DEVELOPMENT OF THE MULTINATIONAL REPOSITORY CONCEPT: EXPLORING ALTERNATIVE APPROACHES TO FINANCING A MULTINATIONAL REPOSITORY

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Abstract

The amounts of waste generated in the nuclear power lifecycle is small compared to other power generation options and normalised to power produced [1]. In particular, because of the enormous energy density in uranium, nuclear power plants produce much smaller quantities of waste than fossil plants. Although there are several back–end management options that result in different waste forms for countries generating spent fuel and high-level radioactive waste, a geologic disposal capability is required.

High-level Radioactive Waste (HLW) and/or Spent Fuel (SF) need technologically advanced treatment and management procedures from interim storage to final disposal. To prevent any negative impact on the environment or and human health, HLW and SF must be adequately isolated. Disposal in a Deep Geological Repository (DGR) is internationally recognised as the most technologically developed and safest approach to isolating these wastes from the biosphere. Development of a DGR involves high fixed costs that carry an associated economy of scale. A DGR with a capacity of 10,000 metric tonnes can cost little more than one to dispose of 5,000. This means that smaller nuclear programs could benefit greatly from the opportunity to participate in a Multinational Repository (MNR).

The MNR concept provides a shared solution to the challenges of SF and HLW disposal. The concept involves a service provider country developing a geologic repository and accepting SF from several customer countries. Although financing is an issue shared by all repository projects, a MNR project presents a unique case regarding issues associated with the sources of funds, timing of revenues and expenditures, and risk allocation. Different international organisations are approaching this issue from diverse aspects. Recent developments regarding the identification of financing approaches for an MNR have been observed among different fora and will be presented in the paper. These activities include actions of different intergovernmental and international organisations (i.e. IAEA, OECD, WNA, … [2]), however this paper will focus mainly on results of recent work done by the International Framework for Nuclear Energy Cooperation's (IFNEC) Reliable Nuclear Fuel Services Working Group [3].

1. INTRODUCTION

For the past decade the International Framework for Nuclear Energy Cooperation (IFNEC) has worked to advance the Multinational Repository (MNR) Concept. The concept involves countries that share the challenge of disposing of spent fuel or high level radioactive waste working together toward shared solutions, and has been discussed and developed in a number of IAEA publications going as far back as 1998 [4, 5, 6, 7].

Countries that have programs to develop a national disposal capability while also pursuing opportunities to work with other countries on the MNR concept are following what is referred to as the Dual Track Approach. This approach was perhaps first described in detail in a European Commission sponsored project called SAPIERR II as reported in its 2008 report [8], and was further developed in a report developed by IFNEC in 2016 [9].

One of the key challenges associated with the development of an MNR is financing. As part of the IFNEC work on the MNR concept, a workshop was held in Paris in December 2018 [3], to begin a dialogue on the various approaches that might be used to finance an MNR. This paper summarizes the outcomes of that workshop.

There has been very little work in the past on this topic and the workshop served to begin a discussion that should continue in the future as the MNR concept is further developed and individual country interests in shared solutions increase.

2. WHY AN MNR?

Many countries currently have small nuclear power programs that generate relatively small amounts of spent fuel and/or high- level waste. The number of countries adding nuclear power generation to their energy mix is expected to increase over time, and this will likewise increase the number of nuclear power programs generating relatively small amounts of spent fuel.

There are over 250,000 metric tons of spent fuel in temporarily storage in thirty-three countries worldwide. This number is an estimate given in the latest IAEA publication [10]) from 2018. It takes the total from 2013 367,000 metric tons of spent fuel and subtracts the spent fuel that has been reprocessed (120,000). Almost none of these countries have a clear path to final disposal of this fuel or of the wastes that could arise from its reprocessing. These wastes require technologically advanced treatment and management procedures from storage to final disposal.

The long timescales over which some waste remains radioactive has led to the idea of deep disposal in underground repositories in stable geological formations. Isolation is provided by a combination of engineered and natural barriers (rock, salt, clay) and no obligation to actively maintain the facility is passed on to future generations. Deep geological repository (DGR) disposal is the preferred option for nuclear waste management in several countries including Argentina, Australia, Belgium, Canada, Czech Republic, Finland, France, Japan, the Netherlands, Republic of Korea, Russia, Spain, Sweden, Switzerland, the UK, and the USA [11].

Development of a DGR involves high fixed costs that possess an associated economy of scale. A DGR to dispose of 10,000 metric tons can cost a little more than one to dispose of 5,000. This means that smaller nuclear programs would benefit greatly from the opportunity to participate in a project where many countries dispose of their wastes in a single DGR. Accordingly, the MNR concept involves a service provider country developing a geologic repository and accepting spent fuel and high level radioactive waste from several customer countries.

3. CHARACTERISTICS OF A DGR PROJECT

3.1. Phases and spending profiles.

There are four basic phases for the development of a DGR project given below. Some generally applicable durations and spending profiles based on reviewing available information from national DGR programs were estimated and are given here:

- Siting and Licensing – 20 years – 15% of total costs;
- Construction – 15 years – 35% of total costs;
- Operations – 40 years – 45% of total costs;
- Decommissioning, closure, long term monitoring – 75 years – 5% of total costs.

Programs reviewed included France, US, Finland, Sweden, and others.

The nominal 35 year period from project initiation to commencing operations is well beyond that of most construction projects. Although the initial siting and licensing phases do not require large upfront investments, as much as 50% of the total costs are incurred before disposal operations can begin.

Note that these time periods are conservative (based on expectations for a project done today) and present significant financing challenges. If assumptions are added that include completed national experience in

developing a DGR, it is possible that the time periods could be reduced to perhaps 13-15 years for Siting and Licensing and 10 years for Construction. Under these assumptions perhaps the lower costs of Siting and Licensing could occur without significant financing, and the financing that would be required for Construction would be for a 10 year period, closer to existing experience in financing project before revenues begin.

3.2. Per Unit disposal costs

Guidance for cost estimation has been published by the NEA, EDRAM, and the IAEA, and some nations have formal guidance on costing major national infrastructure projects extending over long periods.

A DGR project will have both fixed and variable costs that described as:

(a) Fixed
- (i) Site selection and permitting;
- (ii) Surface handling facilities;
- (iii) Transport infrastructure;
- (iv) Access shafts/tunnels;
- (v) Access closure and sealing;
- (vi) Environmental monitoring.

(b) Variable
- (i) Emplacement tunnels, vaults, boreholes;
- (ii) Disposal operations;
- (iii) Encapsulation of sf/hlw.

Estimates for the costs of disposal are around $1 million USD per metric ton of spent fuel. Because of the significant fixed costs, the costs will be lower per unit for large volume repositories and higher per unit for small repositories. The understanding of disposal costs will continue to be projections until there is actual experience with an operational project.

4. MNR FINANCING

Although financing is an issue shared by all repository projects, as a multinational project an MNR presents a unique case with issues such as the sources of funds, timing of revenues and expenditures, and the allocations of risk. The IFNEC workshop on approaches to financing an MNR was intended to serve as a starting point for fostering robust discussions that would identify and develop those issues [12].

In organizing the workshop IFNEC asked a group of international experts [13] on financing and nuclear project development to propose their own creative approach to financing an MNR. The approaches were presented in some detail. The following are brief summaries of each. Note that these approaches are intended to be conceptual, hopefully encouraging further creative thought and discussion.

4.1. Approach 1: It is clearly challenging to finance one MNR…but may be easier to finance several

This approach assumes a consortium of countries in different regions of the world interested in developing an MNR. The first MNR (MNR-1) will have the largest risk in terms of siting, licensing and construction, however all participating governments would share the upfront risk for siting, licensing and construction. Private funding will come in during the commercial operation. Based on a harmonized approach and replication to the extent possible, risk for MNR-2, MNR-3, MNR-4, etc. should decrease. Siting, licensing and construction times should also decrease.

4.2. Approach 2: Two Approaches: government lead with and without customer investment

This presentation identified two approaches to financing. The first approach (Option 1) involves the government developing the project and providing initial financing from development through initial operation

(waste emplacement), at which point an exit strategy (in part) could be utilized. The second approach (Option 2) focuses on the early financial participation of the Customers through the purchase of shares in the repository project, with finances managed in an arms-length fund. In the case of Option 1, the government leads the overall effort, with its role decreasing over time. With Option 2, the effort is co-led by the government and one or more customers that take membership interests in the project.

Both Options assume the following:

(a) The government will need to provide overall leadership with an underpinning of public and political support, legal & regulatory regimes, and the necessary supporting infrastructure;
(b) Initial participation, while supported by commercial commitments, will rely on government-to-government relationships to establish participation from customer countries, with contractual commitments that are backstopped by sovereign guarantees.

4.3. Approach 3: Sell shares in the repository project with return on investment coming from fees collected during operation

This approach to financing posits a country sponsoring the development of a geologic repository project through a state-owned agency that would be empowered to enter into multilateral agreements with other countries selling equity shares in the project. Shares would be sold in a venture capital style model, with funding rounds reflecting the project's current status. Parties to the project would appoint a trustee to manage the funds to ensure transparency.

4.4. Approach 4: Financing with a staged interim storage/repository approach

A staged repository consists of an initial phase of developing and operating a spent fuel storage facility (dry storage) with a portion of revenue allocated to development of a co-located repository. This approach would facilitate commercial investor involvement in a step-wise fashion, and build credibility and experience for nuclear fuel management by phasing out "by and for governments only" and replacing with commercial investment based on optimized cost and knowledge management. It includes selling shares in the repository project with return on investment coming from fees collected during operation.

5. CONCLUSION

As a matter of policy, countries that generate spent nuclear fuel set aside funds to support disposal. Those funds could be used, depending on national authorities, for developing in-country disposal capability, or purchasing an international disposal service. Funding for an MNR exists today. The financial challenge lies in identifying the financing arrangements for developing the project that are attractive for all stakeholders: governments, the service provider, the customer, investors, etc.

The Workshop was an initial effort to identify non-traditional financing approaches for a unique case, i.e., financing the construction and operation of an MNR. It is interesting that even though independently developed, there are common themes in the approaches presented. Each approach may present opportunities for further consideration and analysis.

There is considerable international interest in the MNR concept. IFNEC is pleased to have initiated what is hoped will be the first of many further discussions on this topic. We suggest that further discussions addressing approaches to financing an MNR could be the key to unlocking the first MNR project.

REFERENCES

[1] MCCOMBIE, C., JEFFERSON, M., Renewable and nuclear electricity: Comparison of environmental impacts, Energy Policy **96** (2016) 758–769.

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Framework and Challenges for Initiating Multinational Cooperation for the Development of a Radioactive Waste Repository, IAEA Nuclear Energy Series No. NW-T-1.5, IAEA, Vienna (2016).

[3] INTERNATIONAL FRAMEWORK FOR NUCLEAR COOPERATION., Financing Multinational Repositories Workshop, Approaches to Financing a Multinational Repository – Challenges and Alternate Approaches, IFNEC, RNFSWG, Paris (2018).
https://www.ifnec.org/ifnec/jcms/g_11435/rnfswg-mnr-financing-workshop

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Technical, institutional, ad economic factors important for developing a multinational radioactive waste repository, IAEA-TECDOC-1021, IAEA, Vienna (1998).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Developing multinational radioactive waste repositories: Infrastructural framework and scenarios of cooperation, IAEA-TECDOC-1413, IAEA, Vienna (2004).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Technical, economic and institutional aspects of regional spent fuel storage facilities, IAEA-TECDOC-1482, IAEA, Vienna (2005).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Viability of sharing facilities for the disposal of spent fuel and nuclear waste, IAEA-TECDOC-1658, IAEA, Vienna (2011).

[8] EUROPEAN COMMISSION, Strategic action plan for implementation of European regional repositories: Stage 2, SAPPIER II, Brussels (2008).

[9] INTERNATIONAL FRAMEWORK FOR NUCLEAR COOPERATION., Practical Considerations to Begin Resolving the Final Spent Fuel Disposal Pathway for Countries with Small Nuclear Programs (2016) https://www.ifnec.org/ifnec/jcms/g_10234/2016-ifnec-practical-considerations-to-begin-resolving-the-final-spent-fuel-disposal-pathway-for-countries-with-small-nuclear-programs

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, Status and Trends in Spent Fuel and Radioactive Waste Management, IAEA Nuclear Energy Series NW-T-1.14, IAEA, Vienna (2018).

[11] WORLD NUCLEAR ASSOCIATION., Storage and Disposal of Radioactive Waste (2018), https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/storage-and-disposal-of-radioactive-waste.aspx

[12] A report of the workshop will be completed shortly and placed on the IFNEC.org website. Currently the website includes the presentation made at the workshop, see URL noted in reference [3]. INTERNATIONAL FRAMEWORK FOR NUCLEAR COOPERATION, (2019) https://www.ifnec.org/ifnec/jcms/j_6/home

[13] The experts that developed the four financing approaches were:

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