Regional Cooperation on Spent Fuel management
Status and Prospects in Europe, Arab Regions and Asia

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Abstract.

Safe and secure management of spent fuel is a major responsibility for all countries operating nuclear plants and a major challenge for potential new entrants to nuclear power. The greatest challenge is implementing a long-term strategy leading to final disposal of the spent fuel or the high level wastes derived from reprocessing. Implementation of deep geological repositories is technically challenging, lengthy, costly and sensitive. Countries with few or no nuclear power plants may have difficulties in making available sufficient financial and human resources to meet this challenge and the potential economic, safety and security benefits of shared repositories are widely recognized. The last few years have seen growth in initiatives aimed at exploring the opportunities for shared storage or disposal facilities for countries in the same geographical region. Regional concepts have moved ahead through efforts supported by the IAEA, the European Commission and the Arab Atomic Energy Agency, and through study projects run by the NTI, CSIS and IFNEC. A significant part of the work promoting regional concepts has been performed by the Arius Association, which provides the secretariat for the self-funded Working Group on a European Repository Development Organisation (ERDO-WG) and also runs projects exploring regional concepts in the Arabian Gulf region, North Africa and South East Asia, with financial support for the non-European work provided by the Sloan and Hewlett Foundations. The most advanced initiative currently is in Europe, where the ERDO-WG has since 2009 been coordinating the efforts of ten countries. This paper summarizes advances during the last years in each of these global regions.

1. Introduction

Safe and secure management of spent fuel is a major responsibility for all countries operating nuclear plants and a major challenge for potential new entrants to nuclear power. The greatest challenge is implementing a long-term strategy leading to final disposal of the spent fuel or the high level wastes derived from processing the fuel. An unavoidable element of such a strategy is ensuring that a deep geological repository will be available. However, implementation of deep geological repositories is a technically challenging, lengthy, costly and sensitive challenge for any nation with an inventory of long-lived radioactive wastes. Countries with few or no nuclear power plants may have difficulties in making available sufficient financial and human resources to meet this challenge. For this reason, the potential economic, safety and security benefits of shared repositories are widely recognized. Cooperation between countries has long been a feature of radioactive waste management. National programs participate in discussion forums and joint projects, many run under the auspices of international organizations such as the International Atomic Energy Agency (IAEA), the European Commission (EC) or the Nuclear Energy Agency (NEA). The national political and public sensitivities related to accepting radioactive waste from a foreign country have, however, caused initiatives for multinational repositories to progress only very slowly. Nevertheless, the last few years have seen continuous growth in interest in specific initiatives aimed at exploring the opportunities for making shared storage or disposal facilities available to countries in the same geographical region. Regional

concepts of this type have been moved ahead through efforts supported by international organisations, such as the IAEA, the European Commission (EC), the Arab Atomic Energy Agency (AAEA), and through specific study projects run by entities such as the NTI, the CSIS and the IFNEC Project. A significant part of the work promoting regional concepts has been performed by the Arius Association which provides the secretariat for the self-funded Working Group on a European Repository Development Organisation (ERDO-WG) and also runs projects that are exploring regional concepts in the Arabian Gulf region, North Africa and South East Asia, with financial support for the non-European work provided by the Sloan and Hewlett Foundations in the United States.

1.1. Are shared repositories ethical and credible?

Before moving to the documentation of specific initiatives aimed at promoting multinational concepts, it is instructive to re-visit two objections that have often been raised concerning regional shared repositories. It has been asserted that they are not ethical, since each country should look after its own waste, and that they are not credible, since there are, as yet, no volunteer host countries.

Ethical aspects:

Implementing disposal implies that the present and immediately following generations accept operational risks and invest resources in order to protect far-future individuals. The issue is then whether we are being fair to present and future generations – i.e. a question of *intergenerational equity*. Does waste disposal really present unique ethical issues? There are, in fact, other activities today for which the same dilemma arises. Global warming due to CO_2 is the most topical subject, but there are numerous older examples for which the issue of fairness to future generations has not been recognised explicitly enough. A clear case is the exploitation of natural resources in Earth's crust. However, it must be acknowledged that the prevailing atmosphere of nuclear fear in many countries results in a debate on the long-term aspects of radioactive waste disposal that is much more intensive than for other cases. When we move to the issue of transfer of wastes to another country, the ethical debate has often become even more intense.

The principal argument put forward against multinational repositories is that they are "unethical", since each country using nuclear technologies should dispose of wastes on its own territory. This is certainly not the view of the numerous countries considering the regional option, nor of international organisations like the IAEA and the EC, both of which are on record as recognising that such transfers are not only ethical, but can also be environmentally beneficial. What is perhaps unethical is for major nuclear nations to transfer nuclear technologies to smaller nations, without consideration of the long-term challenges resulting from managing the radioactive wastes produced. The large nuclear nations have been happy to export nuclear fuel cycle products and services (including reactors, fuel fabrication, reprocessing etc.) to any country that would purchase these. It is self-serving and inconsistent to single out disposal as the one part of the nuclear fuel cycle that may not be internationalised. Arguments for national nuclear self-sufficiency ring rather hollow in countries that depend upon imported uranium and thus avoid all problems associated with mining – the fuel cycle step that has the most environmental impact.

Credibility of regional concepts

A further objection often raised by those skeptical of regional repositories are that they are not credible because no volunteer host country or site has been identified at present. This is perhaps even more eccentric. If it is to be a criterion for credibility, then virtually all national spent fuel and HLW waste geological disposal programmes are not credible, since only Finland, Sweden and France have identified deep disposal sites. In reality, no site or country is currently nominated for a multinational repository for exactly the same reason that national programmes do not nominate a site at the very beginning of their efforts. Both national and multinational programmes must fulfil some important prerequisites before taking the important step of selecting preferred sites:

- Getting all participants on board concerning the desirability of finding a common site (or sites) – that is, recognition of a common need.

- Identifying and transparently documenting all of the technical and non-technical criteria that a site would need to satisfy.
- Establishing, documenting and discussing with the involved public the advantages (and drawbacks) that a site would experience.
- Building trust in the organisations that are charged with identifying and developing the site.

Only then should one move to discussion of specific siting options. This is the gradual process envisioned by the Arius Association and in the ERDO-Working Group, whose activities are described below. Neglecting to satisfy adequately all of these prerequisites before moving to repository siting has led to setbacks or failures in various national disposal programmes around the world.

2. A brief history of multinational initiatives at the back-end of the fuel cycle

A comprehensive history of early proposals for multinational storage and disposal is given in IAEAdocuments from 2004 and 2010 [1,2]. These reports contain details of the list of older initiatives given below.

- Regional Nuclear Fuel Cycle Centres (RFCC) (1975-77)
- International Spent Fuel Management Group (1975/1982)
- International Plutonium Storage (IPS) 1980
- OECD/NEA Study (1987)
- Synroc Study Group in Australia (mid-1980s)
- IAEA Expert Groups (1994/95, 2001/02)
- International Working Group (late 1990s)
- Marshall Islands (1995-97)
- Wake Island/Palmyra Island (mid 1990s)
- Pangea (1997-2002)
- Non Proliferation Trust (NPT) (1998-2000)

Around the turn of the century, interest arose again in multinational or multilateral approaches in the fuel cycle. This was partly due to increasing concerns about ensuring safety and security in a world where nuclear power seemed to be set to expand. Various specific project proposals were made, as listed below, and specific support actions were initiated by international organisations, as is detailed in section 3.

- Russian proposals (2001- present)

Minatom was involved in several of the proposals mentioned above and over the past few years Russia has become increasingly serious about spent fuel import. It is the only country that has publicly supported this at government level. There is some ambiguity regarding the options for returning the wastes resulting from reprocessing in Russia to the client country, but definite agreements have been made in some cases for take-back of Russian fuel with no return of wastes (e.g. with Iran).

- Kazakhstan proposals (2001, 2002)

The Government of Kazakhstan declared its intention to host an international repository in the Mangistan region. Once again, however, political opposition to the proposal led to the concept being dropped.

- 12 NFC Proposals at the IAEA

Around the time of the IAEA General Conferences in 2005 and 2006, twelve proposals related to multinational fuel cycle concepts were put forward [3]. These all focussed on nuclear security and non-proliferation and they mostly focussed suggestions related to the front end of the fuel cycle.

The exceptions were the Global Nuclear Power Infrastructure (GNPI) concept from Russia and the Global Nuclear Energy Partnership (GNEP) from the USA. Both these proposals included options for fuel supplier countries to take back the spent fuel or, at least, to organise a take-away option to a multinational facility in a third country. However, GNEP effectively dropped this option and transformed itself into the International Framework for Nuclear Cooperation (IFNEC), which continues to organise discussion groups, including one devoted to consolidated spent fuel management. The Russian initiative continues to be active and the possibility of being offered a spent fuel take back arrangement may be functioning as a powerful argument for new entrant nuclear countries to opt for Russian technology.

- SAPIERR projects (2003-2009) [4]

The SAPIERR I Pilot Project for European Regional Repositories, initiated by Arius, studied potential options for regional collaboration and for regional repositories to be identified, though it did not extend to site identification. Following this pilot study, the SAPIERR II project assessed the feasibility of European regional waste repositories. The tasks were:

- Preparation of a management study on the legal and business options for establishing a multinational repository organisation.
- Study on the legal liability issues of international waste transfer within Europe.
- Study of the potential economic implications of European regional storage facilities and repositories.
- Outline examination of the safety and security impacts of implementing one or two regional stores or repositories relative to a large number of national facilities.
- A review of public and political attitudes in Europe towards the concept of shared regional repositories.
- Development of a Strategy and a Project Plan for the work of the multinational organisation.

Organisations from around half of the 28 EU Member States participated in some part of the SAPIERR work and, at its conclusion, several of these countries joined the European Repository Development Organisation Working Group (ERDO-WG), which is described below.

3. Currently active cooperation initiatives

3.1. IAEA support for multilateral initiatives

The IAEA was an early champion of multinational cooperation in nuclear fuel cycle issues, as indicated above. With the rise in interest around the turn of the century, direct support was expressed at the highest levels in the Agency. The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, finalised in 1997, recognised that each country has a direct responsibility for managing its own radioactive wastes, but acknowledged *"…that, in certain circumstances, safe and efficient management of spent fuel and radioactive waste might be fostered through agreements among Contracting Parties to use facilities in one of them for the benefit of the other Parties, particularly where waste originates from joint projects".* The IAEA has also published a series of technical documents addressing the key issues related to implementation of shared storage or disposal facilities. These include [1,2,5,6,7].

The most recent of these reports describes phased development of a multinational repository and also directly discusses the risks attached to such projects. The 2004 document introduced an important classification of multinational approaches, by identifying three potential options. The first is a *cooperation scenario* in which a shared repository is developed by a group of partner countries. If the countries are adjacent or close, the repository is labelled as regional; otherwise, it is a multinational

repository. The second option is an *add-on scenario*, which assumes that a host country that has already implemented a national repository offers, at some later stage, to complement its national inventory of wastes for disposal by wastes imported from other countries. The third variant is an *international or supranational scenario* in which a repository (or network of repositories) would be fully in the hands of an international body and each host country would cede control of the necessary site to the specified international body. This last option was judged the least feasible, but increasing concerns over proliferation and nuclear security today might imply that such an approach could become credible.

The IAEA document with the greatest weight was, however, the report on Multilateral Approaches to the Nuclear Fuel Cycle, produced in 2005 by a high level Expert Group at the request of the Director General [8]. This report looked at multilateral approaches that could be employed in enrichment, reprocessing and final disposal. Of most relevance here are the conclusions that the Expert Group drew concerning spent fuel disposal. These are reproduced here, since they reflect directly the situation that still prevails today.

"At present there is no international market for spent fuel disposal services, as all undertakings are strictly national. The final disposal of spent fuel is thus a candidate for multilateral approaches. It offers major economic benefits and substantial non-proliferation benefits, although it presents legal, political and public acceptance challenges in many countries. The Agency should continue its efforts in that direction by working on all the underlying factors, and by assuming political leadership to encourage such undertakings.

……. Small countries should keep options open (national, regional or international), be it only to maintain a minimum national technical competence necessary to act in an international context.

The Agency has indeed continued its efforts. This is illustrated by the reports subsequently produced, by the efforts of the IAEA Technical Cooperation Department to support regional activities and by the on-going work on the INPRO project, which only some weeks ago ran a Dialogue Forum in Vienna on the topic *Cooperative Approaches to the Bank End of Nuclear Fuel Cycle: Drivers and Legal, Institutional and Financial Impediments.*

3.2. EC back-end cooperation projects

For some smaller EU Member States, implementation of a national geological repository on anything other than very long timescales is not practicable, because inventories are too small and costs too high. For such States, timely access to safe and secure disposal facilities will remain problematic or even infeasible unless regional, shared repositories can be implemented.

A significant strategic development took place in 2010 when the EC adopted the Directive on the Management of Spent Fuel and Radioactive Waste [9]. In the context of the present paper, the main message is that the option of EU Member States sharing repositories is kept open by Clause 3 in Article 4 on General Principles, which states that *"Radioactive waste shall be disposed of in the Member State in which it was generated, unless at the time of shipment an agreement ... has entered into force between the Member State concerned and another Member State or a third country to use a disposal facility in one of them."* The Directive implies that regional cooperation could be an important aspect of the detailed plans that the EC expects Member States to produce within 4 years. Nevertheless, the binding text of the Directive reflects the earlier views in the IAEA Join Convention and emphasises that countries should not use the prospects of regional disposal as a justification for remaining inactive.

The Radioactive Waste management sub-group of the European Nuclear Energy Forum (ENEF) has subsequently produced guidance for EU Member States [10] on how to meet those requirements of the Waste Directive that are focussed on R&D. In practice, the EC has provided support for numerous multilateral R&D projects that can contribute to enhancing cooperation at the back-end of the fuel cycle. An important step was the introduction of a Technology Platform on Implementing Geological

Disposal [11], aimed primarily at helping the advanced EU national programmes to move towards construction and operation of such facilities. It is noticeable that all current EC activities tend to focus specifically on R&D. However, for many Member States with less advanced programmes, long-term R&D on radioactive waste management disposal solutions is a less immediate need than the necessity for real-time strategic advice and help. The extensive EC support to countries with advanced geological disposal research should be paralleled by support to the many other Member States who are seeking practical solutions today for immediate issues affecting European nuclear safety and security, associated with existing spent fuel and radioactive wastes.

3.3. The Arius Association

Arius [12] was established in 2002 as the first formal body dedicated to supporting concepts for shared disposal facilities. A key objective is to explore ways of making provision for shared storage and disposal facilities for smaller users, who may not wish to - or may not have the resources to - develop facilities of their own. A decision was taken early to focus on the European region, since cooperation frameworks already existed. Arius was then instrumental in managing the SAPIERR projects described above. These projects led directly to the establishment of the ERDO-WG, whose activities are described below, and Arius currently provides the secretariat for the ERDO-WG. But efforts have not been restricted to Europe.

Every one of the comprehensive list of IAEA documents referred to above has had major input from Arius. In fact, Arius was the key advisor to the Expert Group set up by the Director General when it debated options for cooperation at the back-end. Arius has also been requested to provide input on multinational approaches to a number of projects or studies that have examined the future of nuclear power, or developments in nuclear fuel cycles. These include initiatives by the following organisations:

- **AAAS:** The American Academy of Arts and sciences (AAAS) supports, as part of its Global Nuclear Futures initiative a project which focuses on the merits of regional storage centers for spent fuel, in particular in South East Asia [13].
- **NTI/CSIS**: Arius has participated in workshops in Paris and in Taipei on "New Approaches to the Nuclear Fuel Cycle" co-hosted by the Nuclear Threat Initiative (NTI) and the Proliferation Prevention Program at the Center for Strategic and International Studies (CSIS) [14]. The Taipei meeting was followed by a CSIS-NTI Workshop focusing on proliferation issues associated with multinational back-end initiatives.
- **IFNEC/CFS:** International Framework for Nuclear Energy Cooperation (IFNEC) has a Reliable Nuclear Fuel Services Working Group, which organised a meeting on Developing Options and Pathways for Disposal of Spent Nuclear Fuel and High-Level Waste. Arius was invited to participate in this meeting. Key conclusions drawn included the following: *For several reasons, including safety, security and economy, the concept of a multinational repository merits being addressed within an international forum, like IFNEC.*

Wide and sustained Arius engagement in multinational initiatives has also been made possible over the past several years with the financial support of the US Sloan and Hewlett Foundations. Original funding from the Hewlett Foundation was to support the European efforts, whereas the Sloan Foundation funding was explicitly to look at multinational opportunities outside Europe. Subsequently, both Foundations provided equal funding for a pilot project assessing the feasibility of applying the ERDO concept outside Europe. This study was completed in early 2011 and a follow up project was developed, concentrating on feasibility studies in the Arabian Gulf region and in South East Asia. This 4 year feasibility study is now nearing completion and its conclusions feed into the comments in Section 4 on the possible global future of multinational disposal concepts.

Arius took various steps to present the European work to other groupings in Arab regions and in South East Asia. Workshops on Regional Collaboration on Radioactive Waste Management in MENA Countries were organised by the IAEA together with Arius, with significant input from the AAEA, in the UAE and in Tunisia. These events made it clear that the priorities in those Arab regions with active

nuclear power development differ significantly from those in less wealthy Arab states that are concerned mainly with ensuring safe storage and disposal of spent radiation sources, NORM and other materials. In both cases, however, there is a strong interest in partnering initiatives that pool resources and benefit from economies of scale. Arius has also been involved in discussions in Vietnam and in Indonesia amongst countries in South East Asia that are interested in moving into nuclear power and, accordingly, need to establish credible waste management strategies.

3.4. The ERDO Working Group

The European region was identified as the most promising starting place for concrete planning because a political framework already existed, the European Parliament had expressed positive views and the binding Waste Directive of the EC explicitly includes sharing facilities between Member States to be an acceptable approach to fulfilling waste management responsibilities. Accordingly, the ERDO-WG was formed with the mission of preparing the groundwork for a truly multinational waste management organization. The national waste management strategy favored by ERDO-WG members is a "dual track" approach in which a national disposal concept is worked on in parallel with working with partner countries to assess the feasibility of implementing shared multinational facilities. The dual track approach has been explicitly structured by the ERDO-WG.

Ten EU countries have been involved in ERDO-WG activities[1]. The ERDO-WG reacted to the publication of the EC Radioactive Waste Directive by preparing guidance for small EU Member States with small nuclear programmes and subsequently by submitting to EU governments structured proposals for a multinational European waste management organization.

Some of the ERDO-WG members have already taken a decision to include the dual-track approach as a part of their national waste management strategy. The key issues that will determine the success or otherwise of the ERDO initiative are the political and public acceptance of transferring spent fuel to another country and the economic benefits that can be derived from multinational cooperation. The organizational documents represent the first stages of the ERDO business plan, which will be required by any potential partner countries before reaching any final decisions on the establishment of a formal ERDO domiciled in one of the participating countries.

3.5. Status of the "take-back" option

Another spent fuel management option that could contribute to global security and could ease nuclear problems for new entrants would be for nuclear-fuel suppliers to take back the spent fuel under a fuel 'leasing' arrangement, in which they would provide fresh fuel and take it back after irradiation, or for a large nuclear power program to accept spent fuel from smaller countries as an "add-on" to its national inventory. They would then add this spent fuel to their own larger stocks to be stored for later disposal, or for reprocessing and recycling into new fuel. In fact, the political challenges for any potential service providers may be insuperable until such time as they have implemented their own disposal facilities Consequently, whilst conceptually attractive, leasing and take-back seem to remain as far out of reach of the emerging and nuclear power nations (and of the possible supplier nations) as it has been for the last 30 years. In addition, depending on how they were to be set up contractually, leasing arrangements might only solve part of the problem of spent fuel management, as long-lived wastes from recycling might be returned to the user countries for disposal.

4. Prospects for further progress

Today, the right of nations to pursue a dual track approach which considers both national and multinational options is recognised widely. In addition, the potential benefits of smaller programmes proceeding jointly have been emphasised by independent bodies, such as the National Academy of Sciences in the USA or the Royal Society in the UK, as well as by some larger programmes that will

[1] Austria, Bulgaria, Denmark, Ireland, Italy, Lithuania, Netherlands, Poland, Slovakia and Slovenia.

certainly need to implement their own facilities (e.g. USA and UK). The interesting question is whether the current initiatives and debates will lead to further progress towards implementation. We address this question below for different global regions.

4.1. Europe

The most structured approach currently is certainly that of the ERDO-WG in Europe. Advances have been made, as described above, and in principle the countries participating in the Working Group could decide at any time to establish an actual repository implementing organisation that would work in parallel to the national waste management organisations in other EU Member States. This step would involve appointing a small dedicated staff (perhaps including delegated experts from the participating countries) and setting these to work in a central location domiciled in one of the participant countries (without, however, prejudicing the later choice of repository sites). This first step will, however, be a major milestone and it is unlikely that it could be taken without intensive prior debate on issues such as the remit of the organisation, the siting strategy to be followed, the required funding levels and the allocation of costs to different sizes of user organisations. Current indications are that some smaller nuclear power programmes, such as the Netherlands and Slovenia, may be close to being able to make such commitments, but that others will require more time. Meanwhile, the ERDO-WG has become increasingly aware that its focus must be broadened beyond the long-term issue of final disposal and should cover more immediate strategic issues related to safe and secure management of all radioactive wastes. The WG recently, together with further EU Member States, such as Portugal and Greece, proposed to the EC that some funding should be allocated to support this. As pointed out earlier, however, EC support for cooperation on radioactive waste management currently focusses on R&D issues rather than strategic planning, so that funding avenues must be further explored.

4.2. Arab regions

As already pointed out, the challenges of ensuring safe radioactive waste management are different in differing Arab nations. Several non-nuclear countries in North Africa have expressed interest in introducing nuclear power and have also been involved, through the AAEA and the IAEA, in joint discussions on waste management. However, the current unrest across the region and the lack of human and financial resources make it unlikely that much progress will be made over the coming years. The most dynamic new nuclear power programme in the world at present is, perhaps, that of the UAE, where up to 8 nuclear power plants will be built. Work is in progress on the first four and ambitious start-up dates are scheduled. The UAE have been acting as a role model for new nuclear programmes in that they follow very strictly the advice provided by the IAEA in its milestones documents. The UAE have also publicly announced that they are following a “dual track” disposal strategy, which keeps open both options – a national repository and a shared regional facility. Arius was contracted to examine in detail the implications of the regional approach. In the six countries comprising the Gulf Cooperation Council (GCC) region, which includes two nations with expanding nuclear power programs (the UAE and Saudi Arabia), one attractive concept is the launching of a joint project on the feasibility of shared storage and/or disposal facilities. Also, Jordan has recently agreed to have a Russian built power plant and, even if it succeeds in obtaining a fuel send back agreement, it will need access to a geological repository for its other long-lived wastes. Arius has submitted to the Gulf Coordination Council (GCC) proposals for an in-depth study of the benefits and challenges associated with establishing a multinational Waste Management Organisation (WMO) that would be co-owned by all interested States in the region.

4.3. Asia

In Asia, there are a few major nuclear power users (Japan, South Korea, Taiwan, and China) and many other nations that could potentially introduce nuclear energy. For the small programmes alone, there exists already one organisational framework within which the issue of cooperation on spent fuel and radioactive waste could be discussed. This is the ASEAN network, which includes Vietnam, Indonesia, Malaysia, Thailand, Philippines, Singapore, Cambodia, Brunei, Laos and Myanmar. In addition, Bangladesh has definite nuclear plans and Turkey, Mongolia and Kazakhstan, which straddle

the Asian – European boundaries, have also all expressed interest in, or are already initiating, nuclear power programmes. Lastly, Australia has a traditional anti-nuclear power position, but returns repeatedly to the issue. There is also a network, the Japanese led Forum for Nuclear Cooperation in Asia (FNCA), which has participants from Australia, Bangladesh, China, Indonesia, Japan, Kazakhstan, Korea, Malaysia, Mongolia, the Philippines, Thailand and Vietnam. To date, however, only Vietnam and, perhaps, Malaysia from the ASEAN countries are sufficiently serious about nuclear power to be concerned already about spent fuel management options. What, then, are the prospects in Asia for multinational cooperation at the back-end?

4.4. Other global regions

The most obvious further region of the globe in which cooperation on spent fuel management could be valuable is in Central and South America. Mexico could ultimately send its spent fuel to the USA. Argentina and Brazil currently have nuclear power reactors in operation and have agreed to develop further nuclear power reactors jointly. In 2011, an agreement was signed under which they will jointly build two research reactors. Linking their spent fuel management strategies seems an obvious further step. In South America, Venezuela also has nuclear plans and has established a nuclear cooperation agreement with Russia. Chile has also expressed interest and has established cooperation with France. The opportunities for considering regional South American cooperation on management of spent fuel at the outset are apparent.

Finally, interest in introducing nuclear power to sub-Saharan Africa has been expressed at times by Kenya, Nigeria and Namibia. The obvious approach here would be for South Africa, the only experience nuclear power country in the region, to take a leading role in promoting cooperation, if and when the intention of these countries turn into specific plans.

5. Conclusions

This round-up of recent developments highlights a widespread interest in regional solutions at the back-end. In Europe, a good indicator of the further progress will be given over the next few years as EU Member States fulfill their requirements under the Waste Directive. It is certain that some Member States will include in their submissions a dual track approach. For the regional partnering approach to be as credible as a purely national strategy, the path towards establishment of a jointly owned European Waste Management Organisation should be clear. The ERDO-WG provides a framework for European countries that wish to make progress in this direction. In the other global regions where shared solutions are currently being considered, the European approach might continue to be used as a role model, leading to further partnerships, e.g. one for the GCC, one for other Arab countries and one in Asia. There may be benefits in this approach for other regions too, such as Central and South America, or sub-Saharan Africa.

Despite the setback to global nuclear energy that resulted from the Fukushima disaster, many countries are expanding or introducing nuclear power programs. Moreover, large numbers of countries make use of nuclear technologies in medicine, research and industry that also lead to long-lived radioactive waste arisings. It is imperative that all such wastes are handled, treated and disposed of in a manner that minimizes safety and security risks. For many small countries, this can be best achieved by pooling their efforts in a regional, multinational framework. Nevertheless, large, advanced nuclear programs could help more than they currently do. The greatest help would, of course, be to take back or take away spent fuel from small countries. If this continues to be politically unacceptable, then moral, technical and even financial support to the multinational management and disposal initiatives of new nuclear power nations that purchase their expensive facilities from the large players would be valuable.

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REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Developing and Implementing Multinational Repositories: infrastructural framework and scenarios of co-operation. TECDOC 1413 (2004)

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Viability of Sharing Facilities for the Disposition of Spent Fuel and Nuclear Waste – An Assessment of Recent Proposals, TECDOC 1658 (2011)

[3] Rauf T. and Vovchok Z., Fuel for Thought, IAEA Bulletin 49-2, (2008) https://www.iaea.org/sites/default/files/49204845963.pdf

[4] SAPIERR PROJECT Reports, www.sapierr.net or www.erdo-wg.eu

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Technical, Institutional and Economic Factors Important for Developing a Multinational Radioactive Waste Repository, TECDOC-1021 (1998)

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Technical, Economic and Institutional Aspects of Regional Spent Fuel Storage Facilities, TECDOC-1482 (2005)

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Institutional Considerations in the Development of a Multinational Repository (2013)

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Multilateral Approaches to the Nuclear Fuel Cycle: Expert Group Report to the Director General of the International Atomic Energy Agency (2005)

[9] EUROPEAN COMMISSION, Council Directive on the management of spent fuel and radioactive waste, SEC (2010) 1290 and SEC (2010) 1289, Brussels (2010)

[10] ENEF Working Group Risk, Working Group on National Programmes NAPRO, Guidelines on the responsible and safe management of spent fuel and radioactive waste for the establishment and notification of National Programmes (2013)

[11] Implementing Geological Disposal-technology Platform (IGD-TP), http://www.igdtp.eu/

[12] Arius Association www.arius-world.org

[13] AAAS The Global Nuclear Future Project, (2015) https://www.amacad.org/content/Research/research.aspx?d=289

[14] Hartigan K., et al, NTI/CSIS project A New Approach to the Nuclear Fuel Cycle, (2015) http://csis.org/files/publication/150129_squassoni_nuclear_fuel_cycle.pdf