

## **The Importance of Storage and Disposal in Multinational Approaches to the Fuel Cycle**

**Charles McCombie, Neil Chapman**  
**Arius, Switzerland**

### **The global need for storage and disposal facilities**

Virtually all countries in the world with nuclear power programmes have concluded that geological disposal is a necessity, if we are to make the nuclear fuel cycle safe and environmentally acceptable without putting undue burdens on future generations (IAEA 2002). For technical reasons related to the initial rapid decay of radioactivity and heat output, disposal of spent nuclear fuel (SNF) or high-level wastes (HLW) can take place only after storage periods of decades or more. For societal or economic reasons, some countries have decided on much longer interim storage, e.g. the Netherlands intends to store for 100 or more years – although it is nevertheless recognised that geological disposal is the only feasible subsequent step.

Even for countries that would like to move relatively quickly to disposal, storage has become a key issue. This is because, unfortunately for the progress of nuclear power, moving towards geological disposal has proven to be a very difficult task, even in the most advanced countries. There will be no SNF/HLW repository in operation until the next decade and many countries are looking towards the middle of the century. For the larger, advanced nuclear programmes the problems are mainly societal issues associated with achieving sufficient public and political acceptance for specific sites for a national repository. For small countries, however, or countries with limited nuclear power programmes or countries with no nuclear power but long-lived wastes from other applications, a national deep geological repository may be ruled out on economic or environmental grounds. If SNF and HLW are not to remain dispersed for indefinite periods in dozens of surface stores around the world, these small countries need access to geological repositories.

This implies that multinational facilities for disposal of SNF/HLW are a prerequisite for the sustainable, safe and environmentally friendly use of nuclear power and other nuclear applications. Other activities in the nuclear fuel cycle – uranium supply, enrichment, fuel fabrication, reactor construction, reprocessing – are all provided as international services. The same status must be achieved for disposal. For storage, the economic arguments for multinational facilities are more debatable, since the facilities are less costly and the economies of scale less dramatic. There are, however, other strong arguments for rationalising global storage strategies, as pointed out in the following section.

### **Non-proliferation and security of increasing importance**

In addition to the economic, safety and environmental benefits that multinational repositories can offer, the non-proliferation advantages have often been stressed (IAEA

2004, Stoll and McCombie 2001). In recent years, in particular following the series of terrorist attacks from 2001 onwards, increasing attention has focussed on both non-proliferation and security aspects (see Alvarez et al 2003, USNRC 2003, NRC 2005). Repeated statements by the Director General of the IAEA have pointed out the need to control the most sensitive parts of the fuel cycle (e.g. ElBaradei 2003). It is important to note that these include not only enrichment of fissile uranium and reprocessing, to separate plutonium, but also long term storage and disposal of SNF/HLW. This point is made clear in the February 2005 report published by the Multinational Approaches (MNA) Expert Group that the DG set up in mid-2004 (IAEA 2005a). The MNA report addresses the security and non-proliferation issues in a manner directly applicable 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.

### **Assurance of non-proliferation and of supply and services**

The MNA Group sets out as deciding 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. There are currently 35 countries with nuclear power plants (with more than 500 plants operating, being constructed or planned) and a total of 69 with research reactors. A total of 674 research reactors were operational, shutdown, under construction or planned in 1997, according to the most recent survey in the IAEA database (<http://www.iaea.or.at/worldatom/rrdb/>). Leaving spent fuel in all of these locations for many decades is obviously less proliferation resistant than collecting the material into a smaller number of facilities with very strong safeguards controls. In practice, the existing strict controls of the IAEA and EURATOM might even be enhanced by a further level of direct international control over a storage or disposal facility for SNF.

For the short and intermediate time frames, shared storage facilities alone would suffice to contain the proliferation risk. Shipping spent fuel removed from reactors to one of a few centralised facilities as soon as it has cooled enough for transport would be a sensible approach. Technically, with assured centralised interim storage, the question of implementing repositories could be postponed. There have been various proposals from potential hosts and user countries for shared storage facilities (see for example Bunn et al 2001, Ansolabehere 2003,). However, in practice, as is strongly emphasised in the IAEA multinational storage report currently being drafted (IAEA 2005b), 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 would simply reinstate the current proliferation risks of dispersed storage. Returning HLW from reprocessed spent fuel reduces proliferation risks by retaining central storage of plutonium, but increases security concerns. Moreover, accepting returned 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 is best attained by early implementation of shared storage facilities, with the essential ingredient of an agreed further step of disposal in multilateral repositories – either in the countries storing the waste or in a limited number of other volunteering host nations.

How could one guarantee assurance of supply and services in a situation where many countries are relying on storage or disposal facilities being available in another country? One obvious answer is to have more than one multinational facility and thereby avoid the danger of creating a monopoly. An alternative or a complementary measure is to have direct international guarantees that avoid monopolistic behaviour. One way to achieve this is for the IAEA itself to guarantee continued provision of storage and disposal services. This could be done by establishment of specific internationally operated facilities, whereby agreements with the host country or countries would be required. An alternative is that the IAEA promotes binding arrangements between the service providers, ensuring that each will agree to taking over commitments of others, should these cease to provide promised services for storage or disposal.

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 both of the multinational repository scenarios defined by the IAEA – “partnering” and “add-on” (by a large nuclear nation), as documented in TECDOC 1314 (IAEA 2004). These possibilities are discussed below.

## **Specific scenarios for multinational approaches to disposal**

The “add-on” scenario is one in which a large nuclear programme accepts wastes from smaller ones. There are several conditions that could enhance the probability of an add-on scenario being successfully implemented:

- The international community should recognise that any country offering storage or disposal services is potentially a contributor to global safety and security.
- A willing host country (or countries) must come forward, and should be able to demonstrate to the international community that they have the necessary level of support for the project within the host country.
- Appropriate benefits for the host(s) must be agreed. These need not be purely financial; strategic and political issues may also be involved.
- The potential user countries of a multinational repository must not abdicate all responsibilities. They should, singly or as a structured group, develop mechanisms to assure that the safety standards in a multinational repository are not lower than those that each would accept for a national repository.

- International or supranational bodies (e.g. the IAEA or the EC) must be willing to play an active role in developing and controlling the multinational initiatives. This involves not only safety, security and non-proliferation aspects, but also the assurance of supply issues discussed above.
- Real interest in sending spent fuel to any country with an international repository will be shown by small countries only if existing backlogs of stored spent fuel, HLW and LL-ILW can also be transferred, since complete avoidance of the need for an expensive deep repository will be the driver.

In recent times most discussion on the add-on option has revolved around concepts in which Russia acts as host country. Over the past few years Russia has been seriously examining the issue of spent fuel import and is currently the only country supporting this at government level. Specific proposals that could advance the Russian initiative are included at the end of this paper.

For the “partnering” scenario, in which a group of usually smaller countries cooperate to move towards shared disposal facilities, exploratory studies have been performed most recently by the Arius Association, which also co-manages the European Commission SAPIERR project on regional repositories (Arius 2005, SAPIERR 2005).

The following stages can be envisioned for a partnering scenario. It is interesting that they do not differ greatly from steps taken within a federally organised state to seek a national disposal solution.

**Pilot feasibility studies:** A sufficient number of interested national organisations cooperate to organise and fund pilot studies aimed at establishing the basic technical, legal, economic and political feasibility of multinational repositories.

**A formalised study consortium:** To progress to the detailed level of study needed, a structured project team must be created, staffed and funded at the appropriate level. At this stage, participating countries can still choose to leave open the question of whether all partners are potential hosts or whether some, perhaps with small areas or with no nuclear power production, can choose to enter only as potential users of a shared repository. The study consortium must agree the level of funding needed, the distribution of the costs amongst partners and, very importantly, an organisational structure and medium-term (multi-year) programme.

**A dedicated Regional Repository Project Team:** The project team must cover the same key aspects of repository planning that also affect national repositories. Of course, some tasks are more challenging in a multinational context than in national programmes. A sensible option would be to recruit core team members by delegation of appropriate staff from the national programmes involved.

**Siting studies leading to candidate siting areas in different partner countries:** The siting study is clearly the most sensitive work area. Optimally, it should involve working in parallel on a volunteering strategy and on a technical/societal study aimed at ranking options and keeping multiple options open. At this stage, the project is coming close to

moving into the phase of on-site investigations at potential sites. Reorganisation and further formalisation of the cooperation may be appropriate, in order to handle the growing political and technical challenges and the increased financing.

**Establishment of a Business Consortium or a Joint Venture:** The purpose of this organisation is to organise and fund the characterisation of sites, to finalise agreements on the key issue of compensation for host communities and countries, to select a short list of preferred sites and to interact with political and regulatory bodies in the candidate countries. At this stage, at the very latest, it is imperative to assure involvement of and cooperation with relevant international bodies – in particular the EC (for a European venture) and the IAEA.

**Establish a construction and operation company:** It may be necessary to reorganise the existing Joint Venture in order to take account of specific wishes of the hosting country or countries with respect to legal structures, shared liabilities, funding mechanisms, etc.

**Repository operation:** During the decades for which the repository will operate, the relationships between the partners can be of various types. In all cases, it is expected that the user countries will require sufficient insight into operations to enable them to reassure their national publics that required safety standards are being adhered to at the repository. Given the nature of the facility, international oversight by the IAEA will be a necessity (and the EC for a European repository).

**Closure and post-closure:** At some time in the far-future, the regional repository will be closed and possibly monitored for some long time. As with the shared benefits, agreements for sharing liabilities must be agreed long before this final stage is reached. On the liabilities side, the question is how much and for how long partner countries may continue to be liable should any remediation work be required. On the benefits side, one issue is whether partner countries retain any claim to spent fuel should this ever be deliberately recovered from the repository because of the high energy content of the residual fissile materials it contains.

The scenario sketched above is one of many possible variants. At the heart of a successful project lies the siting issue. However, this is a difficult problem even in national programmes – but this has not prevented local communities in some countries agreeing to host repositories. The MNA group of the IAEA also recommends an initial cooperation phase, with participating countries working on a “*Siteless Pilot Project*” – which is, of course, the precise course taken by the European SAPIERR project.

## **The five approaches of the MNA Group and their implications for storage/disposal of SNF**

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. Nevertheless, it is interesting to examine the five suggested approaches for encouraging multinational initiatives and to consider specifically their implications for these two activities.

**Approach 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: 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. Russia is currently re-opening the door for accepting fuel from nuclear power plants in other countries – but only for take-back of fuel elements supplied by Russia. Both Russia and the USA have implemented processes for taking back spent research reactor fuel – for purely non-proliferation reasons. Although initially also restricted to fuel supplied by themselves, this could change. The USA is already negotiating taking non-US fuel from the new Australian OPAL research reactor. In practice, the only commercial offer currently being made for SNF is by Russia – and this is at present restricted to storage, with possible later reprocessing and return of HLW.

The potential acceptability, both within Russia and in a potential customer country, of including disposal in this arrangement, could be greatly enhanced by IAEA support and by an IAEA commitment to rigorously oversee, or even co-manage the facilities. If the Russian approach achieves global acceptance, it is even possible that competition could arise, as other nations realise the commercial opportunity and receive international encouragement to provide such a service.

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

Supply guarantees for a storage or disposal service are important to any customer country. Withdrawal of the services could lead to shortage of storage capacity that can impact on continued reactor operation or could put the country back into its original position of having to implement an expensive geological repository. The latter potential problem will, fortunately, never be an urgent timing issue since disposal is easily postponed. Nevertheless, an IAEA initiative to organise for a group of service providers jointly to guarantee the continued availability of storage/disposal facilities would be of value.

**Approach 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.*

Conversion of existing facilities is currently conceivable only for storage of spent fuel, since no geological repositories for SNF are in operation. For storage it has generally been found, even for small nuclear countries, that implementation of national facilities is affordable and politically feasible, especially if the stores are at existing nuclear plants. In

fact, shortage of national storage capacity has threatened progress only in the large nuclear programmes of Taiwan and Japan (and, to some extent, the USA). In the USA, a private commercial initiative has been launched to fulfil the growing need for away-from-reactor storage, but it is not at present conceivable that this could be used for storing foreign fuel. For Japan and Taiwan, the possibility to store SNF for some decades in another country, such as Russia, could be of interest because of the difficulties in siting new storage facilities.

In the case of geological repositories, although none is operating, several countries have advanced projects leading to implementation – in particular Finland, the USA, Sweden and France. All of these, however, have 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, then these should continue – but this should not be interpreted as evidence that only national programmes can succeed.

**Approach 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.*

For geological disposal, the creation in the future of new multinational and/or regional repositories is the most promising approach. Interest in the partnering scenario that could lead to these is clearly evidenced by recent developments, in particular in Europe. The Arius Association, founded in 2002, pursues this concept as its main activity. Organisations from eight countries are currently involved. 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”. The Commission is also funding the SAPIERR project, which is studying the necessary boundary conditions for regional repositories in Europe. Organisations from 14 European countries participate in SAPIERR. The key question of siting is deliberately not addressed in the current phase. Consistent with the remarks made above on avoiding monopolies, it may be advisable ultimately to seek more than one site.

Of course, new multinational facilities might also be constructed in the “add-on” scenario. Again, Russian possibilities have as yet been most discussed. In 2003, and again this year, delegations have visited the Krasnokamensk site in Eastern Siberia, where the local population is in favour of implementation of a store and a repository for spent nuclear fuel from other countries. (Laverov et al 2003).

**Approach 5:** *The scenario of a further expansion of nuclear energy around the world might call for the development of a **nuclear fuel cycle with strong***

***multilateral arrangements — by region or by continent — and broader cooperation involving the IAEA and the international community.***

This conclusion of the MNA group is very relevant now that interest in increased use of nuclear power is higher than it has been for decades. On the topic of multinational geological disposal, unfortunately, there has been controversy as well as cooperation between IAEA Member States. However, the advanced national disposal programmes are becoming more confident of success and subsequently feel less threatened by multinational initiatives, and the active support of the IAEA and the EC has become stronger. There should, therefore, be little difficulty in the international community further supporting broader cooperation on multinational approaches and no obstacles in the way of intensive IAEA involvement.

## **Conclusions**

There is clear recognition internationally that multinational approaches in the overall nuclear fuel cycle can enhance security and can help hinder proliferation. Despite earlier controversies, the potential advantages are also recognised for multinational storage and disposal facilities. What concrete steps can be taken to move beyond empty expressions of support towards specific practical initiatives?

Specific repository projects involving technical and societal efforts towards siting and constructing a shared repository will need closer coordination, direct involvement of the interested countries and the international agencies, and significantly increased resources. Most of the small countries that could benefit most directly from shared repositories have not yet accumulated sufficient funds to implement a national repository. However, there are certainly sufficient resources available in these countries, if pooled, to support a serious joint waste disposal programme. Initially, this would be aimed at clarifying the options for a shared regional facility. However, more support for backend studies on storage and disposal is needed. The relatively large funding which is proposed for tackling security issues at the front end could be complemented by increased – although still comparatively modest – financial support for progressing shared repository projects for commercial reactor fuels. The “partnering” scenario outlined earlier in this paper exemplifies one possible practical approach.

In addition to implementing comprehensive multinational disposal projects that closely parallel national projects in their structure, siting strategies and timescales, the international community could also support more specific, limited initiatives, e.g. strengthening on-going efforts to secure all spent sealed sources world wide or to repatriate research reactor fuel. Significant progress in these areas has been made in recent years.

However, the biggest, potentially fully international, storage/disposal initiative that could be grasped and developed immediately is that proposed by Russia. A combination of fuel leasing, allowing take-back of Russian origin fuels, and acceptance of foreign fuels requiring USA consent under existing fuel-flagging rules would be a first step.



In our view, however, the Russian storage initiative will only be acceptable if the endpoint of disposal is available – this means actually available, or specifically planned and financed, rather than held out as a vague future prospect. If the international community thus wants to make a really useful contribution to global security and safety then this is where it could direct its resources. Specifically, we propose that the IAEA offers to assist Russia to move forward by assembling both the funding and the enormous expertise that exists internationally to develop, in a timely fashion, a state-of-the-art international deep geological repository. Currently, some movement in this direction is taking place, as evidenced by the present Conference and also by the meetings organised with IAEA support in June by the Russian and American Academies of Science. In return for this offer, Russia should agree to a new level of transparency and international oversight in the development work. Only in this way can the trust of the international community be enhanced to a level needed for other countries to enter into long-term commitments to transfer fuel to the Russian Federation. This would be a truly worthy project with truly global benefits – it is surely to promote solutions such as this that the IAEA was founded and exists today.

Of course, as emphasised above, a single supplier of disposal services could present strategic and economic risks for potential customer countries. Global waste inventories, however, easily justify multiple international repositories and commercial competition could conceivably encourage this. If the international community acknowledges the global value of having international repositories available and is prepared to support their development, then it is not unlikely that other candidates could also appear. These might be other large countries or they might be smaller countries willing to consider hosting a facility implemented with partners.

We need bold initiatives for global solutions if we are to achieve multinational goals. These solutions need not only the strongest of support from the United Nations and its Member States but they also need to be championed by the major countries, working together. The present conference is an excellent forum for progressing appropriate initiatives.

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