

RWM and the Nuclear Renaissance

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1. Introduction

For many years, nuclear supporters have been talking of a possible nuclear power renaissance. Today there are definite signs that this is finally beginning to happen. New plants are being built or planned in China, Japan, Korea, Finland, France and even the USA. Phase-out policies are being rethought in countries like Sweden, Belgium and Germany. Countries like Vietnam, Indonesia, the Baltic States and even Australia are choosing or debating initiating a nuclear programme.

Support for these nuclear power developments will be strongly influenced by the progress of waste management programmes, especially final disposal. Conversely, the growing realisation of the potential global benefits of nuclear power may well lead to increased support, effort and funding for initiatives to ensure that all nations have access to safe and secure waste management facilities. This implies that large nuclear programmes must make progress with implementation of treatment, storage and disposal facilities for all of their radioactive wastes. For small nuclear programmes (and for countries with nuclear applications other than power generation) such facilities are also necessary. However, for economic and other reasons, these small programmes may not be able to implement all of the required national facilities. Multinational cooperation is needed. This can be realised by large countries providing back-end services such as reprocessing and disposal, or by small countries forming regional or international partnerships to implement shared facilities for storage and/or disposal.

This paper traces through the past decades the mutual interactions between programmes in nuclear power and in waste management. The relevant issues of concern for both include radiological safety, environmental impacts and, most topically, non-proliferation and security. Debates on these issues have strongly affected national efforts to implement power plants and repositories, and also influenced the international debate on multinational cooperation in each area.

The paper therefore complements the introductory brief summary of the status of nuclear power developments with a review of how national waste management programmes are progressing (or not progressing) and of how the credibility of multinational concepts is being enhanced by a number of current initiatives. These include Russian proposals for international facilities, the recent GNEP initiative of the USA, studies on regional repositories in the SAPIERR project and IAEA and EC support for both types of initiative.

2 A brief look back at nuclear power

2.1 Unfulfilled promise

Nuclear energy had an uneasy birth period, since the public first became aware of the power locked in the atom through its use in the atomic bombs used to end World War II. Shortly afterwards, however, nations realised the immense potential for peaceful uses and the first power reactors to produce electricity were opened to great public and media acclaim. Fuel elements with a volume of only a few cubic metres could produce 1000 MW of electricity for a year, release little to the atmosphere and generate only small quantities of waste. With coal, 2000 rail cars are required to generate the same amount of energy and hundreds of thousands of tons of gases and ash are produced. The economics of nuclear power were also expected to be very favourable – resulting in the infamous prediction of Lewis Strauss in 1954 that nuclear electricity would be “*too cheap to meter*”.

The promising new energy source did not, however, live up to expectations. Reactors took longer than predicted to build, performance was often far below design targets and the costs escalated, in part

because long delays led to huge interest fees on the high capital investments needed. Already in the 1970s, this led to a large drop in new plant orders in the USA and then Europe, although developments continued in Asia. Next, however, came some serious accidents – Windscale in the UK, Browns Ferry in the USA and then the catastrophe of Chernobyl, Russia. Parallel to all this, opposition to all kinds of nuclear activities was growing in many countries.

The opposition has diverse causes: a widespread fear of radiation (enhanced perhaps by its original military use); a general growing suspicion of “big technologies” over which the individual felt he had no control; and in addition four specific arguments that have recurred repeatedly over the past decades. These arguments are:

- the operational safety of nuclear power plants
- the economics of nuclear power
- the fear of proliferation of nuclear weapons and
- the “unsolved problem” of radioactive waste disposal.

Opponents of nuclear have chosen to stress different arguments in this list at different times. Today, all these objections can be countered by pro-nuclear persons in such a convincing way that a global renaissance of nuclear power is an undeniable prospect. The following section summarises the current position on each point before narrowing in to the prime focus of this paper – namely the mutual impacts of radioactive waste management programmes and nuclear power development.

2.2 Increasing support for nuclear power

Some of the main arguments brought by nuclear opponents have been disproved by the documented experience with nuclear power plants. The safety of their operation is proven by over 12000 reactor-years of electricity production by over 400 power plants in 37 countries. The only really large accident was at Chernobyl – and this was caused by highly unusual experiments being incompletely carried out on a special reactor type that has far less safety features than normal facilities. The health consequences of Chernobyl are large – but much less than originally postulated [1].

The economics of nuclear power have changed due to improved performance of the plants as well as to the alarming ramping up of fossil fuels. A recent NEA study [2] showed that nuclear was more competitive than fossil fuel for 7 out of the 10 countries considered, even with a relatively high discount rate of 10%. The exceptions are coal-rich countries that are prepared to tolerate very large CO₂ emissions. In free market economics, older nuclear plants are fetching high prices because of the large revenues they can generate. Purely economic consideration today favour producing electricity by nuclear power – and rationalising and shortening the long, complex procedures would make the case even more clear.

Perhaps the strongest motivation for nuclear today, however, is its environmental advantages. The effects on global climate of CO₂ emissions are now very widely recognised, as are the catastrophic effects on human civilisations that a changed climate could cause. This issue has led to prominent environmentalists publicly changing their earlier attitudes towards nuclear power. Patrick Moore, a co-founder of Greenpeace International, is convinced that the ideological opposition of that organisation to nuclear power itself now posed an environmental hazard. James Lovelock, the father of the Gaia thesis of global environmental balance, argues that we need nuclear power to avert catastrophic climate changes. In Australia, the popular scientist and author, Tim Flannery, also favours nuclear.

The key remaining concerns about nuclear power concern security/non-proliferation issues and the not yet fully resolved challenge of long-term waste management. These are to some extent, linked issues since the HLW and spent nuclear fuel that must be managed for long times can certainly present security and proliferation problems if appropriate measures are not taken. The most urgent security concerns,

however, are related to technologies for uranium enrichment and for fuel reprocessing since both of these can produce weapons quality materials.

These concerns have led to a series of recent initiatives intended to control existing weapons materials and to prevent the production of further quantities. The USA and Russia have both repatriated fissile materials (primarily HEU from research reactors) from a number of countries across the world. Spent sealed sources have also been collected. Steps are taken to hinder the spread of enrichment and reprocessing facilities, e.g. by offering to guarantee such services. New initiatives from Russia [3, 4] and from the USA [5], aim to allow nuclear power to be used ever more widely, while at the same time minimising security and proliferation problems.

All of the above developments have contributed to the recent sharp increase in the interest in nuclear power. Today new plants are being built or planned in China, Russia, India, Japan, Korea, Finland, France, South Africa and the USA. National policy on nuclear is being rethought in the UK, Belgium, Sweden, Germany and Italy. The introduction of nuclear power is being discussed in Vietnam, Indonesia, Poland and the Baltic States. In Australia, the debate on nuclear has never been so intense.

In any country that uses or plans to use nuclear power, decisions will be strongly influenced by the reality of, and the perception of, the availability of safe, secure and environmentally benign approaches to managing the resulting radioactive wastes. In fact, even those countries with no nuclear plants must be interested in safe radioactive waste management since almost all these countries do produce radioactive wastes from some of the very many peaceful applications of nuclear technology. Accordingly, the remainder of this paper is devoted to describing how radioactive waste management concepts have developed over the years, what the global situation is today and how we can ensure that safe management technologies (especially final disposal) can be made available to all nuclear countries, large or small.

3 A brief look back at waste management

Geological disposal was not (despite the assertions of some of its opponents) chosen as a "cheap and dirty" option to get the radioactive waste "out of sight and out of mind". The concept of geological disposal is a logical consequence of the easily observable decay of radioactivity with time, which leads to a continuous reduction in toxicity of these wastes. Finite hazardous lifetimes (and low volumes of wastes) led to:

- development of concepts where environmental protection could be aimed at by isolating wastes from man's surroundings for long enough to allow such decay to occur and
- a search for environments which showed sufficient stability for the time periods involved - namely thousands or even hundreds of thousands of years.

There are not many environments for which we have evidence of their evolution and their stability over hundreds of thousands of years. Old, deep geological formations are the most obvious candidate environments that can be accessed with today's technology. Other options have, in fact, been considered. A comprehensive document on all these options was published already in 1974 [6]. Concepts that have been examined (more than once) include disposal in space, under ice caps, in subduction zones, etc., but all have been judged infeasible or unsafe. Transmutation is still being studied in various countries. In the view of most experts, it may eventually change the nature or quantity of radioactive wastes to be disposed, but transmutation will not remove the need for geological disposal.

Consequently, concepts for geological disposal under the continental earth's crust have been developed over many years and the concept of disposal in deep geological formations was recognised by the US National Academy of Sciences as early as 1957 [7] to be the most promising form of confinement for long-lived wastes from the nuclear fuel cycle.

Despite the above historical facts, accusations that nuclear power was started without any consideration having been given to the management of its wastes have often been made by anti-nuclear groups. These

opponents have likened the construction of the first nuclear power plants to “building a house with no toilet”. The experts in the nuclear community see this differently. They point out also that for many years, or even decades, there was no technical need for disposal. The quantities of high level waste or spent fuel were too small to justify implementing repositories and, in any case, a cooling time of around 40 years was the sensible technical choice.

In retrospect, however, there was indeed too little effort invested into organising long-term management and disposal; most attention was devoted to implementing practical measures for handling and storing radioactive wastes safely. This is now recognized as a mistake. Even the famous nuclear pioneer Alvin Weinberg has been quoted as saying *"During my years at ORNL, I paid too little attention to the waste problem. Designing and building reactors, not nuclear waste, was what turned me on . . . [A]s I think about what I would do differently had I to do it over again, it would be to elevate waste disposal to the very top of ORNL's agenda"*

With time, however, things changed; dynamic waste disposal initiatives were started - and, paradoxically, the nuclear opponents were in large measure to thank for this. Because they asserted that lack of demonstrated safe technologies for disposal should preclude the use of nuclear power, governments were pressured to demand specific projects that could provide this demonstration.

The first example was in Sweden, where the Stipulation Act of 1977 made credible disposal concepts a pre-condition for the start up of new power stations. This led directly to the establishment of the pioneering KBS project which developed technical disposal concepts that are valid still today. A similar situation resulted in Switzerland when the new Atomic Energy Act of 1975 and associated regulatory requirements demanded demonstration projects before the year 1985 if new nuclear plants were to be introduced to the country, or even if the existing stations could continue operation. These are clear examples of cases where nuclear sceptics or opponents have given a positive impulse to the planning of geological disposal.

There are also striking counter-examples, i.e. cases where nuclear opponents have slowed or stopped any progress in disposal. In the UK, the Government abandoned a HLW disposal in the 1980s in order to avoid public conflicts over drilling sites; in Spain a specific repository siting programme was scrapped for the same reason; in the Netherlands, the Government blocked a highly interesting programme on disposal in salt domes and ruled that storage for at least 100 years was the option to be chosen. The reasons for opposition to progressing repository programmes are diverse. Some people genuinely believe that the safety of deep geological disposals has not been demonstrated sufficiently and that allowing years or decades for further work will produce some as yet undefined better solution – a “magic bullet”. Others object for tactical reasons – an accepted waste disposal solution would remove one of their last anti-nuclear arguments, now that operational safety and economics are both clearly favourable.

A real danger resulting from those tactical manoeuvres of opponents is that an “unholy alliance” could result. By this I mean that indefinite storage could become the common solution that satisfies both the nuclear opponents (who wish to block a real final solution) and extremists in the nuclear industry (who know very well that the storage option is much less costly than implementing geological repositories). The losers, in this case, are our children and grandchildren, the future generations who then inherit an unsolved problem passed on to them by us because we did too little to clear up our own mess.

Where are we today on all of the issues influencing efforts made towards implementing deep geological disposal? Unfortunately for the world in general, but productively for waste management, a new and frightening aspect has kept to the forefront. This is the growing concern about the misuse of nuclear materials by nations that are intent on gaining nuclear weapons capabilities, or even more worrying, the possibility of nuclear terrorist acts. In the recent past – in particular since the terrorist attacks on the USA in 2001 – the security issues associated with management of nuclear materials, including wastes, have assumed high profile.

The concerns about the spread of sensitive technologies such as enrichment and reprocessing have correctly taken front place. These concerns have led directly to the Russian and American fuel cycle

initiatives described later. However, the back-end of the nuclear fuel cycle cannot be neglected when we are trying to minimise security concerns. Spent nuclear fuel and HLW must be kept away from persons, organisations or governments that might misuse it. A very effective way to make these materials inaccessible is to emplace them in a limited number of highly controlled national or multinational underground facilities. The latter of these options is discussed in more detail later in this paper. First, however, a brief overview is given of how national programmes are progressing with implementation of safe, secure and environmentally friendly final repositories for spent nuclear fuel and HLW.

4 Status of Geological Disposal Programmes

For at least 25 years after the original 1950's publications on the concept of geological disposal, the validity of this approach was not questioned. It was formally adopted as a final goal, through policy or legal decisions, in many countries, including the USA, Canada, Sweden, Finland, Belgium, Switzerland, France, Spain, South Korea, and Japan. As mentioned above, several of these countries initiated active scientific and technical programmes aiming at implementing disposal, usually some 20 years or so into the future. International organisations such as the OECD/NEA, the IAEA, and the EC established working groups and networks of the organisations involved. Special journals started up. Innumerable conferences were organised around the world; for example the major annual International Waste Management Conference in Tucson, Arizona, USA was held in 2006 for the 32nd time.

However, virtually every geological waste disposal programme in the world ran into difficulties in keeping to originally proposed schedules. For example, in the US programme, in 1982 [8], a target date for repository operation of 1998 was set. In stages afterwards, the target for a US repository at Yucca Mountain was moved back to 2010 because of unresolved technical, licensing and legal issues – and today there is no official target date specified by USDOE. Other programmes have also been compelled to move target dates back. Through to the present, the only active programme that met its early deadlines has been Finland.

Slippages in deadlines, however, are common in large projects; disposal programmes are not unusual in this respect. Less common are decisions of the type taken in some countries – namely to indefinitely postpone implementation of geological repositories. This has happened several times, in each case due to public opposition leading to governmental decisions to halt siting processes. Examples are the Netherlands, Spain, the United Kingdom, Argentina and the Czech Republic.

In a few countries, there has been a still more radical political reaction to problems encountered by geological disposal programmes. This began in France, where intense opposition to siting efforts in crystalline rock areas, together with growing opposition to disposal per se, led in 1990 to a new law in which the geological disposal option was treated as one of three lines to be followed. The other two, transmutation and long-term storage, were to be studied with equal intensity at least up to a decision date set for 2006. A key result of the major project that resulted from this French programme is the decision taken in by the French Parliament this year that a geologic repository for HLW should be implemented by the year 2025.

Backing off from the choice of geological disposal as the preferred national strategy has taken place in two further countries, namely the UK and Canada. The UK government decided to re-open all alternatives and to have a very wide public debate before choosing a preferred future course. This decision followed on the loss of the proposed Sellafield site as a result of a public hearing that severely criticised the scientific, engineering and societal aspects of work by UK Nirex. In Canada, the Government also decided to re-open discussion on all conceivable long-term spent fuel management options following the review by the Seaborn Committee [9] of the major study submitted by AECL. In the Canadian case, the science and technology was not faulted; the proposed repository concept was judged technically capable of providing safety. However, it was also judged that the public confidence in the safety was insufficient to allow an implementer to proceed to specific repository siting.

For carrying out these re-evaluations, the governments of the UK and Canada set up special bodies, respectively the Committee of Radioactive Waste Management (CoRWM) and the Nuclear Waste

Management Organisation (NUMO). After extensive consultation exercises, both have recently produced recommendations that geological programmes should move ahead, although in an extended staged process. (see www.corwm.org.uk and www.nwmo.ca)

The above rather sobering look at the slow progress of geological repositories in some countries contrasts with the advances made in some other parts of the world. In the USA, the WIPP deep repository for transuranic wastes has been operating successfully for some years and has recently been recertified to continue doing so. Furthermore, since the US congress has decided that a licensing application should be prepared for the Yucca Mountain Project in Nevada, a deep repository for used nuclear fuel may well be constructed and operated in the United States in the foreseeable future (although significant hurdles are still faced). In the Scandinavian countries, Finland and Sweden, the deep repository programmes are very advanced and steering towards definitive dates for implementation. More influential, perhaps, than the technical developments that have been initiated in these countries, are the societal processes that have been invoked to try and ensure that the repository has a sufficient level of acceptance. In most other countries of the world, the combined technical and societal approaches employed in the Scandinavian countries are looked upon as role models for how things might be arranged also in other programmes.

In the European Union, a 2002 draft directive instructed all European Union member states that specific deadlines for siting repositories and for implementing these facilities must be set. Although the over-ambitious deadlines proposed in the initial draft were dropped, the thrust of the initiative will likely remain. This thrust confirms, at least for the European Union, that deep geological disposal is indeed the preferred waste management strategy for used nuclear fuel and high-level wastes.

A broad look at the actual situation around the world today reveals the following. The present position is that technologies for implementing deep geological disposal have been developed and extensively tested in a number of countries, although fully implemented in only very few cases. These technologies are based on different conceptual designs for a deep repository, including the choice of the engineered barriers that enclose the used nuclear fuel and also the geological medium in which the repository will be sited. In all of these different programmes the safety of the deep geological system - as assessed by the range of methodologies developed for this purpose - is invariably shown to be very high. The development of the safety assessment methodology itself has involved many man-years of intellectual effort and also extensive collaboration between researchers in different countries around the globe. Assessing the safety is based upon analysing how the entire repository system will behave far into the future. This estimation in turn is based upon a sound scientific understanding of how the materials will evolve in the deep geological environment, and of how any radionuclides released might be transported through the deep underground, back towards the environment of humans. The safety assessment is not a purely theoretical desk exercise. The models are based upon experimentation in the laboratory and in the field. The understanding that is built up is checked by observing, how natural systems with similar properties behave over the very long time-scales considered.

As a complement to these overarching comments on the status of geological disposal, many publications include good overviews of programmes world-wide. A recent example is the review by Witherspoon and Bodvarsson [10]. In addition, the IAEA maintains a web site that documents current general trends and also developments in individual countries. Finally, most national waste disposal organisations have their own web sites.

The current status of national geological disposal programmes is thus well documented and it illustrates that progress is being made in many countries – but that this is a slow process. For some countries national repositories may be difficult or unfeasible because of the lack of favourable geological formations, shortage of technical resources, or unacceptably high costs. For these multinational repositories are a potential solution and, in recent years, there has been a rapid increase in interest in this possibility as described in the following section.

5 Multinational initiatives

In the early years of nuclear development, the concept of nuclear fuel cycle centres, including international repositories, was topical. The IAEA charter itself allowed the Agency to be involved in centralized plutonium storage and management. Various studies were performed on regional nuclear fuel cycle centres and on international spent fuel management. These are documented in [11]. Since this conference is taking place in Australia, two of the past studies of relevance to this continent are briefly described below.

5.1 Australian connections

The first is the Synroc Study Group. In 1983, the Australian government commissioned a report from the Australian Science and Technology Council on Australia's role in the nuclear fuel cycle. The 1984 ASTEC report recommended not only proceeding with uranium mining, but also becoming involved with other stages of the fuel cycle such as enrichment. It also flagged the "*particular need for international collaboration in developing (high-level) waste management programs*" and the desirability of enabling access to the highest quality geological sites for disposal of those wastes. Later, in 1998, the Synroc Study Group was set up by the Australian government to study the commercial potential for Synroc in a global context. It was conducted by four leading Australian resource companies, assisted by ANSTO and the Australian National University, and advised by SKB Sweden. The study [12] also considered the option of Australia hosting an international repository. It led on to the Pangea Project described below.

The Pangea project introduced a technical concept based on a particular "high isolation" proposal [13] and regions of the world possessing especially favourable geological and geographical environments were identified in Australia, Southern Africa, Argentina and China [14]. The main emphasis was on Australia and a commercial approach to implementing an international repository was developed in detail [15]. The project raised the profile of the global debate on international repositories. It received solid support in scientific and business circles world-wide and in Australia. However, due in part to the premature leaking to the media of an explanatory video on the project, political opposition in Australia and in West Australia was strong from the initial announcement and the project was dropped by its sponsors. The project, however, remains a topic of discussion in the current Australian nuclear debate. Moreover, some of the technical team involved are currently engaged in the work of the Arius Association, whose work on multinational repositories is mentioned later.

5.2 Current Status

The past five years have seen a continual growth in the interest of many national waste management programmes – especially those of small countries – in the concept of multinational or regional disposal facilities. The prime drivers were originally the economic and political problems that might be lessened by being shared between countries facing the same challenges. The potential safety and safeguards benefits were also recognised at this early stage. Increasingly – in particular after the terrorist attacks in the USA in 2001 and in connection with nuclear proliferation concerns – attention focused on the security advantages that could result. . The most recent manifestation of this is the Global Nuclear Energy Partnership (GNEP) promoted currently by the US Government. The IAEA, honoured in 2005 with the Nobel Prize for its efforts to reduce nuclear risks, has not neglected to point out that these risks can also be important at the "back-end of the back-end" of the nuclear fuel cycle, i.e. not only in enrichment and reprocessing but also in storage and disposal, in particular of spent fuel.

In its publications in this area and in recent statements of representatives of the IAEA, two potential routes to achieving international disposal have been described. One of these, the "add on approach", is the inclusion of disposal within a broader scheme of internationalised fuel-cycle services provision. The other, which does not require global strategic developments and agreements, is the "partnering scenario", in which a number of countries agree to look for a common disposal solution involving one or two shared repositories. These should be sited in locations to be decided by the multinational participants in the same democratic, consensual approach that has been used by potential siting communities in the more successful national programmes.

In both potential disposal approaches to multinational disposal, significant progress is being made. Below, we describe the add-on approach, using the topical examples of Russia and then examine the partnering scenario, using experience gained in the SAPIERR project of the EC.

5.3 The add on option

A single country, or a network of countries with appropriate facilities working together, by providing extended fuel-cycle services to countries adhering to the NPT and wishing to use nuclear power, could limit the spread of those sensitive technologies that are allowed under the Treaty, namely enrichment, reprocessing and storage/disposal of fuel. Crucial pre-requisites would be security of supply of services to all co-operating users (as emphasised by the Multilateral Approaches Group established by the IAEA [16]) and close international monitoring by the IAEA. The whole concept has been raised again very recently by IAEA Director General, Mohammed ElBaradei [17, 18]. It is very topical because of the concerns with nations such as Iran expanding their nuclear capabilities to include fuel enrichment.

Although emphasis is on the front end of the fuel cycle, where most security concerns arise, back-end services would also be offered as part of this suite of provisions, either by countries establishing new, dedicated multinational storage and disposal facilities to fit into the scheme or by countries with existing facilities that could be extended for international use.

Within this international fuel cycle scheme, the fuel leasing component is certainly the closest to being an accepted practice. This is almost the practice followed by the former USSR with its satellite States. More recent global concerns about security have led to it being the universally preferred solution, if nuclear power plants are to be operated in countries such as Iran and North Korea. Recent proposals from the US Government have indicated its support for such a scheme. Should it come to pass, the gate will be opened for other large nuclear fuel suppliers to improve the attractiveness of their fuel services, while at the same time enhancing global security. Potential network partners in internationalising the fuel-cycle would all have to be NPT signatories and could clearly include the major suppliers of uranium or of fuel cycle services or of power reactors, i.e. the list includes countries such as Argentina, Australia, Canada, France, Japan, Russia, the UK and the USA.

The most likely country to offer to act as host in this add-on scenario is recognised to be the Russian Federation. Support has been expressed at Government level. The law currently allows import of spent fuel for storage or for reprocessing with return of residues. However, there is solid support for expanding this service to include final acceptance of fuel or even high level radioactive wastes (and, it is acknowledged, also strong opposition). Moreover, once a first move is made, it is not impossible that competition could even arise. Supporters of hosting an international repository have spoken up in Kazakhstan and China in the past and recently again in Australia. Acting as a host is economically attractive for Russia since it would provide either income from provision of services or fuel for the future, or both. However, as has been recently pointed out [19], the law would have to be changed and a number of other conditions would have to be fulfilled if a range of important international stakeholders are to be comfortable with what is offered and the conditions attached.

The recent GNEP proposal from the USA is primarily aimed at making the nuclear fuel cycle more secure. This should be achieved by restricting sensitive the processes of enrichment and reprocessing to a restricted number of trustworthy countries (or existing weapon States) that should then provide services to other countries wishing to use nuclear power for peaceful purposes. For this to be attractive to these customer countries there must be sufficient incentives and the supply of services must be guaranteed. One incentive would be to have no HLW or spent fuel to be managed long-term and intimately disposed. This requires the fuel suppliers to take back the spent fuel – probably under a leasing arrangement – or for a third party, trustworthy country to offer storage and disposal services. Proposals to host an “international nuclear waste dump” have, not unexpectedly, led to public and political opposition. However, offering a global service that enhances world security, and is for the host country both safe and profitable, maybe more acceptable [20].

A fundamental point is that purely unilateral initiatives (whether they are in Russia, the USA or elsewhere) will very probably not succeed – a proper multinational approach is absolutely essential. The time is now ripe for initiating such an approach by bringing the key players together in a free and open discussion to develop plans for how a specific project can be established.

5.4 The partnering approach: SAPIERR

The second option for implementing multinational repositories - partnering by smaller countries - has been particularly supported by the European Union through its promotion of the potential benefits of regional solution, i.e. facilities shared by contiguous or close Member States. For the “partnering” scenario, in which a group of usually smaller countries cooperate to move towards shared disposal facilities, exploratory studies have been performed most recently by the Arius Association, which also co-manages the European Commission SAPIERR project on regional repositories [21].

The Support Action: Pilot Initiative for European Regional Repositories (SAPIERR) project finished at the end of 2005 after 2 years of work involving organisations from 14 different countries. This should be succeeded by a follow-on SAPIERR-2 project (Strategic Action Plan for Implementation of European Regional Repositories – Stage 2). This would establish a dedicated multinational organisation that would develop the shared repository option in a staged process similar to that favoured by national programmes. The SAPIERR-2 project looks in more detail at the following topics: multinational legal and business structures; legal liabilities; economics (costs, benefits); safety and security; public and political attitudes.

6 Conclusions

The conclusions that can be drawn from this review of the past history and present status of geological disposal can be summarised as follows:

- Nuclear power did not live up to early expectations: it was technically more complex than assumed, economically less attractive than expected and socially became progressively less supported after its promising start.
- Opposition stopped or slowed growth: the nuclear industry did not make sufficient efforts to inform and consult with the public, leaving the field open for intensive and effective lobbying by anti-nuclear forces.
- The list of counter-arguments (often recycled) focussed on reactor safety, economics, security and waste management
- Despite some severe setbacks, nuclear power over some decades proved itself increasingly to be reliable, safe and economic; many of the objections were thus countered.
- In addition the positive environmental aspects of nuclear power are becoming increasingly recognized by a public that is becoming ever more aware of the catastrophic consequences that can result from unabated consumption of fossil fuels.
- Despite the widening acceptance or support for nuclear, serious reservations continue to be expressed on two issues – nuclear security and long-term waste management.
- These issues are linked and are both being addressed today by intensifying efforts to ensure that all hazardous radioactive materials (and in particular fissile materials) are being moved into well safeguarded storage facilities.
- In parallel, many nations are trying to progress plans and projects for implementing deep the geological repositories that will be needed to provide long-term safety and security in any credible waste management system.
- For some countries, it will be infeasible or impossible to implement the costly deep repositories that will be needed to safely store their relatively small quantities of hazardous long lived wastes and/or spent fuel.
- Therefore national efforts must be complemented by multinational cooperative initiatives that will make appropriate storage and disposal facilities available to all countries that make use of nuclear technologies.

- Implementation projects that arise from such cooperation could bring huge and mutual benefits to both host countries and user countries of shared multinational repositories.

At the origin of nuclear power development, too little attention was devoted to the challenges of ensuring safe long-term management of the resulting radioactive wastes. For some long time now, however, the proponents of nuclear power, as well as the opponents, have realised that continued use or expansion of nuclear power is justified only if there is a consensus that the wastes can be safely managed. This realisation has, of course, led opponents to sometimes use the “unsolved” waste issue as a tool to attack the nuclear industry. It has also, however, spurred the industry on to try to implement safe solutions – in particular geological repositories. The recent rapid growth in recognition of the potential environmental benefits of nuclear energy, together with the alarming rises in fossil fuel prices, has led to increased interest in expanding nuclear power. Hopefully, this will encourage the industry to maintain its efforts to prepare for geological disposal and will also cause the opponents to help rather than hinder progress towards a safe and responsible waste management system that protect humans and the environment and will thus help to remove the last barrier to expanded use of safe and non-polluting nuclear energy.

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