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THE CRUCIAL IMPORTANCE OF THE BACK-END IN MULTINATIONAL INITIATIVES TO ENHANCE FUEL CYCLE SECURITY

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ABSTRACT

There have been repeated proposals for establishing multinational cooperation approaches that could reduce the security concerns of spreading nuclear technologies. Most recently, there have been initiatives by both Russia (GNPI) and the USA (GNEP) – each aimed at promoting nuclear power whilst limiting security concerns. In practice, both initiatives place emphasis on the supply of reactors and enriched fuel but neither has made clear and specific proposals about the back-end part of the arrangement. The primary incentive offered to the user countries is "security of supply" of the front end services. However, there is no current shortage of supply of front end services, so that the incentives are not large. A much greater incentive could be the provision of a spent fuel or waste disposal service. The fuel supplied to Tier 2 countries could be shipped back (with no return of wastes) to the supplier or else to an accepted third party country that is trusted to operate safe and secure disposal facilities. If a comprehensive service that obviates the need for a national deep repository is offered to small countries then there will be a really strong incentive for them to sign up to GNEP or GNPI type deals.

MULTINATIONAL APPROACHES – AN OLD AND NEW IDEA

For many decades there have been repeated proposals for initiatives that could reduce the security concerns of spreading nuclear technologies by establishing multinational cooperation approaches. If implemented, these would restrict the most sensitive nuclear technologies to a limited number of countries so that strict safeguards and security measures can be more easily applied the number of locations for these highly sensitive facilities is minimised. In the early days after the foundation of the IAEA, various schemes, such as the two examples described below, were being proposed – but little progress was made towards their implementation. The current set of initiatives that are being discussed have been broadened to comprehensively address the full fuel cycle. They may have better chances for success, but only if true partnership approaches rather than top-down pressures are applied.

Regional Nuclear Fuel Cycle Centres RFCC (1975-7): As early as 1975 the IAEA launched a study project to examine the economic, safety, safeguards and security aspects of a multinational approach to nuclear fuel cycle facilities. RFCCs were envisaged to include spent fuel storage, fuel reprocessing, plutonium fuel fabrication and waste disposal. The study group reported in 1977 (Meckoni et al 1977) with very encouraging results, arguing that from many perspectives considerable advantages could be expected from the RFCC concept. Firstly, the intergovernmental agreements envisaged for RFCCs would bring non-proliferation advantages. These agreements would lead to enhanced safeguards and physical protection, and improved siting of facilities. Secondly, the study argued that economic and operational advantages in

geological disposal could also be expected if multinational repositories were to be implemented.

International Plutonium Storage (IPS): The expert group on IPS was set up to develop ideas for how the IAEA could act upon the rights provided for in article XII.A.5 of its 1957 statute, which allows for it to implement international storage facilities for excess plutonium. The group set out a number of concepts for an IPS. The study was based on the assumption that under an IPS agreement, all separated plutonium in excess of current requirements for safeguarded use in reactors, fuel production and research would be stored under international control (IAEA 1982). Problems were encountered in developing practicable approaches, however, and the idea was effectively dropped until around 1993 when further international controls on fissile materials were again discussed at the IAEA General Conference. Two new concerns had arisen in the intervening years. First, nuclear weapons disarmament meant that large stockpiles of special fissionable materials - plutonium and HEU - were expected to be recovered from dismantled weapons. Second, stocks of separated civil plutonium were seen to be growing and these also needed transparent safeguarding.

The fact that many of the issues being raised again today were considered – but not followed through – over 15 years ago is illustrated by the following list of issues discussed in the 1980 publication of the Stockholm Institute for Peace Research (SIPRI 1980):

- Diversion by National Governments
- Diversion by Non-Governmental Organisations
- Nuclear Power – a Trojan Horse for Terrorists
- Internationalisation of the Nuclear Fuel Cycle
- International Storage of Spent Fuel Elements
- A Nuclear Fuel Cycle Pool or Bank
- Regional Planning of the Nuclear Fuel Cycle
- Multinational Arrangements for Enrichment and Reprocessing

Some significant progress in restricting the spread of sensitive nuclear technologies has been achieved, however – in particular for the most alarming of all nuclear technologies, namely production of nuclear weapons. This first major success, in 1968, was the opening for signatures of the NPT. Almost all States are now Members of this, the notable exceptions being Cuba, Israel, India, Pakistan and North Korea (which withdrew).

In recent years, increasing concerns that further countries like Libya, Iraq, North Korea, and Iran were trying join the "nuclear club" have led to new proposals for enhanced international cooperation. In addition to the IAEA, the large nuclear powers, Russia and the USA, have made independent suggestions, as described below. The driving force today is not solely reduction of proliferation attempts by States. Limiting security threats from sub-State terrorist groups is also a powerful motivation (Isaacs and Choi 2006). Most recently, a third driver has increased in importance, namely encouraging a wider use of nuclear energy as part of the solution to concerns about the effects of fossil fuels on world climate.

The results have been initiatives by the political leaders of both Russia and the USA – the Global Nuclear Power Infrastructure Initiative (GNPI)) by President Putin and the Global Nuclear Energy Partnership (GNEP) by President Bush – each aimed at promoting nuclear power technologies while at the same time addressing security concerns. These are discussed below. At the end of 2006 a joint US-Russian high level Working Group was established with a list of strategic aims. The most relevant of these in the present context are *"the development of exportable small-and-medium power reactors"* and *"developing methods for providing international nuclear fuel cycle services"*. Strong international backing for such efforts was provided by the IAEA, through numerous public policy statements of its Director General as well as through the MNA Initiative described below

THE MNA INITIATIVE OF THE IAEA

It is important to note that the sensitive parts of the fuel cycle include not only enrichment of fissile uranium and reprocessing, but also long term storage and disposal of spent nuclear fuel and high level radioactive wastes (SNF/HLW). This point is made clear in the 2005 report published by the Multilateral Approaches (MNA) Expert Group that the Director General of the IAEA set up in mid-2004 (IAEA 2005). The MNA report addresses the security and non-proliferation issues in a manner directly applicable to all aspects of the nuclear fuel cycle, and suggests five specific approaches for multinational initiatives. The implications of these proposals for storage and disposal concepts are discussed below.

The MNA Group identified as factors influencing the assessment of multilateral approaches *"assurance of non-proliferation"* and *"assurance of supply and services"*. The former objective is clearly easier to achieve if multinational

storage and disposal facilities can be made available. Leaving spent fuel in dozens of locations for many decades is obviously less proliferation resistant than collecting the material into a smaller number of facilities in stable host countries with very strong safeguards controls. There have, in fact, been various proposals from potential hosts and user countries for shared storage facilities that can be well secured (see for example Bunn et al 2001). However, in practice, it will be difficult to transfer SNF/HLW to another country for storage without some clarity on the end-point of the agreement. Returning cooled spent fuel to many countries after several decades or returning HLW from reprocessed spent fuel would simply reinstate the current proliferation and security risks of dispersed storage. Moreover, accepting returned SNF or HLW would compel small countries to seek national deep disposal solutions – in which case they may as well have retained the fuel for disposal.

In short the assurance of non-proliferation sought by the MNA Group could be most expeditiously attained by early implementation of shared storage facilities – but only with the essential ingredient of an agreed further step of disposal in multinational repositories. These could be either in the countries storing the waste or in a limited number of other, volunteering, host nations.

The MNA Group recognises in its report that there is currently no international market for storage or disposal and recommends that the IAEA supports the concept "*by assuming political leadership to encourage such undertakings*". Specific ways forward are possible based on two multinational repository scenarios that have already been defined by the IAEA – "partnering" (between small nations) and "add-on" (by a large nuclear nation), as documented in TECDOC 1314 (IAEA 2004). It is emphasised correctly by the MNA Group that disposal and storage of SNF/HLW should not be looked at in isolation, but as part of a broader nuclear strategy. Some of the Group's five suggested approaches for encouraging multinational initiatives have specific implications for multinational disposal.

One proposal is "*reinforcing existing commercial market mechanisms***",** e.g. by commercial fuel banks, fuel leasing and fuel take-back and commercial offers to store and dispose of spent fuel. Commercial market mechanisms in the past have made possible the transfer of SNF with no return of wastes, e.g. to reprocessing plants in France, the UK and Russia. Increasing public and political pressures on the organisations involved led to these services being withdrawn. The potential acceptability of reintroducing disposal arrangements could be greatly enhanced by IAEA support and by an IAEA commitment to oversee rigorously, or even to co-manage, the facilities.

The most promising multilateral approach for geological disposal may be "*creating, through voluntary agreements and contracts, multinational, and in particular regional, MNAs for new facilities based on joint ownership, drawing rights or co-management*". This can be done for front-end and back-end nuclear facilities, such as uranium enrichment; fuel reprocessing; disposal and storage of spent fuel. Recent Russian enrichment proposals go in this direction. For disposal, interest in the partnering scenario that could lead to regional facilities is clearly evidenced by recent developments, in particular in Europe. The Arius Association, founded in 2002, pursues this concept as its main activity. The European Commission has promoted the concept of regional repositories in Europe in its Council Directive on "the management of spent nuclear fuel and radioactive waste" and is also funding the SAPIERR project, which is studying the potential for regional repositories in Europe.

Another suggestion is "*promoting voluntary conversion of existing facilities*" to MNAs. In the case of geological repositories, there are no facilities currently in existence, although several countries have advanced projects leading to implementation – in particular Finland, the USA, Sweden and France. Each of these, however, has made it very clear that the repositories are purely national and will not accept foreign fuel or wastes. The general consensus in the waste disposal community is that success in these programmes will help the cause of geological disposal world-wide. If this success is currently more assured by purely national approaches, it should not be interpreted as evidence that only national programmes can succeed. Of course, new multinational facilities might also be constructed in the "add-on" scenario, involving a large nuclear programme. The current Russian and USA proposals in this area are described below.

RUSSIAN PROPOSALS

For several years, discussions have been on-going about Russian proposals to offer a commercial service by accepting foreign spent fuel for storage and reprocessing national laws have been amended to allow this, but the option of final disposal of the radioactive wastes in Russia is not currently open. On 25 January, 2006 Russian President, Vladimir Putin, announced a broader initiative which is intended as a practical input into the implementation of the G8 accords reflected in the Declarations on Non-Proliferation at the summits in 2005 and 2006. The concept is to develop a Global Nuclear Power Infrastructure (GNPI) capable of providing access to

the benefits of nuclear energy to all interested countries while remaining in compliance with non-proliferation requirements. Establishment of a network of international nuclear fuel centres (INFCC), including enrichment services, under IAEA safeguards should become a key element of such an infrastructure. Specific proposals for action have been already been put forward.

Sergei Kirienko, head of the Russian Federal Agency for Atomic Energy, has announced a first step towards Russian multinational facilities - the establishment of a so-called International Enrichment Centre (Ruchkin and Loginov 2006). This would be located at the Angarsk Electrolysis Chemical Combine Federal State Unitary Enterprise, a nuclear facility with experience in the enrichment of uranium and the production of fuel for nuclear power stations. The concept is that the enrichment centre would be established by the governments of interested states using the form of an intergovernmental agreement or a joint venture. The prices for services will be consistent with world market rates, but there would be no access to the enrichment technology by participants or shareholders. Russia will implement IAEA safeguards and would begin operation as soon as there are a sufficient number of countries willing to participate.

In the context of the present back-end discussion, it is interesting to note the potential follow-up stages of GNPI-INFCC implementation that are mentioned by Russia. These include organising a *"timely solution of SNF management issues by reprocessing and the disposal of residual waste within the framework of international NFC centres"*. Currently, however, there are no details given about the potential return of spent fuel to the INFCCs.

In practice, there is considerable scepticism in the international community about Russian proposals to manage imported spent nuclear fuel safely – not least because of the questionable history of Russia in dealing with its own radioactive wastes. Below, we list what we believe are the likely requirements that the international community would place on the development and use of back-end (storage and disposal) facilities for spent fuel in Russia. These points have been presented in Russia in more detail (McCombie and Chapman, 2005).

The pre-requisites needed to make international stakeholders highly comfortable with what is offered and the conditions for such a facility to be feasible in Russia are, in brief:

- **The import of spent fuel for disposal, not just storage, should be permissible.** This means that a new law will be required in the Russian Federation to allow disposal of any fuel that is not to be, or cannot be, recycled (reprocessed or regenerated).

- **The services offered should include a final disposal option (geological repository) not only for spent fuel, but also for vitrified high-level wastes and other long-lived wastes.** A country wishing to divest itself of the requirement to build a geological repository for spent fuel will equally wish not to have to build one for returned reprocessing wastes or for its other long-lived wastes.

- **Overall acceptability of the scheme to the international community is a necessity.** All nations and groups of nations that become involved will have to present the scheme's credentials to their own public and institutions with great commitment.

- **Clear economic advantages must result, both to the users and to Russia.** Economically, Russia stands to benefit substantially by being able to charge appropriate rates for a valuable service not currently available anywhere else. The users should be prepared to pay for avoiding the problems and unpredictable costs of running their own national disposal programmes.

- **There must be guarantees of long-term availability of the facilities for user countries.** The facilities, or others like them, need to be available over the period that wastes will be generated by a user country in order that all wastes for deep geological disposal can be exported – otherwise their national problems are not solved

- **International support and recognition is essential.** The major nuclear nations and international agencies and associations should acknowledge that Russia wishes to provide a valuable international service that will enhance the global security and safety environment because all technical aspects of the project will be developed to the highest international standards.

- **An open and transparent project management structure**. Information on the way that the scheme is managed, along with all its significant technical, societal and economic aspects, should be available to interested parties.

- **Use of the best knowledge and expertise.** Both transparency and international standards will be

achieved by ensuring the direct participation of the best technical experts, selected worldwide.

- **Active involvement of the IAEA** in establishing the project (and, later, in an oversight monitoring role), thus underwriting its overall credibility.

These requirements are well-recognised, but satisfying each of them presents its own challenges, especially since some of the main players have very different views. A series of meetings held in Moscow and in Vienna over the past few years have allowed views to be expressed. However, they have not been aimed specifically at resolving the problems or even at suggesting a specific way forward.

THE US GNEP PROPOSAL

In early 2006, President Bush announced the Global Nuclear Energy Partnership (GNEP), under which America intends to work with nations that have advanced civilian nuclear energy programmes, such as France, Japan, and Russia. The prime domestic aim is to develop and deploy innovative, advanced reactors and new methods to recycle spent nuclear fuel. GNEP is, however, also meant to provide a reliable fuel services programme, under which a consortium of nations with advanced nuclear technologies would provide fuel and reactors to other countries that agree to refrain from fuel cycle activities. The hope is to develop an international regime that will allow for fuel leasing, so that fuel can be leased to a country interested in building a reactor and taking fuel, but then the fuel can be taken back to the fuel cycle country. This fuel leasing approach would provide an incentive for nations to forgo enrichment and reprocessing technology. The recipient countries should benefit from "*the certainty that fresh fuel would be available when needed and that used fuel would be taken back under agreed and reasonable terms*".

The brief document published by USDOE in January 2007 (USDOE, 2007) provides a timely and useful overview of the GNEP vision and of how DOE intends to implement this. The three goals:

- wider-scale use of nuclear energy;
- decreasing risks of proliferation and nuclear terrorism;
- addressing the challenges of disposal;

are all of great importance for global environmental, safety and security reasons.

The plan concentrates strongly on technological issues associated with enhancing the US capabilities for undertaking key fuel cycle activities. This is obviously important because of the US expertise that has been lost over the past decades. It also highlights the view that GNEP can postpone for a long time the need for a second repository in the USA, provided that the facilities for advanced fuel cycle operations are brought on line. The strategy is however, needs to be strengthened in one key point – how to win the support of other nations and thus achieve success in the area of enhancing global security. This crucial issue is addressed below.

The DOE document claims that *"the GNEP vision has been well received by the international community"* – but continues with the phrase *"particularly among the leading fuel cycle states"*. However, support by such States is relatively easy to achieve; GNEP can only help to restrict the market in a way that helps providers of fuel cycle services. However, GNEP can work on the hoped for global scale only if the "P" for partnership includes also the smaller or the new nuclear programmes (Tier 2 countries) around the globe that are to be prevented from having fuel cycle facilities (enrichment and reprocessing) that are their right under the current NPT that they have signed up to.

Currently, the only real incentive being offered to these Tier 2 countries is *"reliable access at reasonable cost to fuel for civil nuclear power reactors"*. However, they need to have guarantees that costs will be indeed reasonable and – perhaps more important – guarantees of security of supply of fuel cycle services. For some small countries, the existing US consent over transfer and use of US origin nuclear materials has had negative impacts in the past (e.g. delays in shipping fuel for countries like Switzerland; ban of reprocessing for South Korea, etc.). Why should small countries now welcome a new regime that even more firmly creates a two tier status in the nuclear world? Unless the USDOE also engages the small countries in discussion and unless it can offer greater incentives than at present, there is little or no incentive for them to buy-in to the GNEP initiative.

For enrichment, fuel fabrication, reactor construction and reprocessing there is a already a sufficiently competitive market. No activities in these areas have been blocked or slowed due to a lack of willing vendors. With GNEP, this competitive market may well shrink. What extra incentives does GNEP offer? The most tangible additional service offer is the take-back of spent fuel. This could, in principle, be extremely attractive, since deep geological repositories for limited amounts of wastes are very expensive and are also difficult to site, for both technical and societal reasons. Removing the disposal problem from small nuclear programmes could outweigh the possible disadvantages that GNEP might bring them.

But will GNEP actually remove the problem? Currently the stated principles include *"taking back spent fuel for recycling"*. The text is silent about whether the HLW resulting from recycling will be retained by the recycling service provider. These wastes were previously retained in the case of the UK, France and Russia – but all of these subsequently altered this policy due to public and political pressure. Will the USA (and other Tier 1 GNEP countries) be able to accept foreign HLW) for final disposal? This question will certainly cause intense debate further down the GNEP line.

The situation concerning radioactive wastes or spent fuel is, in fact, even more problematic. Small countries with existing modest inventories of spent fuel will have little incentive to send future spent fuel arisings to a foreign recycler if they have to implement a national deep repository anyway. Moreover, even those countries that initiate civilian nuclear programmes under a GNEP agreement for returning spent fuel will have small quantities of other long-lived radioactive residues from activities in power production, research and industry – and these must also be disposed of in a geological repository. As was pointed out in the Russian case, a comprehensive geological disposal service will have much greater chances of acceptance by users.

Currently, the back-end issues associated with GNEP are open and no global impact can be guaranteed. The USA can still build its proposed new fuel cycle facilities, including advanced reactors and reprocessing plants, and can hope in this way to revitalise nuclear programmes in the USA and even to postpone the necessary decisions about a second national repository. However, to achieve fully the laudable global environmental and security goals, the back-end must be addressed directly. The overdue discussions to be held must include not only the Tier 1 service suppliers but also the potential Tier 2 service users. A key component of the GNEP strategy will be greatly strengthened when USDOE gets directly involved in communicating with the relevant organisations in Tier 2 GNEP states.

INVOLVING OTHER NATIONS

There are further multinational disposal options that could change the global picture. The fuel supplied to small countries could be shipped back, not to the supplier, but rather to an accepted third party country that has the required capability and is trusted to operate safe and secure disposal facilities. Australia has been mentioned often in the past as a nation that has many geological, technical and political attributes that would make it an extremely suitable host for such a repository. In fact, in the current debate in Australia on the use of its huge uranium reserves and on the possibility of its introducing nuclear power options for introducing all facets of the nuclear fuel cycle have also been addressed.

Alternatively, small countries might get together in a partnership arrangement that would lead to shared repositories in one or more willing host countries that would work to complement the GNEP activities. They could do this by accepting the foreign HLW from reprocessing activities in GNEP Tier 1 countries and/or accepting spent nuclear fuel for disposal from those countries that do not wish to have their fuel reprocessed in GNEP and/or by leaving the HLW/SNF management and disposal to GNEP countries whilst providing a geological disposal route for long-lived but less active wastes from the small partners.

The concept of shared regional geological repositories is being developed in European Union. The SAPIERR project, which is funded by the EC (Stefula, 2006) clearly demonstrates the potential advantages of such an approach. However, EU policy is for disposal of EU wastes within the Community so that other complementary regional schemes or a change of policy would still be required for a comprehensive global scheme to be established.

CONCLUSIONS

A major objective of the global nuclear community today is to restrict the spread not just of weapons technology but also of the facilities, techniques and the materials that could lead there. The techniques in question – so-called latent proliferation capabilities - are mainly enrichment and processing. The sensitive materials include all fissile materials such as HEU and plutonium, but also SNF and HLW. The concept being proposed is that the large powers could supply smaller countries with the reactors needed to produce nuclear energy, but would provide the fuel only if it is returned to the supplier for reprocessing or disposal. In practice, both major initiatives, GNEP and GNPI, place emphasis on the supply of the reactors and enriched fuel. Neither has yet made clear and specific proposals about the take-back part of the arrangement. The primary incentive offered to the small user countries is "security of supply" of the front end services.

However, there is no current shortage of supply of front end services; in fact, there is strong competition to supply reactors and fuel. From the point of view of the recipient country, the incentives are thus not large. A much greater incentive could be the provision of a spent fuel or waste disposal service. This would alleviate the considerable economic, technical and political challenges faced by a

small country attempting to build up a geological disposal programme. The back-end service offered would have to go beyond the simple return of supplied reactor fuel. Only if a comprehensive service that obviates the need for a national deep repository is offered to small countries, will there be a really strong incentive for them to sign up to GNEP or GNPI type deals. Serious negotiations are required concerning the conditions for the return of plutonium-laden spent fuel from nuclear power user countries to major fuel cycle service nations. Apart from questions of supply security, comprehensiveness of the service, costs etc., there may also be other important back-end issues – e.g. the question of long term ownership of recycled fissile materials such plutonium, should advanced reactor cycles make an early breakthrough.

Both GNEP and the GNPI, as currently being promulgated, need to deal comprehensively with the fuel cycle if they are to be accepted by the target community of developing nations and if they are to have a serious impact on international security. The key messages today for the large country proposers of schemes for restricting nuclear technologies are that:

- the potential "Tier 2" countries receiving nuclear services must be included in discussions on feasible arrangements;
- the incentives offered should include back-end services that cover disposal of spent fuel and also other long-lived wastes;
- the necessary, final shared repositories may be in the fuel supplier country, in a third party or in a shared partner repository – in all of these cases, active political and technical support of the Tier 1 countries will greatly increase the chances of success.

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