are present. Spent fuel contains a large amount of fission products in addition to uranium and plutonium.

The plutonium content of commercial MOX fuel varies between 3 and 10% depending on the design of the fuel. Reactor-grade plutonium dioxide is mixed with depleted uranium dioxide. A MOX production plant typically obtains its plutonium and uranium from the reprocessing of spent nuclear-power reactor fuel. A MOX plant and a reprocessing plant, therefore, normally work hand in hand.

MOX consisting of about 7% reactor-grade plutonium mixed with depleted uranium is equivalent to uranium oxide fuel enriched to about 4.5% in uranium-235, assuming that the plutonium has about two thirds fissile isotopes. This MOX is suitable for use in a typical ordinary nuclear-power reactor and a number of LWR's are currently fuelled with MOX. A hundred kilograms of typical MOX would, therefore, contain about 4.5 kg of fissile plutonium, enough for one nuclear weapon.

If the world moves into a plutonium economy an increasing amount of MOX fuel is likely to be used. MOX fuel will be increasingly easy to acquire.

238 Ibid. See, H.A.Feiveson, *Nuclear Power, Nuclear Proliferation, and Global Warming*, Forum on Physics and Society of the American Physical Society, January 2003.

Because plutonium and uranium have quite different chemistries, the clandestine chemical separation of uranium and plutonium in MOX is relatively straightforward (described in detail in reference 4). In MOX, plutonium and uranium dioxides are fused together by heat to form a ceramic. Because spent MOX fuel may be reprocessed, MOX is designed to be readily soluble in concentrated nitric acid. This makes clandestine reprocessing easier.

Once the plutonium dioxide is separated it can be converted to plutonium metal and the metal used to fabricate a nuclear weapon. The procedures required in these steps are relatively simple and the information required is readily available in the open literature.

Three types of method could be used:[239] one uses an ion-exchange resin[240]; one is a carrier method based on the one used in 1941 by Glenn Seaborg in the Manhattan Project to develop nuclear weapons during the Second World War[241]; and the third uses chelating resins.[242] Of them, the ion-exchange method is the simplest and could be used by, for example, terrorists if they acquired MOX fuel. Seaborg's original method used bismuth phosphate as a carrier to separate plutonium from uranium but lanthanum fluoride, cerium fluoride or neodymium fluoride are better carriers and were later used instead of bismuth phosphate. The effectiveness of the use of neodymium fluoride as a carrier is described in reference.[243]

An ion-exchange method could be used as a rapid single-stage process to separate plutonium of high purity with good efficiency. Suitable resins are much used industrially, for example, for water softening and for waste treatment. The resin AG-X4 has been used for the separation of plutonium from uranium, giving excellent recovery efficiency.[244] The method is used at the University of Kiev for the separation of uranium-234 from plutonium-238.[245]

If the nuclear renaissance ever becomes a reality, the world will move ever deeper into the plutonium economy, as MOX fuel is increasingly used in thermal nuclear-power reactors and plutonium is used to fuel generation IV reactors. Any country able to acquire MOX fuel or is operating generation IV reactors will have relatively easy access to plutonium usable to fabricate effective nuclear weapons and will have

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239 Frank Barnaby and David Knight, The production of primitive nuclear explosives from MOX fuel, unpublished paper, 1998.

240 Guseva, L.I. and Tikhomira, G.S., Simultaneous determination of natural and man-made actinides in environmental samples using ion exchange and mineral acid solutions, Radiochemistry 36, 55-61.

241 Seaborg, G.T. *Man-made transuranium elements*, Prentice-Hall; Englewood Cliffs, New Jersey.

242 U.S. Department of Energy, *Sequestering Agents for the removal of transuranics from radioactive waste*, ainespom/esp44.html.

243 Rao, R.R., and Cooper, E.L., *Separation of low levels of actinides by selective oxidation-reduction and coprecipitation with neodymium fluoride*, J.Radioanalyt. and Nuc.Chem. 197, 133-148, 1995.

244 Araujo, B.F., Matsuda, H.T., Carvalho, E.I., and Araujo, I.C., *Plutonium removal by ion-exchange chromatography*, J.Radioanalyt. and Nuc.Chem.-Letters 165; 209-218, 1992.

245 Personal communication Sergei Mikhalovsky, formerly of the University of Kiev, now at the University of Brighton, Brighton, Surrey, England.

competent nuclear workers who could design and fabricate them. Because they could produce a nuclear force in a relatively short time these countries are latent nuclear-weapon powers. It must be expected that some of them will take the political decision to become actual nuclear-weapon powers.

The risk that nuclear weapons will proliferate is increased by the fact that small countries could reprocess spent nuclear-power reactor fuel clandestinely in small, clandestine reprocessing plants and use the plutonium to fabricate nuclear weapons. This greatly increases the difficulty of controlling the spread of nuclear weapons. In particular, it makes it much more difficult, to say the least, for the IAEA to verify that a country is not diverting its civil nuclear activities to military purposes. Moreover, if a country clandestinely reprocesses spent fuel that is many years old it will be very difficult for any agency to detect the diversion to a military programme of the plutonium produced because the bulk of the krypton-85 (the radioactive isotope normally used in such detection) in the spent fuel will have undergone radioactive decay.

When delegates at the May NPT review conference are debating the rights of states under Article IV of the NPT, it these problems of global stocks of bomb material in commercial nuclear programs, the inability of safeguards to detect diversion and what a global nuclear renaissance would actually mean in global security terms that should be uppermost in their minds. Almost certainly they will not be, but unless the international community grapples effectively with the issues associated with the spread of nuclear weapons in a plutonium economy we will move into an unregulated and very dangerous nuclearized world.