The Japanese Geological Programme in an International Context

Charles McCombie

Introduction

Geological disposal was first proposed around 50 years ago by the US National Academy of Science and is now recognised by all nuclear nations as the only safe approach with currently available technology to the final disposal of long-lived wastes. This conclusion has been re-affirmed most recently in Canada and in the UK, in each case after an intensive public consultation exercise. In Japan, geological disposal has been set into the national legal framework. Over the last decades enormous amounts of R&D have been performed in advanced nuclear nations in order to understand the processes and the events which determine the long-term safety of geological repositories. However, progress towards implementation of such facilities has been slow.

There are practical reasons why repositories for high level wastes or spent nuclear fuel were not implemented much sooner. The most obvious of these is that the 40-50 year cooling period that most countries foresee in order to avoid problems with unacceptably high temperatures in the repository. But repository implementers have also faced specific challenges that make their task an undertaking that lasts years or decades. Some of the challenges are scientific and technical – but most remaining hurdles are socio-political. The greatest of these is identifying sites that are geologically and environmentally suitable and that are acceptable to the local community. In practice, only in Finland has a site for deep disposal been agreed at all necessary regulatory and legal levels. A few other countries are quite close to this stage (e.g. Sweden, USA and France), but they have not yet cleared the final hurdles. Furthermore, all these programmes, including the Finnish success, have spent decades in the siting process.

In the following sections, I will look briefly at the two key challenges of geological disposal and comment on progress being made in these areas by the NUMO programme. The goals are:

- Building credible science, technology and engineering capabilities that are needed for constructing and operating safe repositories.
- Establishing a transparent and fair process that will result in identification of a suitable site which is accepted by the local host community.

The goals are, of course, not independent of one another. Sound science is a necessary – but not sufficient – prerequisite for successful siting.

The roles of R&D in Geological Disposal

One of the fascinating aspects of working in repository development is the multi-disciplinary nature of the challenges faced. Although the actual technologies applied are much less high-tech than in many other fields, designing and understanding the multi-barrier safety system of a deep repository requires expertise in nuclear physics, chemistry, engineering, earth sciences and bio-sciences. Moreover, the unprecedented timescales that repository safety analysts must consider adds a new dimension to the complexity of their work. Various human activities have extremely long-lasting or permanent consequences for our environment (e.g. exploitation of raw materials, increasing of atmospheric CO_2). However, only with the advent of the challenge of disposing of very long-lived radioactive waste did society become directly aware of such far-future issues. Multidisciplinary waste management teams trying to understand how a repository system might evolve over many thousands of years have played a pioneering role, which will be followed in other environmental areas.

Is there still a need for further R&D? This question has been posed often by those organisations that fund the corresponding work – often along with a reference to the claims of the nuclear community that safe solutions to disposal are already available. In practice, there are several justifications for further scientific and technical work. These can be summarised as follows.

Developing technical solutions to unsolved problems: Although there are no major unsolved problems hindering stepwise progress toward implementation, final choices for some technologies, e.g. backfilling and sealing or monitoring technologies, require further R&D.
Increasing confidence is the safety of repositories: More data and studies (e.g. from long-term experiments, analogue studies or field investigations) are definitely needed to improve scientific understanding and to demonstrate more convincingly to other stakeholders that scientists do have adequate understanding of the key processes determining long-term repository behaviour.
Replacing (over) conservatism by well-justified realism: In numerous areas, very conservative assumptions are made when designing repositories or when modelling their performance.
Technical or economic optimisation: Examples of developments which could help optimisation are simplifying container design or emplacement techniques, improving site-characterisation methods, repository construction methods, etc.
Transfer of new technologies developed in other fields (if cost/benefit justifies): Because the development and operation of waste management facilities runs over many decades, there could be opportunities for using or adapting new technical or scientific ideas developed in elsewhere.
Developing next generation technology (if needed): This is a goal to which significant R&D efforts are being applied today. Since current disposal concepts do indeed provide high levels of safety, then careful consideration is needed concerning the cost/benefit ratio of such work.
Sound applied science & technology are needed for carrying through waste management processes: A key point to be noted by scientists and technologists in waste programmes, and by programme funding bodies, is that the application of high quality science and technology will be necessary for a long time because of the challenging nature of tasks such as radioactive characterisation of diverse waste streams that will change as reactor fuel cycles develop, geological characterisation of repository sites with increasingly sophisticated tools, and communication of information and knowledge with new technologies.

The above list should make obvious that there is a wide range of proper justification for continuing scientific efforts in the waste management field. A final key point is that a sound scientific and technical programme that engages a wide spectrum of the national research community and is transparent to experts and to the public can contribute greatly to the acceptance of a repository programme. This is an important consideration in the sensitive process of repository siting.

The Challenge of Repository Siting

Over the past decades, there has been an evolution in approaches to selecting specific potential sites for waste management. In an early the phase, the use of "expert judgement" was common – often exercised, however, behind closed doors. Groups, primarily of technologists, would gather together in order to select specific sites and they would proceed then to plan how best to "decide, announce and defend" their decisions. This was not highly successful. Following this, hope was then placed in developing a logical, traceable procedure, which would narrow in progressively to single sites, which everyone must logically recognize as the "best choice". However, this approach is extremely problematic; the element of subjective judgement in narrowing the options remains high enough to fuel disputes even amongst the experts. Moreover, the technical criteria that were proposed for use commonly neglected key societal aspects.

The next approach – and currently the most common – is to use a multi-attribute analysis. This is a technique that attempts to identify all criteria influencing the choice of options, to quantify how well each option matches the criteria, and to combine the quantified scores, using appropriate weighting factors in order to give a ranking of preferences. The scores and especially the weightings can be allocated by different stakeholder groups, a feature which allows one to include also the wider non-technical issues. This approach is promising – provided that there is full transparency concerning the parameters and also the weighting factors, which are employed when combing judgements on the individual parameters.

A final approach is to select potential sites by soliciting volunteer communities. Current siting guidelines from the IAEA recognize the validity of the volunteering approach with one key provision, namely that "the selected site provides an adequate level of safety". Volunteering or, at a minimum consenting, to be a potential repository host is becoming more common. Canada and the USA have recently chosen this route and, as expanded on below, NUMO has been a pioneer in the volunteering approach.

Today the characteristics of a suitable siting process are broadly agreed to be as follows:

- It is adaptively staged and acknowledged to be a multi-year process that will evolve as the implementers take on board feedback from all stakeholders.
- The siting process is based on objective, transparent, pre-defined and well-documented criteria.
- The objective is to identify sites that are demonstrably safe and the process is not based on claims that a "safest" site can be identified.
- The process includes true dialogue between all stakeholders, especially potential hosts, with the objective of ensuring that it is regarded as fair and equitable by all.
- The aim is to identify informed and willing repository hosts that will subsequently be full partners in the repository implementation process.

The Japanese HLW Programme in an International Context

How does the work being done in Japan on HLW disposal measure up against the international consensus positions on R&D and on siting, as they are sketched above?

R&D Work

In the R&D area, a long period of building Japanese expertise and research capacity has taken place. Early work by JAEA (or its earlier component bodies JNC and JAERI), CRIEPI and RWMC gave a firm foundation for the NUMO work. Key products were research facilities like ENTRY, QUALITY and the underground research laboratories as well as conceptual designs such as those in the H-12 study. When NUMO was created following the careful preparatory work of SHP, it was able to focus on using this basis, along with input from foreign disposal programmes, to set its own priorities in developing an R&D programme. The NUMO approach to integrating results of other national programmes was particularly well structured. The International Technical Advisory Committee (ITAC) which was established included individuals with intimate knowledge of what had been successful (as well as of what lessons had been learned from failures) in a wide range of national disposal programmes. The combining of ITAC advice with local knowledge from NUMO's Domestic Committee (DTAC) should continue in future to guarantee a well structured R&D programme.

The emphases that NUMO has set in its technical work in its early years have been determined directly by key features of the Japanese HLW programme. Because of the volunteering system, which could lead to consideration of a wide variety of potential disposal environments, great importance has been ascribed to developing a flexible range of repository concepts and site investigation programmes. In addition, organisational approaches have had to be developed for managing the evolution in concepts, designs and programmes as the repository implementation process proceeds. Particular attention has been paid to studies of the engineered barrier system, which is a rational strategy, given the uncertainty in which geological the environments will become relevant as volunteers emerge. In the earth sciences, NUMO has correctly decided that it must become a world leader in the tectonics field, given the geological conditions that prevail in the country. The ITM group organised by NUMO have established the combined expertise of the Japanese and international participants as being at the forefront in this area. This is recognised globally.

Siting

In its approach to site selection, NUMO, soon after its establishment, became a focus of attention world-wide. Having observed that the greatest siting problems were associated not with technical difficulties but rather with achieving public acceptance, NUMO decided to initiate a purely volunteering approach. This was not, however, done without careful preparation of the documentation that was thought to be essential for potential volunteer communities. Part of this documentation illustrated the technical aspects of repository design construction and operation. This part emphasised the flexibility that was available to tailor repository concepts to specific siting environments in a way that could guarantee feasibility, safety and economic viability.

Even more important was the early publication of siting factors that would allow potential host communities to independently verify that they could be acceptable hosts and would demonstrate to the public that only geologically suitable siting areas would be considered by NUMO. This crucial step corresponds directly to the second of the consensus siting requirements listed above. Unfortunately for NUMO, the further requirement concerning initiating true dialogue with potential siting communities has been as yet impossible to satisfy fully – primarily because the mechanics of the formal volunteering process provided more opportunities for nuclear opponents to put their views than it did for close interactions with NUMO. This situation may change with the recent amendments of the Disposal Law.

In the context of the present Forum on R&D, it is vital for NUMO, as for any disposal body, to note that its activities in the areas of R&D and of siting strategy are tightly interconnected. A well-justified, transparent and competently run R&D programme not only delivers the technical input upon which progress is dependent. It also can greatly enhance the credibility of the implementing organisation and hence make an important contribution to the public acceptance of a repository programme.

Conclusions

The following brief conclusions can be made concerning the Japanese HLW disposal programme – and in particular its R&D components:

- Taken together, the R&D work being done by the wide range of Japanese organisations involved results in an extensive portfolio of research projects in the area of geological disposal.
- There is scope for further coordination of R&D work between the numerous organisations involved.
- Based on R&D work done in the long preparatory phase before its formation, NUMO has built up a structured technical programme with R&D reflecting the priorities of a implementer.
- NUMO has made particularly effective use of existing knowledge and expertise through its use of Japanese and international guiding bodies It has also placed emphasis on developing structured approaches to tracing the future developments in data, plans or boundary conditions in its programme.
- The nature of both the technical repository concept development work and of the siting studies properly reflects the flexible approach need in NUMO’s volunteer siting approach.
- A credible scientific and technical programme is an essential basis for the acceptance of a repository implementation programme. For maximum effectiveness in this regard, it is also necessary that the scientific work be openly available to all interested parties and that the technical staff be aware of their additional role in addressing a wider public through their scientific and engineering work.
- For successful siting, the sound technical work must be complemented by socio-political measures that encourage dialogue with interested parties at all levels in the Japanese system, from Government Agencies to local communities and individuals.
- The scientific, technical, engineering and socio-political challenges facing NUMO will extend over many years into the future. This will necessitate interdisciplinary project work that is carried out in a sustainable fashion by dedicated, long-term staff, a structured recruitment policy and special training programmes.