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## Editorial

The New Year brings us at Arius into our third year of activities and sees the launch of our first major project – the SAPIERR pilot study for European regional repositories. You will be hearing much more over the coming months as this two year project, which has established an extensive group of national participants, gets off the ground.

The last few months have seen a continued increase in exposure for the shared repository concept in international debates. It remains a contentious issue, attracting ever more supporters, but also meeting opposition. The Swedish and Finnish repository programmes, in particular, continue to feel threatened by the increased interest – as the European leaders they are worried that the penalty for their likely success in 'getting there first' may mean that they could somehow be compelled to take other European wastes. This concern seems exaggerated – as demonstrated by this month's strong resolution by Members of the European Parliament that no country should be obliged to import wastes against its will. If this resolve is supported by strong and open commitments from a national government and the national waste management organisation, it is inconceivable that any EU country could be legally compelled to accept wastes. It would be more constructive if countries that wish to follow purely national solutions emphasised their own position in this way, rather than opposing the concept of others acting collectively. The right of willing partners to seek common solutions for ensuring that environmentally correct and economically viable disposal is available for all should be undeniable – a point that also emerged from the European Parliament resolution – and in the first review of the IAEA Joint Convention.

All of this ongoing debate is reported further in several items in this issue. We also bring you the long-promised look into shared long-term storage of spent fuel in this issue's Topical Article – a shift of focus from shared disposal.

Neil Chapman  
Baden

## Arius Internal News

### Third Annual Assembly of Members

The Arius Assembly of Members (AoM) normally meets twice a year, at an extraordinary meeting in the autumn to plan for the coming year, and at a formal Annual AoM in the early part of the year to consider end-of-year reports from the previous financial and management year. The third Annual AoM will take place on 19<sup>th</sup> February 2004 to finalise the work of 2003. The venue chosen is Piestany in Slovakia, owing to the close interaction with the EC SAPIERR project that has its initial Workshop in Piestany, immediately following the Arius AoM.

The business aspects of the AoM concern approval of the activities report (whose contents are summarised in an accompanying Newsletter item), of the finances for 2003 and of the programme and budget for 2004. A key item will be discussion of possible amendments to the funding mechanism for Arius – in particular the structuring of membership fees.

Both organisational and individual Members of Arius are invited to attend the AoM.

### SAPIERR project on regional repositories begins

In previous Newsletters we have described the evolution of the SAPIERR project (*Support Action for a Pilot Initiative on Regional Repositories*) that was submitted to the European Commission as part of its 6<sup>th</sup> Framework Programme. The good news that arrived as a 2003 Christmas gift is that the project has now been finally approved and will be conducted with EC financing for the next two years. In practice, the funding comes from two sources. Decom Slovakia, the Project Coordinator, will receive support directly from the EC in Brussels. Arius, the Swiss partner in the joint project, will be funded directly by the Swiss government Department of Education and Science. An important part of the resources being provided by the EC will be used to support travel to SAPIERR meetings by representatives from European countries that cannot themselves provide financing.

The first SAPIERR Workshop is scheduled to take place in Piestany, Slovakia, on 19<sup>th</sup>/20<sup>th</sup> February 2004. Representatives from organisations in about a dozen European countries will attend the meeting. After reviewing the current status of concepts for shared storage and disposal, the Working Group will concentrate on specifying in more detail the work to be done in the first two work packages in SAPIERR. These work packages look at the inventories of European wastes that must eventually go to a deep geological repository and at the legal and political

constraints on development of regional European concepts.

The pilot phase of SAPIERR does not include any specific study of potential siting options in Europe. As is the normal case, also in purely national disposal programmes, the boundary conditions for developing a disposal strategy and programme must be settled before addressing the challenge of siting.

The SAPIERR team, consisting of staff from Decom and Arius, is looking forward to a landmark meeting involving experts from the current and the expanded European Union.

### **Promotion of international concepts throughout 2003**

An important part of the Arius mission is to promote the concept of shared storage and disposal facilities on the international stage. During 2003, this has been achieved by a series of presentations at meetings world-wide and by publications in technical and scientific journals.

Today Arius is well known in the nuclear waste management community and is regularly invited to make contributions of this kind. In the table below, we give a concise overview of activities that were

undertaken and papers that have been published.

Published papers will be made available on the Arius web site and all members can also request individual copies.

### **Contacts with international organisations maintained throughout 2003**

From its inception, Arius has ensured that international organisations in the nuclear area are informed of its activities and that a productive interaction takes place. 2003 was a particularly active year in this respect.

The draft IAEA report on *“Developing and Implementing Multinational Repositories”*, authored by a group of experts from Argentina, Austria, Belgium, Italy, Lithuania, Slovakia, Slovenia, South Africa, Sweden, Switzerland, USA and the European Commission, was edited at Arius before being distributed by the Agency for review by Member States.

The review process led to a one week Advisory Group Meeting in Vienna in September 2003 and a revised version was produced by the IAEA secretariat with assistance from Arius. The final report is due to be published in 2004.

Conference	Venue	Paper presented
WNA strategic working group (WG) on - Waste Management and Decommissioning	London, UK, January 15, 2003	Presentation on Arius to WG.
2003 International High-Level Radioactive Waste Management Conference (IHLRWM)	Las Vegas Nevada, March 30 - April 2, 2003	Regional & International Solutions for Long-Lived Radioactive Waste Disposal: the ARIUS Initiative
ICEM'03 The 9 <sup>th</sup> International Conference on Radioactive Waste Management and Environmental Remediation	Oxford, UK, 21 - 25 September, 2003	Progress with Multinational Storage and Disposal Concepts
<i>Problems of Managing Spent Nuclear Fuel and Selection of a Site for Its Storage:</i> International Seminar organized by Russian Academy of Sciences, U.S. National Academies, and the Russel Family Foundation	Moscow, Russia 14 - 15 May, 2003	Site Selection for Spent Fuel Storage and Disposal of High Level Waste: Experience of European Countries
10 <sup>th</sup> Anniversary of DECOM Slovakia, Conference	Piestany, Slovakia 26 - 28 August, 2003	Challenges for the Future: Sharing Geological Repositories
Nuclear Energy and Science for the 21 <sup>st</sup> Century: Atoms for Peace + 50	Saclay, France 22 October 2003	Regional and International Mechanisms for Management of Nuclear Materials
Board on Radioactive Waste Management (BRWM) of the US National Research Council: Open session	Washington D.C., USA December 2003	Progress with Multinational Disposal Concepts
Publication	Date	Article
WNA Newsletter	January 2003	The WNA requested permission to publish an abridged version of the article on ethics in Arius Newsletter No.3
Swiss television documentary	Jan 2003	Arius was invited to present the arguments for international repositories in a documentary on Swiss waste management
National Academy of Engineering The Bridge. Fall 2003	October 2003	International Perspectives on the Reprocessing, Storage, and Disposal of Spent Nuclear Fuel
Nuclear Engineering International/ November 2003	Nov 2003	Enhancing safety and security in a sharing society
The Nuclear Engineer, Volume 44, No. 6- Nov/Dec. 2003	Dec 2003	Increasing Interest in The Safety, Security and Economic Aspects of Multinational Repositories

Further interactions with IAEA staff have resulted from collaboration on the preparation of a Special Session on Multinational Concepts to be held at the major *WM'04 Waste Management Conference* in Tucson, Arizona, in March 2004. This session was proposed by the Agency representative in the Conference Advisory Committee and will be jointly chaired by an Arius representative.

Perhaps the most significant developments at the IAEA, however, have been the increased interest (particularly of small states) in the shared repository concept and the increased support in the Agency at the highest levels. These are documented elsewhere in this Newsletter.

During 2003 there have been continuing, intensive contacts with representatives of the EC in Brussels, primarily centred on development of the SAPIERR Project. Although it is a modestly sized project, the importance of SAPIERR in a political sense is very great. The EC has followed up on its support of the regional repository concept (as documented in its *Draft Directive on Waste Management* issued in 2002) with specific action. The most recent report from the EU on waste issues is described in a separate news item.

As described above, funds from Brussels will support the project work, complemented by funding from the Swiss government, which participates in this way in EC approved projects that involve Swiss organisations. Further contacts with EC staff have been maintained through the invited participation of Arius team members in the review process for the 6<sup>th</sup> Framework Programme research projects, as well as in the preparation of specific waste management publications.

Arius is also connected with various other international organisations. In 2003, Arius became a Member of the World Nuclear Association (WNA) and has participated actively in the *Waste Management Working Group*, as well as attending the major WNA Conference in Moscow.

A further new international organisation that Arius has joined is the *ITC School of Underground Waste Storage and Disposal*. This is an Association with a broad international membership dedicated to propagating knowledge to future generations of scientists, engineers and decision makers who will be involved in waste management. The first course was held in Switzerland in October 2003 and Arius team members were amongst the teaching staff.

Arius was also involved in a small way in 2003 in the numerous events organised to celebrate the 50<sup>th</sup> Anniversary of the landmark "*Atoms for Peace*" speech by President Eisenhower at the United Nations in 1953. The Anniversary led to various events at which the safety and security of all aspects of nuclear technology were reviewed. Arius was invited to some of the events in order to put the case for increasing global safety and security associated with waste nuclear materials by promoting international collaboration and shared facilities.

## International News

### ***Nuclear waste report adopted in European Parliament***

On 13th January 2004 the European Parliament adopted an important non-binding report on nuclear waste by Alejo Vidal-Quadras Roca of Spain. The title of the document is "*Report on the proposal for a Council Directive (Euratom) on the management of spent nuclear fuel and radioactive waste*".

In the non-binding draft resolution on the management of spent nuclear fuel and radioactive waste, MEPs emphasised that action must be taken soon to avoid passing on responsibility for managing the growing quantities of spent fuel held in temporary storage to future generations. The Parliament rules out certain methods of disposal of radioactive waste for environmental reasons, including dumping at sea, disposal in under-sea repositories and disposal in space.

The European Parliament supported the concept of deep geological disposal as an effective solution for high-level and long-lived radioactive wastes. Owing to the different situations in Member States, Parliament disagreed with the Commission's proposal for a single implementation timetable for all Member States. Instead, it suggested a two step approach towards the development of deep geological disposal sites, which, it felt, would be more effective and feasible

Member States should take all necessary measures to ensure that spent nuclear fuel and radioactive waste are managed without endangering human health or the environment, in particular without using processes or methods that could result in the radioactive contamination of water, soil or airspace.

The Parliament also approved the possibility of shipments of nuclear waste from one Member State to another or to a third country. However, it was emphasised that Member States must not transfer wastes to third countries whose facilities do not meet EU and international norms and standards. This is fully in accord with the principles of Arius:

- each country has a direct responsibility for safe management and disposal of its wastes;
- this may be achieved by purely national projects or by cooperation in implementing multinational facilities;
- these facilities must meet the same high safety and environmental standards, no matter where they are implemented.

### ***IAEA Director General voices support for multinational repositories***

The IAEA has always been supportive of its Member States collaborating to ensure that safe disposal solutions will be achieved in all of them. The Joint Convention on Spent Nuclear Fuel and Radioactive

Waste Management left open the option of multinational repositories, whilst acknowledging the right of any state to opt for purely national solutions. The recent increased awareness throughout the world of the security advantages of having hazardous nuclear materials carefully controlled has strengthened the arguments for effective collaboration. The report referred to above that was produced in 2003 by an Advisory Group of the IAEA on multinational repositories is direct evidence of the readiness of the Agency to support such initiatives.

In the last quarter of 2003, the position of the IAEA was made very clear in various statements made by its Director General Mohammed ElBaradei. In speeches to the General Conference of the IAEA in September and at the major Waste Management Conference in December in Stockholm, the potential advantages of small countries sharing disposal solutions were pointed out. Still wider attention to the issue was drawn by an invited article by DG ElBaradei published in the Economist (see Newsletter 5).

The portion of the article that is of most relevance for Arius Members is reproduced here:

*".... we should consider multinational approaches to the management and disposal of spent fuel and radioactive waste. More than 50 countries have spent fuel stored in temporary sites, awaiting reprocessing or disposal. Not all countries have the right geology to store waste underground and, for many countries with small nuclear programmes for electricity generation or for research, the costs of such a facility are prohibitive.*

*Considerable advantages—in cost, safety, security and non-proliferation—would be gained from international co-operation in these stages of the nuclear fuel cycle. These initiatives would not simply add more non-proliferation controls, to limit access to weapon-usable nuclear material; they would also provide access to the benefits of nuclear technology for more people in more countries."*

### **Central European countries explore cooperation on high level waste disposal**

Following informal discussions during the course of the IAEA Joint Convention Review Meeting in November 2003, representations from several Central European countries met in Ljubljana to discuss informally possible regional solutions for high-level waste disposal projects. The meeting included experts from waste agencies or government bodies in Austria, Bulgaria, Croatia, the Czech Republic, Hungary, Slovakia and Slovenia.

The participants reaffirmed the potential safety, security and economic advantages of shared solutions and discussed actions that could lead to official government commitments being made within the next few years. The obvious links to the work being undertaken in the SAPIERR project were recognized and the group agreed to meet again after reviewing the results of the 1<sup>st</sup> SAPIERR meeting in Piestany, Slovakia in February 2004.

### **Russian interest in international spent nuclear fuel centres**

In a speech to the U.N. General Assembly's disarmament committee in November, Russian Atomic Energy Minister Alexander Rumyantsev described the threat posed by growing stockpiles of spent nuclear fuel created by civilian nuclear power plants and research reactors around the world.

Rumyantsev reminded the audience that more than 200,000 metric tons of spent fuel have been created since the beginning of the civilian nuclear power industry and that 10,000 metric tons are created every year. To solve the problem of safe management, he proposed the creation of several major international spent nuclear fuel management centres, to be operated under IAEA oversight. Such facilities would ensure spent fuel safety and help strengthen the international nuclear non-proliferation regime.

Although he said that Russia would cooperate with such a project, Rumyantsev did not say whether he envisaged that one or more of the proposed spent fuel management centres would be built in Russia. The Russian Atomic Energy Ministry has long proposed that such centres be constructed in Russia, but a major hurdle to basing a spent fuel centre in Russia is U.S. policy concerning spent fuel of U.S. origin. Currently, the United States has the authority to consent to the final disposition of such fuel.

Rumyantsev's proposal appeared to complement remarks made earlier to the U.N. by IAEA Director General Mohamed ElBaradei, who suggested that the processing of weapon-grade materials and the production of new nuclear materials should be limited to facilities under multilateral control.

The current situation regarding import of spent nuclear fuel to Russia was clarified by the head of the Russian Federal Monitoring Authority for Nuclear and Radiation Safety (Gosatomnadzor) that will supervise and monitor the storage of any foreign nuclear materials in the country's territory. The head of this state agency, Andrey Malyshev, explained that *"under present Russian legislation, spent fuel from foreign nuclear power stations can be accepted for storage for up to 50 years, provided it is eventually returned to the supplier"*. He emphasised that such centres could have also important security benefits, but pointed out that at present Russia is importing fuel, for storage and reprocessing only, from nuclear power stations which were originally built by Soviet nuclear specialists.

### **Italian Environment League calls for European repository**

In the wake of the Italian government's announcement of, then rapid withdrawal from, Scanzano Ionico as the site for storage and disposal of the country's radioactive wastes, Roberto Della Seta, President of *Legambiente* called for exploration of a European solution. As the 'nuclear directive' was going through the European Parliament (see item on page 3) he suggested that Italy should urge the EU to consider community solutions for radioactive wastes.

## Joint Convention First Review Comments on International Options

The IAEA Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management held its first review meeting of the contracting parties in November 2003 in Vienna. Among many other issues discussed, the meeting commented upon international disposal options:

*"...there were large variations reported in the status of national plans for the ultimate management solution of spent fuel and radioactive wastes. Some Contracting Parties had disposal facilities for certain categories of waste, others have facilities under development or construction, others have consultation programmes underway after which decisions will be made, others have no existing plans for disposal, some Contracting Parties expressed interest in exploring possible regional solutions for the management of radioactive waste, and at least one country sends its wastes to another. It was agreed that the Convention and the Review Meeting had given Contracting Parties the opportunity to exchange views and examine areas of good practice in this important area."*

However, it was also noted that several Contracting Parties reported that their legislative and regulatory requirements prohibited the importation of radioactive wastes except for disused sealed sources or the recovery of usable materials.

There was also a discussion on disposal of spent fuel in countries with only research reactors or with small nuclear power programmes and the long-term management of radioactive waste in small countries without nuclear power programmes. The possibility of a solution based upon regional disposal facilities was discussed. The report notes that:

*"Contracting Parties indicated that regional solutions would depend upon a co-operative approach, but, it was important that the search for such a solution should not jeopardize the ongoing national programmes."*

## Developments elsewhere around the world

**Netherlands:** On 30<sup>th</sup> September, Arius was amongst the guest organisations invited to the Netherlands for the official opening by Queen Beatrix of the HABOG interim storage facility for high-level waste (HLW). The storage facility – located near the Borssele nuclear power plant – is operated by COVRA, the Dutch central organisation for the disposal of radioactive waste, and is designed to store HLW for 100 years. The facility will store vitrified waste from spent fuel from the Borssele and Dodewaard plants as well as spent fuel from Dutch research reactors. Although there have been comprehensive studies on geological disposal, particularly in salt domes, there are no concrete plans for a disposal facility for HLW in the Netherlands. The option is kept open, however, and the Netherlands is also interested in regional solutions for disposal, as witnessed by their participation in the SAPIERR project.

**Australia:** The siting of the national low-active waste repository continues to be a party political issue, with the Labour opposition party saying that it would rescind the decision to develop the repository in South Australia, as a due process of consultation was not carried out. Although the national government had said that this was the 'safest site' in Australia, it later acknowledged that safe sites could be found in other states.

**United Kingdom:** An advisory committee (CoRWM: Committee on Radioactive Waste Management) has been established to make a rigorous and public review of alternative options for management of Britain's radioactive wastes, including underground disposal and surface storage. CoRWM is to advise on when enough information had been gathered to decide the best option or combination of options. The target date for recommendations is the end of 2005. The committee will report directly to the UK Government and the devolved administrations for Scotland, Wales and Northern Ireland.

## Topical Article

### Long-term storage of spent fuel

by Anne Claudel

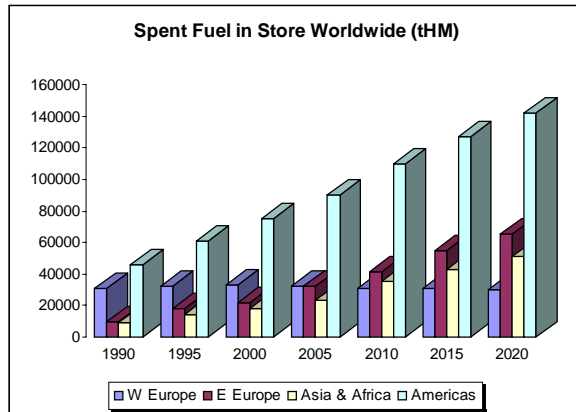
Final disposal of spent nuclear fuel will not take place anywhere in the world for some considerable time. Those countries trying to move as rapidly as possible towards implementing deep repositories have experienced delays. Some countries have deliberately chosen implementation dates that lie decades in the future. Moreover, the reprocessing option, which was originally thought to imply that spent fuel would be removed from reactor sites after a few years of cooling, has not been taken up, or has been dropped, by various national programmes. Accordingly, in recent years the importance of developing safe, flexible and cost-effective interim storage approaches has grown in many waste management programmes.

More than 50 countries have spent fuel stored in temporary sites (see figure on next page). However, many storage facilities are nearing capacity, and building new facilities inevitably encounters political difficulties. This has led to a reassessment of storage as a spent fuel management approach. This paper discusses the option of long-term storage vs. disposal, existing technical solutions, the issues to be addressed in the case of extended storage and the option of multinational or regional storage facilities.

### Storage and disposal options

Interim storage is by definition a temporary measure, designed to be safe and secure during a defined period when humans and their institutions are monitoring it. Based on a technically established technology, easier and quicker to realise than geologic repositories, it is widely practised today and will continue to be necessary for many decades into the future. An intermediate storage period is necessary to allow the wastes to cool before any

further steps can be taken. At the same time, it cannot be regarded as a permanent solution that assures both safety and security. Given the instability of human societies, it should be recognised that continued storage is not a substitute for deep geological disposal.



However, the question of public acceptance of repositories has now risen in importance, leading discussions on waste retrievability, disposal reversibility, monitoring, institutional control, phased approaches, etc. The general public seems indeed to have a higher degree of confidence in the physical control of storage facilities by today's society, than it does in long-term risk calculations for repositories, even when the outcome of the latter shows a negligible risk. In recent years, issues connected to the future of nuclear energy have also been brought up, such as the debate over whether spent fuel should be stored for possible reprocessing to recover fissile material or should be directly disposed of. Furthermore, because of difficulties encountered in proceeding with the development and construction of disposal facilities, stores originally intended as temporary facilities have had their lifetimes extended and communities hosting fuel stores are concerned that these do not become permanent.

In several countries, serious consideration has therefore been given to the use of storage as a long-term management option, with storage periods up to ~300 years. Indeed, there is a tendency towards the merging of concepts between underground "interim" storage facilities and geological repositories kept unsealed for extended periods of time. In some cases, the term "indefinite storage" has been used to refer to facilities which would be neither backfilled nor sealed and would therefore allow the retrieval of the waste at any time without excessive effort or expenditure and without a specific time limitation. However, the general view is that extended storage would be a means of gaining time for the resolution of technical and social issues, and that it should be followed either by spent fuel reprocessing or by transfer to a geological repository.

Other options being studied for finally disposing of radioactive materials (e.g. by transmutation) are not judged by experts as being able to remove the need for final disposal, even if they can alter the quantities and forms of the wastes.

In a study conducted in 2001, comparing indefinite surface or near-surface storage and disposal of long-lived radioactive waste on the basis of a multi-attribute analysis, the authors (Hill and Gunton) concluded that disposal almost always showed distinct advantages over storage, with the exception of the flexibility regarding the courses of action open to future generations. During the first 100 years, however, only small differences could be identified, with storage being the preferred option in terms of financial costs.

The long-term storage option has been considered as part of the range of management concepts in many countries such as Sweden, the USA, Netherlands, and Switzerland, but relatively few steps have been taken towards implementation. In France, the three lines of research established by the Nuclear Waste Management Law of 1991 include very long term storage as well as deep disposal and partitioning and transmutation. A report on the three options should be submitted to the government by 2006.

In a similar way, the new Canadian Nuclear Fuel Waste Act requires a study on the long-term management of nuclear waste – including approaches based both on storage (on-site or centralised, with a service life of ~200 years) and disposal – to be completed by the end of 2005. In the United Kingdom also, a public consultation exercise is considering all long-term management options, with no *a priori* preference being given to geological disposal.

In the Netherlands, where no formal decision has been yet taken regarding disposal, spent fuel from research reactors will be stored for at least 100 years. During this time it is intended to build up sufficient funds for a final disposal plan, thus bringing the present financial burden to an acceptable level. The storage and treatment facility HABOG was commissioned in late 2003.

### Concepts and existing technical solutions

There is a variety of technological options for storage of spent nuclear fuels. Early facilities consisted primarily of water pools, usually on reactor sites (wet storage). Increasingly, with those facilities nearing capacity, and due to the greater operating complexity, costs and security issues related to wet storage, dry storage systems are being employed. If large quantities of spent fuel are ready for storage, a dry vault system can be used. Increasingly, however, storage in strong, sealed and shielded containers (dry storage) is being used. The combination of simplicity, modularity, enhanced safety and security and low operational costs offered by dry cask storage systems make them attractive for many storage applications and especially for long storage periods.

If large quantities of spent fuel (above about 600t) are ready for extended storage at one time, then the most economical approach can be dry storage in a gas cooled vault. This system was already employed, for example, in 1970 at the Wylfa plant in the UK. Vault stores can handle large quantities of spent fuel, with

high thermal output, whilst maintaining relatively low fuel cladding temperatures (~200-250°C).

If smaller quantities of spent fuel are stored, or if the incremental rate of SNF arising is modest, then it can be preferable to store in concrete or metal casks, each of which can hold 5-17 tonnes of fuel. The casks can be purchased as required; they do not require a strengthened or strongly shielded building and can even be placed on pads on the open air. The temperature of the cladding of SNF in casks can rise to higher temperatures (~350 C). Concrete casks are often ventilated but metal casks are cooled primarily by radiation and natural convection and can be hotter to touch. The annual running costs of a dry store have been estimated to be less than half those of wet storage. However, the casks are expensive (USD 300,000 – 1 million).



**Centralised dry store for casks of HLW, the Zwiilag facility, Würenlingen, Switzerland**

Storage may take place at centralised or decentralised at reactors. Countries such as France, Sweden, Switzerland and the United Kingdom operate centralised facilities where spent fuel can be transferred after a short period of cooling (between 6 months and 5 years) in a water pool at the reactor site. In Japan, the current intention is also to develop a large centralised facility. The German government has taken the option of keeping spent fuel on site, based upon its assertion that this strategy is justified by the transport risks. However, two central dry storage facilities are available at Ahaus and Gorleben, which are operational. If the licensing proceeds on schedule, all interim storage facilities are expected to be commissioned by 2006.

In the United States, the growing lack of space for wet storage and the absence of a large centralised storage facility have led to the building of numerous dry storage facilities, scattered across 39 states at 70 nuclear plants – and also to private company proposals for this emerging market.

### **Challenges posed by very long term storage**

A major difference between storage and disposal lies in the weighting of the retrievability issue. In a final repository, the option to retrieve the waste is retained – but not easily implemented. Ease of inspection and of retrieval will be a primary function for a storage facility. It should therefore be possible at any time during the storage period, and not require any

excessive effort or expenditure, or involve risks for the operators or the general public. Furthermore, should reprocessing be the ultimate goal of storage, the fuel will have to be maintained in such a condition as to make reprocessing possible and economically viable, even after an extended storage period. This requires active monitoring while providing total containment, which constitutes a technical challenge in itself. The system should also be as simple as possible in order to reduce risks when safety must be assured over long periods of time.

The main technical factors that can affect safety and security are the high activity level of the waste and heat generation, combined with external disruptive events such as earthquakes, climate change, water, landslides, terrorist acts etc. However, in this respect, experience gained with the building and operation of other nuclear sites is available. As the facility would be neither backfilled nor permanently sealed the main containment role must be assumed by the storage canisters, in the absence of a significant geological barrier. Studies performed in recent years, e.g. by the U.S. Nuclear Regulatory Commission, have concluded that the release of a large quantity of radioactive material would require an extremely unlikely chain of events and that the risks of severe accidents are therefore very low. Although the need to handle the waste (e.g. for repackaging) in the course of time increases the probability of an accident, the characteristics of spent fuel itself and the redundancy and robustness of the design of the (dry-storage) fuel containers would make wide dispersal improbable.

Following the terrorist attacks of September 11, 2001, the likelihood and potential effects of sabotage directed at spent fuel storage facilities have been extensively studied. The analyses generally found that aeroplane crashes or the use of explosives would not result in a significant release of radiation – again relying mainly on the characteristics of the dry storage containers as a protective barrier.

Regarding proliferation resistance and physical protection, it can be argued that inspections can be performed more easily for spent fuel stored in surface interim facilities rather than disposed of in a geological repository. However, it is now widely recognised that long-term storage is not an ideal solution to assure security and that the material should be made as inaccessible as possible. At present, following technical controversy arising out of publications by Alvarez et al, on security of pool storage, the US National Research Council is organising a scientific review of the relative merits of wet and dry storage.

Another crucial issue is the need for continued monitoring over long periods of time, especially if storage outlasts either the operational lifetime of the existing facilities (in the case of storage at the reactor sites), or nuclear technology as an energy resource. Even assuming that the facility and the containers perform adequately, replacement and repackaging of the waste should take place periodically.

These technical constraints, as well as the necessity to ensure the 'continuity of knowledge' from the point of view of safeguards, require information to be

passed on to future generations. This leads to the question of whether the stability of future societies and the maintenance of expertise could be ensured to the extent necessary to continue the required monitoring and supervision. Creating or maintaining an institution closely related to the state government or to international organisations is therefore of utmost importance, to ensure both safety and public confidence.

### **Multinational or regional spent fuel storage**

It may not be necessary for all nuclear programmes, however small, to implement national storage facilities. Basically, a regional or multinational spent fuel storage facility would have the same advantages as a regional or multinational disposal site. It would:

- strengthen nuclear material protection and enhance transparency;
- combine efforts to avoid redundancy and reduce costs;
- concentrate public and political interest and decisions on fewer sites, thus providing an option for countries encountering difficulties in building their own storage facility;
- avoid accumulation of plutonium in multiple locations.

The economic arguments for multinational storage are less strong than for disposal, since economies of scale play a lesser role. On the other hand, security arguments are stronger, because spent fuel distributed in many surface stores around the world presents a more immediate threat. Candidate host countries for regional spent fuel storage options would be countries whose radioactive waste volumes do not easily justify a national repository and/or countries which do not have the resources for waste storage to dedicate to a national storage facility project.

Certain issues must be addressed despite these potential benefits. The idea that one country should accept other countries' spent fuel is considered by some to contradict ethical and fairness principles – even if it is agreed that the fuel would eventually be returned to its country of origin. Others maintain that such exchanges between willing partner nations would simply be an extension of the already highly international nuclear fuel cycle service offered throughout the world. Also important for site selection is the suitability of the host country.

Transportation risks must also be addressed. These risks are not necessarily technical but rather emerge from increased transport distances coupled with a wider range of stakeholders, posing greater political obstacles. In this respect, regional solutions would require significant political effort and financial investment, including the setting up of a nuclear infrastructure addressing safety, security, and proliferation concerns, before the beginning of operations. Other critical points include the questions of liability and responsibility. If very long-term storage is considered, information transfer to future generations must also be of concern.

### **Past and current initiatives**

A variety of institutional arrangements to promote shared storage facilities have been discussed since the mid-70s and a number of these are presented briefly below. Some of these initiatives have originated from the IAEA, such as the project on Regional Nuclear Fuel Cycle Centres (RFCC) in 1975-1977, which investigated the economic, safety, safeguards and security aspects of nuclear fuel cycle facilities that would handle spent fuel storage, fuel reprocessing, plutonium fuel fabrication and waste disposal. The conclusions of the study group, although very positive, were not followed by any concrete steps.

Two years later, the International Spent Fuel Management Group was convened following the International Fuel Cycle Evaluation (INFCE) study, to discuss the need to develop international arrangements for spent fuel storage. The final report, published in 1982, concluded that economic advantages might be expected for national programmes generating less than 5000 tonnes of fuel, but that no demand existed in the short term. Around the same time, an IAEA expert group on International Plutonium Storage (IPS) studied various possibilities for storing, under international control, separated plutonium in excess of current requirements for safeguarded use in reactors, fuel production and research. Other IAEA consultant groups have continued investigating international approaches to storage and disposal to the present.

Other proposals include the concept of an Internationally Monitored Retrievable Storage System (IMRSS), where a new international entity would become operationally responsible for the spent fuel after an initial cooling period, and provide the transportation required to a small number of surface (or near surface) storage facilities. The IAEA would be responsible for verifying adherence to safeguarding criteria. The economic and political arrangements would be similar to those of an international bank with operating branches worldwide. Each nation would maintain title to its spent fuel, and be able to withdraw it for peaceful purposes (e.g. recycle or burial). All operations would be on a self-sustaining commercial basis, funded by a megawatt-hour charge on nuclear power.

In a similar way, the International Interim Storage Scheme (IISS) of High Level Radioactive Waste and Spent Fuel was proposed by the Pacific Nuclear Council (PNC) in 1997. The IISS would handle the spent fuel generated from commercial reactors and the high level waste from reprocessing, complementing a national system. During the contractual period, the custodian country would be responsible for safe and secure storage. Participating members would respect the sovereignty of the custodian country providing IISS service, but retain the legal ownership of its HLW and SF. The IISS service provider would receive adequate financial compensation from the contractual parties.

Along with these discussions, the US based Non-Proliferation Trust (NPT) and the Minatom

Development Trust have proposed implementing international storage and disposal facilities in Russia, thus generating revenues needed to clean up contaminated areas. In July 2001, new laws were passed, allowing Russia to store spent fuel on a temporary basis, provided that storage and reprocessing are considered to result in a decrease of radiological risk. Significant issues still remain to be solved (such as the control of funding, or the option of reprocessing – favoured by Minatom, but opposed by NPT) and Minatom might eventually choose to pursue their own proposals rather than the NPT initiative.

Reactions both in Russia and in potentially interested countries have been primarily negative so far, but support in US official circles would seem to be increasing. Indeed, US agreement to spent fuel shipments would be crucial to the success of any of the proposals involving sites in Russia or elsewhere, since most of the spent fuel around the world requires US consent before it can be transferred. A good overview of past and present proposals on multinational storage is provided in the 2001 report from the Harvard Project on 'Managing the Atom'.

### Outlook

The discussions above show that proposals for multinational or regional sites for spent fuel management in general, including storage, are supported by a number of international bodies. Establishing international or regional storage facilities could provide a solution for countries with small nuclear programmes, and make it possible to remove spent fuel from countries where proliferation might be of concern.

The concepts of international storage and disposal are, of course, intimately related. Storage could be a first step towards disposal in an international context, just as it is at the national level. Because of the interactions between the two waste management steps, promoting international storage and disposal are both within the Arius remit, although attention to date has focused on the latter.

Making state-of-the-art storage and disposal facilities available to all countries in which hazardous nuclear materials are present will increase global safety and security. The greatest long-term challenge is ensuring that all countries, however small, have access to safe geological repositories. The most urgent task, however, may well be to ensure that all fissile material, including spent nuclear fuel, is in secure storage facilities.

Besides the obvious siting issue, it would be necessary to address operational aspects, e.g. whether these facilities would be dedicated to storage only (with a discussion of timescale and the establishment of reliable re-transfer arrangements), or whether a disposal site would be available in the same location. Furthermore, the regulatory and institutional questions raised by these initiatives should confront certain basic criteria, such as confidence (between partners), efficacy (technical and economical), long-term stability, environmental compatibility, and acceptability. It is unclear whether

the obstacles faced by these proposals, mostly related to national policies and regulations, as well as to public acceptance, can be overcome in the near term, when storage capacity is effectively needed.

### Selected Bibliography

*Expert Group on International Plutonium Storage (1982): Report to the director general. IAEA-IPS/EG/140. International Atomic Energy Agency, Wien.*

*International Atomic Energy Agency (1999): Storage of spent fuel from power reactors : Proceedings of a symposium held in Vienna, 9-13 November 1998. IAEA-TECDOC-1089. IAEA, Vienna.*

*Starr C.; Häfele W. (2000): Internationally Monitored Retrievable Storage Systems.- Nuclear Cooperation Meeting on Spent Fuel and High-Level Waste Storage and Disposal, Las Vegas, Nevada, March 7-9, 2000. Organised by Lawrence Livermore National Laboratory, 1-7.*

*Bunn M.; Holdren J.P.; Macfarlane A.; Pickett S.E.; Suzuki A.; Suzuki T.; Weeks J. (2001): Interim storage of spent fuel: A joint report from the Harvard University Project on Managing the atom and the University of Tokyo Project on Sociotechnics of nuclear energy. Harvard University; University of Tokyo.*

*Hill M.; Gunton M. (2001): A multi-attribute comparison of indefinite storage and geological disposal of long-lived radioactive wastes. PTR 01-02. Pangea Resources International, Baden.*

*United Kingdom Nirex Limited (2002): Description of long-term management options for radioactive waste investigated internationally. Nirex Report N/050. Nirex, Harwell.*

*General Accounting Office (2003): Spent nuclear fuel: Options exist to further enhance security. GAO-03-426. United States General Accounting Office (GAO), Washington (Report to the Chairman, Subcommittee on Energy and Air Quality, Committee on Energy and Commerce, U.S. House of Representatives).*

*International Atomic Energy Agency (2003): The long term storage of radioactive waste: safety and sustainability: A position paper of international experts. IAEA-LTS/RW. IAEA, Vienna.*

*Alvarez R., Beyea J., Janberg K., Kang J., Lyman E., MacFarlane A., Thompson G., and von Hippel F. (2003), Reducing the hazards from stored spent power-reactor fuel in the United States, Science & Global Security 11 pp. 1–51*

*US Nuclear Regulatory Commission (USNRC) (2003) Review of Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States, Science and Global Security, 11:203–211, 2003*

### Recent Publications on waste management

In this issue we draw attention to a new book published by 2 members of the Arius team, to a widely accessible article in a January issue of the journal *Science* and to new Internet sources, since extensive information on radioactive waste management has been added to the Internet recently.

Looking first at the internet sites, the first set of reports submitted by countries to the IAEA to fulfil their obligations under the Joint Convention on Spent Nuclear Fuel and Radioactive Wastes are of great topical interest. These reports can be accessed at:

<http://www-rasanet.iaea.org/conventions/waste-jointconvention.htm#reports>

The first Review Meeting of the Joint Convention was held in November in Vienna. The summary report on this meeting can also be accessed through the same web site. It records the interest expressed by some Member States in regional repositories.

A further valuable source of information on all aspects of spent fuel waste management is the web site of the new Canadian Waste Agency NWMO. Canada is reviewing all options for long-term management and NWMO has commissioned an extensive list of background papers on all relevant issues. The areas covered include ethical and sociological topics as well as scientific and technical matters. The web site is at:

[www.nwmo.ca](http://www.nwmo.ca)

### ***Principles and Standards for the Disposal of Long-lived Radioactive Wastes***

***N. Chapman, C. McCombie***

This new handbook (No. 3 in the Elsevier Waste Management Series) is concerned with developing principles and standards for the safe disposal of solid radioactive wastes by burial deep in the Earth's crust. Radioactive wastes have focussed thinking on long-term environmental protection issues in an unprecedented way. Consequently, the way in which principles and standards are set, and the thinking behind this, is of wider interest than to the nuclear field alone.

The issues are not just technical and scientific. There is also a much wider philosophical context to the debate, centering on ethics, human values and the expectations of society. In this handbook it is intended that all these issues are brought together, suggesting appropriate ways forward in each area, culminating in a proposed structure for safety regulations. It also aims to provide a detailed discussion of some of the most difficult logical and ethical issues facing those wishing to dispose of long-lived radioactive wastes.

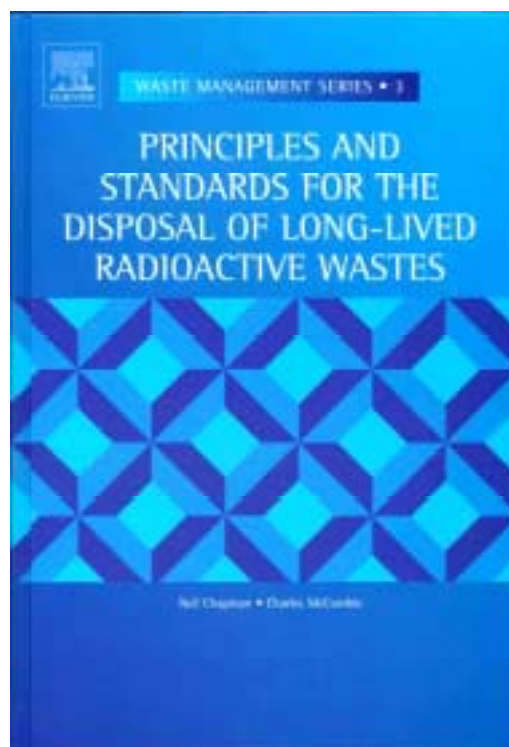
The book includes chapters on:

- Safety and security issues in deep geological disposal.
- Ethics
- Reversibility and retrievability
- Timescales in repository evolution
- Performance measures and appropriate standards

- Siting requirements within standards
- Natural disruptive events and processes
- Intrusion by future generations
- Monitoring and controlling a repository before and after closure
- Preserving records of the existence of a repository Accounting for uncertainty
- Chemotoxicity and radiotoxicity: A common framework?
- Setting new standards.

The book is hardbound and 250 pages long (ISBN: 0-08-044192-0). It is published by Elsevier and can be ordered online at:

[www.elsevier.com/locate/isbn/0080441920](http://www.elsevier.com/locate/isbn/0080441920)



### ***Deep Repositories: Out of Sight, Out of Terrorist's Reach***

***Science, v. 303, pps 161- 164, January 9<sup>th</sup> 2004***

This long article in *Science*, one of the two leading international general scientific journals, reports the current state of play on geological repositories as commented upon by attendees at the IAEA conference in Stockholm in December 2003. It focuses on the current drive to accelerate some national programmes resulting from concerns about terrorist attacks on surface-based spent fuel stores (in particular).

It also covers the topic of shared solutions, with commentators from Scandinavia again expressing worries that their advanced programmes, likely to be

Europe's first repositories, will be compelled to accept other countries' waste. (As an editorial note, we point readers to the recent European Parliament resolutions – see page 3 – which expressly state that no country should be compelled to take another's waste).

The article notes that Russia *"is only too keen to open its planned repository to the world"*, although the lack of adequate legislation and regulation is highlighted as a significant hurdle that Russia would have to overcome if it were to develop this concept.

## Upcoming Conferences

This section of the newsletter highlights conferences in early 2004 that are specifically relevant to Arius activities and objectives. Those at which Arius is attending or presenting papers are indicated.

### February

29<sup>th</sup> February - 4<sup>th</sup> March WM'04 - 30<sup>th</sup> Annual Waste Management Symposium, Tucson, AZ (US)  
**(Arius paper)**

### March

29<sup>th</sup> March – 1<sup>st</sup> April: World Nuclear Association Spring Meeting and 'World Nuclear Fuel Cycle 2004', Madrid, Spain