

Multinational Geological Disposal Facilities

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Introduction

We have contributed to all of the series of review meetings and reports on “Geological Challenges in Radioactive Waste Isolation” since the original took place in Washington DC in 1989, as authors of either national or multinational disposal programmes. It is interesting therefore to look back over the publications from 1991, 1996, 2001, and 2006. In the national programme descriptions, there are several ups and several downs; some of the downs have led to complete restructuring of programmes (e.g. in Switzerland, France, the UK, the USA and Canada), some of the ups and shown reassuringly continuous progress, albeit often with longer delays than was foreseen (e.g. Sweden and Finland). In the present paper, however, or focus is on the issue of multinational disposal concepts. Here also there have been periods of marked progress, but also times when multinational initiatives faced stronger headwinds.

Interestingly, at the first meeting in 1989 the IAEA paper included a section on potential future international cooperation. Here it was stated that concept of international repositories has been “strongly advocated by many of the member states, that IAEA groups have worked on this, and that many countries believe that it is feasible to establish an international waste repository system”. There is then a caveat expressing the view that, “due to the political nature, many international legal, environmental and technical concerns must be addressed prior to further consideration”. In fact, around the turn of the century, there was indeed a sometimes heated debate on the topic of international repositories, with some participants claiming that the concept could damage purely national programmes or even that the concept itself was not ethical. Nevertheless, in the 1996 report, the introductory section on highlights points out that a number of studies had been completed by that time by for example the NEA and the IAEA, and references a paper by the head of the waste management organisation in a small nuclear country, Switzerland, which directly pointed out the potential advantages of the multinational repository for such a programme.

In the 2001 report (which was very upbeat about nuclear power being on the “threshold of a second frontier”) international repositories took a very prominent place. There were three papers presented; one on the general potential benefits, one on the specific non-proliferation advantages, and one from the USA setting out the boundary conditions that would be necessary. In the 2006 report, there was less positive news about some national programmes (e.g. Switzerland had abandoned the Wellenberg programme, the UK had given up its aspirations at the Sellafield site, Japan had started a brave new voluntary siting programme but with no visible results in its first years). In the multinational area, however, significant progress was reported. The IAEA had published its seminal report, TECDOC 1413, on multinational repositories; the EC was supporting the SAPIERR projects directly studying regional/multinational concepts within the EU framework and was preparing drafts of its Waste Directive which would eventually be produced with wording confirming the legality of shared repositories within the EU; the Arius Association had been established in 2002, was directly involved in managing the SAPIERR projects and was making preparations for the establishment of the ERDO working group which has now been in existence for some years.

At the end of our review in 2006 we observed that: *“We need bold initiatives for global solutions if we are to achieve the global improvements in safety, security and economics that multinational repositories can bring”*. As will be seen in the following review, it seems as though this point may now have been reached.

The bigger picture

The concept of developing a multinational GDF (hereafter, we use the acronym MGDF) has been discussed for more than 40 years and has generally been closely linked with wider consideration of multinational fuel cycle activities, often via initiatives taken by the IAEA. Most observers can readily see the advantages that a MGDF would afford, but everyone is cautious about the possibility of delivering such a solution, owing to the cross-national political challenges that clearly exist. Some commentators have seen the political challenges to be so strong, especially in presenting possible difficulties to national RWM programmes within their own country, that they have opposed any form of initiative. This active opposition has sometimes meant that making progress on MGDFs has been an uphill struggle.

Our understanding of the advantages and challenges has changed little since the idea was first mooted in the 1970s, although some of them have become more focused onto the specific needs of certain types of national RWM programme. We look again at the advantages and challenges below.

Advantages that could be provided by a MGDF

- **global nuclear security:** especially in collecting and disposing in a central safe and secure location sensitive nuclear materials from widespread RWM programmes with different paces of development; many with no realistic disposal solution in sight, or with only vague time schedules.
- **economy of scale:** a MGDF would, in principle, allow disposal of wastes at lower cost than in any single national GDF – this is particularly attractive for a group of countries working together towards a shared, regional solution, ‘at cost’.
- **commercial realism:** a commercially-based MGDF operating within a strong, national political and regulatory framework is likely to be driven more efficiently than any national programme (regardless of scale) and achieve more timely and cost-effective results for its users.
- **access for small users:** many countries with no nuclear power programme still have radioactive wastes that require geological disposal, yet it is unlikely that they would develop their own national GDF, owing to the costs and societal difficulties in siting one: access to a MGDF provides an ideal solution.
- **credibility of nuclear power:** the ability for any nuclear power nation to show that it has a closure solution for its RWM underpins all arguments for the continuation or growth of nuclear power.

Challenges that have been experienced to date include

- **concerns about disruption of national RWM programmes:** inability to counter perceived public concerns about possible “dumping of other nations’ nuclear waste in our country” has been a strong counter against progress: several national programmes have presented active opposition to multinational initiatives, in Europe in particular.
- **unwillingness to face the political challenge:** with a national programme in place, no matter how slow, there has been no political imperative for most countries to get together and address the possibility of a multinational approach: national politicians do not want to address arguments from the electorate that a MGDF ‘might be here’.
- **accusations of ‘wait and see’:** opponents of developing a MGDF have emphasised that it is improper for a national RWM programme to cite a MGDF as its eventual solution if no active project exists, as this is simply putting off finding a credible solution.
- **finding the right host:** although a number of possible projects have been advanced around the world over the last decades, it is essential that any country offering possible long-term storage or MDGF services has the strongest non-proliferation, nuclear security and environmental protection credentials: few nations would be universally accepted in this respect.

- **lack of resources:** because multinational solutions have tended to be regarded as something peripheral and because no country has regarded it as their own responsibility, or (until very recently) as an interesting challenge with potential, resources to progress MGDF initiatives have been meagre: the limited funding that has been available has been provided by the European Commission, some US Foundations and the small nations involved with the ERDO working group.

Reviewing these pros and cons, perhaps the three most significant strategic developments that have emerged from the discussions over the last decade have been the growing consensus that multinational repositories will be a valuable or even a necessary complement to national facilities, the adoption of the concept of a 'dual track approach' which keeps options open, and the recognition that all developed industrial countries that use nuclear technologies will need access to geological disposal.

The '**dual track**' concept emerged from European projects, discussed later in this review, during the last few years. The basis of the concept is that any nation pursuing a multinational solution must also have an operational GDF programme that could lead to a national solution. Two drivers were influential in establishing this approach, which is now cited specifically as the national RWM model by several countries. The first was to counter any accusation of 'wait and see'. It is certainly not credible for a national RWM programme to rely entirely on a solution that is not totally within its control and is not assured. The second driver was the requirement to satisfy international legal obligations. The earliest of these was for signatories to the IAEA Joint Convention, which requires regular and formal reporting, open to international scrutiny, which must present a credible national strategy and timeline for RWM. For the European Union countries, the need to have a clear and credible strategy was formalised in European Council Directive 2011/70/EURATOM, which sets out a legal timetable for EU Member States to establish a RWM programme. As referred to above, this Directive also, for the first time, very explicitly acknowledges the legality of transferring radioactive wastes between countries for the purposes of disposal. The current version of the Directive restricts this freedom to transfers to other Member States; for transfers outside the EU, the host country would have to have a deep geological repository actually in operation, and this will not be the case for a long time for any potential foreign host state.

The weight of discussions on multinational solutions has focussed on countries with growing stocks of spent fuel to manage, as these present the greatest security issues and would involve the largest and most costly GDF development projects. Relatively little attention in multinational discussions was given to **non-nuclear power countries** until recently. Most of the advanced industrial countries have long-lived or high activity wastes in storage from medical, research or industrial applications. Although much of this material is under agreement to be returned to the supplier (e.g. radiation sources and research reactor fuel), some countries possess materials that they currently have no final solution for, other than permanent storage. European examples include Denmark, Ireland and Norway. A parallel example is Italy, which exited early from nuclear power in 1984 but, from the relatively brief nuclear era, still has material in store which must be disposed of geologically. Access to a MGDF would provide the most obvious solution to these problems.

Strengthening the documentary basis

Routes to and constraints on MGDF development, along with the surrounding context of multinational co-operation on nuclear fuel cycle activities, have been under more-or-less continuous review over the last decade. The IAEA has been foremost in capturing these discussions and establishing a solid basis of documentation on possible ways forward.

In 2004, the IAEA summarised¹ early work on multinational concepts, going back to the 1970s. In 2005, at the request of the Director General, a high-level expert group produced a comprehensive report² on multilateral approaches to the nuclear fuel cycle, covering enrichment, reprocessing and disposal, with external support to the disposal study being

¹ IAEA (2004) Developing multinational radioactive waste repositories: Infrastructural framework and scenarios of cooperation, IAEA-TECDOC-1413, 2004

² IAEA (2005) Multilateral Approaches to the Nuclear Fuel Cycle: Expert Group Report to the Director General of the IAEA 2005

provided by Arius. Further IAEA reports followed, addressing the viability of multinational repositories³ (2011) and discussing a staged approach for partnering in the implementation of such facilities⁴ (2016). The latter report examines not only the benefits of multinational concepts but also all risks of a technical, financial, institutional or socio-political nature. The report took around three years to be cleared at higher levels in the IAEA, indicating that the topic of multinational disposal is, nevertheless, still sensitive at the Agency. Currently, the INPRO (International Project on Innovative Nuclear Reactors and Fuel Cycles) section at the IAEA is starting a project aimed at studying drivers and impediments to multinational back-end cooperation.

Progress in Europe

Over the last decade, Europe has taken the lead on MGDF concept development. The most comprehensive project to assess technical, economic, legal, security, political and societal aspects of developing a MGDF took place through the SAPIERR projects, which ran from 2005-9. The work was financed by the European Commission and carried out by a consortium of specialists from fourteen EU countries.

The results of the projects highlighted⁵ that, apart from the credibility imparted by having a concrete and common plan, the most obvious advantages are the economic benefits to partner countries and to the EU as a whole. Partner countries could each save billions of EUR by sharing development and disposal costs rather than each having to implement a national GDF, with over half the savings being in shared RD&D. Working together on a common concept, design and, eventually, site can have tremendous economic and political benefits. For the models analysed, the saving to the EU as a whole was estimated at 15 to 25 billion EUR. If a regional MGDF were able to offer disposal as a commercial service to other European countries once it becomes operational, the original partner countries may be able to manage their own current and future wastes with further significant cost reductions. There would also be specific economic benefits to the host country and community.

SAPIERR found that most of the challenges involved in developing a shared regional GDF are closely analogous to those of a national facility. In both national and multinational programmes, finding suitable sites remains the biggest challenge and SAPIERR was influential in formulating a possible staged siting strategy that was published in 2008⁶.

SAPIERR concluded by making proposals for a staged, adaptive implementation strategy leading to a shared European GDF. A smaller group of potential partners was formed: the European Repository Development Organisation Working Group (ERDO-WG). Governments from eight Member States have provided funding and delegated representatives since 2009. The activities of the group have involved consideration of organisational forms and financing models for a European Repository Organisation (ERO) that would initially function as a small sister to existing national organisations. Discussion documents⁷ cover siting strategies for a shared GDF, the size and form of an ERO, outreach activities, operating guidelines and a model constitution. An important part of ERDO-WG activities has been analysing the impact on small radioactive waste programmes of European Council Directive 2011/70/EURATOM, discussed above. A key aspect of this is the need to pursue the dual track approach, with partner countries in a sharing project also maintaining a strong national programme until significant progress has been made on the shared solution.

³ IAEA (2011) Viability of Sharing Facilities for the Disposal of Spent Fuel and Nuclear Waste, IAEA-TECDOC-1658, 2011

⁴ IAEA (2016) Framework and Challenges for Initiating Multinational Cooperation for the Development of Radioactive Waste Repositories, IAEA Nuclear Energy Series NW-T-1.5, 2016

⁵ Ewoud Verhoef, Charles McCombie and Neil Chapman, (2009), SAPIERR-II – Shared, Regional Repositories: Developing a practical implementation strategy; in: Euradwaste '08 Seventh European Commission Conference on the Management and Disposal of Radioactive Waste. European Commission Report EUR 24040, p 519-524.

⁶ Chapman N. and McCombie C. (2008), *Staged Siting Strategy* Nuclear Engineering International, May, 2008

⁷ The ERDO Model Structure and Plan and response to EC Directive 2011/70/EURATOM are available at: <http://www.erdo-wg.eu/Documents.html>

It is important to understand that the ERDO developments have taken place from the bottom upwards. Although the seed funding came from the EC (for SAPIERR), there has been no strategic push or leadership from the EU political institution and its agencies to encourage the idea of a shared European MGDF. In practice, financial support in the radioactive wastes management area has been provided by the EC almost exclusively for cooperative projects focused very directly on technical R&D. The Commission has less flexibility in funding initiatives of a more strategic nature will stop. The position of the EC and the European Parliament is that such developments must come from like-minded countries working together. It can be seen that the step between national organisations discussing the possibility of a shared facility and political endorsement within the EU (with all that this entails inside the European bureaucracy and EU national political interests) is inevitably the highest hurdle that ERDO must overcome.

2016: Australia takes the international lead

Whilst Europe moves slowly forward, by far the most important development to have occurred recently is the initiative by the Government of South Australia to consider the pros and cons of establishing nuclear fuel cycle facilities in the State. South Australia is among the world's major suppliers of uranium and the government wished to consider whether it should develop a whole range of other services, as well as its own nuclear power programme. The Royal Commission established by the Government reported in May 2016. One of its central findings⁸ was that establishment of commercially based storage and disposal facilities for international clients, for spent fuel, HLW and long-lived ILW, would be feasible and of great benefit to South Australia. The sheer economic scale of the storage and MGDF project that was modelled can be astonishing to those outside the nuclear industry: for a waste inventory representative of a significant number of the world's smaller nuclear power programmes the resource turnover was estimated to be some hundreds of billions of dollars.

The report has created considerable interest globally and active discussion within South Australia. The Government will respond to the findings by the end of 2016. The overall tenor of comment is generally positive and an opinion poll carried out while the Commission was at work reported an almost even split between those in favour and those against. This contrasts considerably with public opinion in most national programmes, even some of the more advanced ones, and is certainly very different to the reaction to the Pangea proposal in Australia some 15 years ago. The proposed commercial Pangea project (with similar working assumptions to the current South Australian study) originated within the nuclear industry outside Australia and was initially carried out in secrecy. When it was leaked, just prior to its intended public launch, the political and public reaction was predictable and was terminal for the project. This time, the difference is that the initiative comes from within government and the assessment has been carried out openly and transparently. In practice, the sound scientific and technical studies carried out in the Pangea project⁹ demonstrated the potential benefits of disposal in the stable geological environment to be found in large areas of Australia and these studies may well be of value in the current South Australian initiative.

The response of the Government to the Royal Commission report will be a critical barometer for multinational initiatives. If a state-sponsored multinational initiative in a country with the high global political status and credentials of Australia were to be available, it would change the worldwide paradigm of radioactive waste management forever and for all RWM programmes in almost every country.

Elsewhere in the world

International entities and think tanks continue to study the potential impacts of multinational storage or disposal, in particular of spent fuel. The Arius Association, with the support of the Sloan and Hewlett Foundations, has examined how the European ERDO model might be

⁸ Government of South Australia (2016), Nuclear Fuel Cycle Royal Commission Report, ISBN 978-0-9945776-4-1, <http://nuclearrc.sa.gov.au>

⁹ McCombie C., Pentz D., Kurzeme M. and Miller I. (2000), *Deep Geological Repositories: A Safe and Secure Solution to Disposal of Nuclear Wastes*, GeoEng2000, An International Conference on Geotechnical & Geological Engineering, 19 – 24 November 2000, Melbourne, Australia

extended to countries in the MENA regions (Middle East and North Africa) or in Asia. Workshops focussing on common or regional waste management issues have been run in Tunisia, with participation of MENA nations, and in the UAE, with participation of Gulf Co-ordination Council countries. Some meetings have been held in cooperation with both the IAEA and the Arab Atomic Energy Agency (AAEA).

The Nuclear Threat Initiative (NTI) runs the '*Developing Spent Fuel Strategies*' project, supported by the MacArthur and Hewlett Foundations, which also looks at how multinational facilities might impact on the nuclear fuel cycle. The American Academy of Arts and Sciences (AAAS) also examines this question in its '*Global Nuclear Futures*' project. A current International Framework for Nuclear Energy Cooperation (IFNEC) project organised by the Working Group on Reliable Nuclear Fuel Services is a multi-year study aimed at assessing what small nuclear programmes might do to progress most effectively and efficiently the back-end planning using a dual track approach.

We have focussed above mainly on the general contextual discussions that reverberate among international organisations, on Europe and on Australia. But other initiatives exist, connected with the possibility of leasing and taking back nuclear fuel. There have been several such concepts mooted by Russia over the years, the most recent being in early 2016. In this concept, fuel is leased from and then returned to Russia for reprocessing, fresh REMIX fuel is returned to the user (in an indefinite cycle) and the HLW from reprocessing at each iteration may be disposed of in Russia. It is this latter part that makes the potential offer novel. According to WNA reports¹⁰, the model might be extended to link with the findings of the South Australian Royal Commission: a user acquires uranium from Australia and sends its HLW for disposal in Australia, with an Australian entity owning the uranium throughout the whole REMIX cycle and also the eventual vitrified high-level wastes. In this model Russia (or France, the UK or Japan) handles reprocessing, enrichment of fresh uranium and fuel fabrication.

Arius: moving the concept forwards

A linking thread of almost all the initiatives described has been the Arius Association, which is actively involved as participant or adviser in all the projects described above. Arius (Association for Regional and International Underground Storage) is a non-profit body based in Switzerland, which was founded in 2002 with the mission of promoting concepts for multinational storage and disposal facilities. The Association is funded by a combination of Organisational and Individual Members and by project work. For example, Arius acts as the secretariat for the ERDO-WG and has managed the SAPIERR projects. The activities of Arius have led to the Association building a worldwide reputation as a source of information and ideas related to the important question of how cooperation at the back-end of the fuel cycle can enhance global and national nuclear safety and security. In addition to involvement in virtually all of the initiatives mentioned above, Arius is continually involved in responding to enquiries from the media on multinational issues and is also involved in various university studies on different aspects of the issue. One interesting example here is the involvement of Arius and the ERDO-WG in an ongoing study by the University of Delft into the ethical issues associated with transfer of radioactive wastes between nations¹¹.

Arius has been at the forefront of developments since 2002 and is gratified to observe that the initial, predominant resistance, even hostility, to the MGDF concept, has turned into widespread acknowledgement of its advantages and realisation that its development will benefit many industrialised countries.

The next ten years

Ten years ago, we were optimistic in our outlook for the future – justifiably, we believe, based on the current level of international interest and activity in multinational RWM possibilities. All RWM programmes take time and all GDF projects have experienced delays and restarts, if not outright cancellation and return to square one. The slow development of multinational

¹⁰ World Nuclear News 26th April 2016, <http://www.world-nuclear-news.org/V-Russian-proposal-for-nuclear-fuel-leasing-and-recycling-2604166.html>

¹¹ Behnam Taebi (2015) <http://ethicsandtechnology.eu/projects/multinational-nuclear-waste-repositories-ethics-and-acceptability/>

RWM projects has been no different. However, the situation in national programmes is improving. The world's first spent fuel GDF in Finland received its construction license in 2015 and should be operational in the next 5 years. In parallel, the challenges to MGDFs now look less problematic than they did ten years ago and the balance between challenges and advantages has swung heavily towards appreciation of what such facilities have to offer globally.

When we look forward to the next decade, we expect to see strengthening of the regional European MGDF activities of ERDO, as two or three national GDFs become operational and the smaller nuclear power nations begin to work more confidently together. It remains a point for speculation as to whether any of the national European GDF projects will begin to offer services to other European countries, especially those non-nuclear power countries with just a few cubic metres of waste to dispose of. In other regions of the world, such as the Gulf States, the MENA and ASEAN regions, we expect progress to be more hesitant, with a continuing eye to developments elsewhere and example set by other countries. We certainly expect the Australian initiative to be the main test of the political practicalities of establishing a MDGF. If the South Australian Government decides to move forwards and endorse the establishment of a commercial project that offers a broad range of RWM services internationally, then this could become the only MGDF that is needed globally for the foreseeable future.

In all respects, we believe that multinational RWM solutions are now firmly embedded within the international nuclear power development landscape and, with the considerable security and economic advantages they offer, will be seen as the norm for many countries in the future.

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