German Research & Development for High Level Waste in Light of the New Site Selection Process – 15516

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ABSTRACT

The German government decided 50 years ago, that radioactive waste is to be disposed of in Deep Geologic Repositories, preferably in a salt rock formation. Soon after, in 1967, research in the Asse salt mine was initiated. Since then substantial progress has been achieved in the development of the radioactive waste disposal programme in Germany.

For a geologic repository for High Level Waste in salt a reference concept has been developed, which represented the radioactive waste management processes from transport of High Level Waste and Spent Nuclear Fuel to an interim storage site, waste conditioning and repackaging for disposal, to emplacement of the waste packages. The feasibility of the reference concept has been proven by demonstration tests for all relevant equipment: a pilot conditioning plant has been built as well as the main equipment for the entire transport chain including the shaft transport and emplacement technologies for heavy loads fulfilling strict requirements for nuclear and mining safety. Also the backfilling technology has been optimised for the purposes of a repository for radioactive waste. Finally, tests have been performed to verify thermo-mechanical models for the host rock.

The demonstration tests have been performed to an extent which even would allow immediate licensing of the repository and the employed equipment. The Research & Development work was completed by further optimisation of the reference concept. Construction and operation of deep geologic repositories for low and intermediate level radioactive wastes in Germany benefitted from the above mentioned but also stimulated the knowledge and experience build-up for the repositories for High Level Waste.

Despite the well progressed work for a deep geologic repository in salt R&D work in Germany for already a long time also considered other host rock formations. While work for crystalline rock mainly consisted of relatively small contributions to international research projects due to the limited occurrence of suitable sites in Germany, projects and developments for repositories in clay formations have had an increasing contribution to the overall Research & Development work for radioactive waste repositories in Germany.

In July 2013 a new site selection act was put into force, which set the initiating conditions for the German programme on radioactive waste management. Principally, a process was initiated to search for a site for a deep geologic repository for High Level Waste independent from earlier decisions. This means that a site shall be determined without predetermination by earlier decisions. Nevertheless, to enable a sound decision for a site selection it is necessary to be able draw back on the knowledge and experience from earlier activities. Otherwise, tedious learning processes would have to be experienced again. Since efforts to open up a site selection process again grew since the late 1990s projects had been implemented timely to capture existing knowledge.

The paper at hand describes the achievements of R&D activities in Germany, the change of radioactive waste management policy and the endeavours to maintain the achievements.

INTRODUCTION

In the fall of 2010, the German federal government extended the operating lives of all of the country's NPPs. However, the tragic accident in Fukushima in March 2011 led Germany to reverse its energy policy. Germany's amended Nuclear Energy Act (AtG – Atomgesetz), which took effect in July 2011, mandated the immediate shutdown of eight NPPs and significantly curtailed the operating lives of the remaining nine. Their operating licences will expire between 2015 and the end of 2022. Thus, the new amendment of the AtG put an end to approximately 60 years of successful peaceful use of nuclear energy in Germany.

In addition, Germany's objective regarding the management of spent fuel has changed. Until 1994, the AtG required to reuse the fissile material in the spent fuel. Since July 2005, transport of spent fuel from power reactors for the purposes of reprocessing has been prohibited following an amendment to the AtG which came into force in 2002. Consequently, the direct disposal of existing and future spent fuel is now the only route of waste management in Germany.

As there is yet no repository available for the spent fuel, spent fuel is to be stored in on-site interim storage facilities. At twelve nuclear power plant sites, decentralised interim storage facilities for spent fuel have been licensed under atomic law, constructed and commissioned. They are designed as dry storage facilities in which transport and storage casks loaded with spent fuel are emplaced.

There are conceptual considerations regarding the design of a repository. The concept of direct disposal as considered in Germany provides that following interim storage of several decades, spent fuel will be packed into casks suitable for disposal and that these will be sealed leak-tight and emplaced in drifts or boreholes in deep geological formations. The prototype of a conditioning facility for packaging spent fuel has been built at the centralised storage site at Gorleben. Next to that site an exploration mine exists, the suitability of which as repository is not disproved yet. In fact, the design and safety concept of which has been developed to a high maturity, which is based on comprehensive past Research & Development (R&D) activities.

In the following the impact of the change of nuclear policy on the R&D in Germany is described in more detail.

HISTORIC OUTLINE OF GERMAN HIGH LEVEL WASTE POLICY

Activities in Salt

In December 1957, the first German atomic energy program was adopted, and the need for research work on the disposal of radioactive waste was highlighted, in the memorandum of the German Atomic Energy Committee. In 1959, the Federal Institute for Soil Research in Hanover (which today is the Federal Institute for Geosciences and Natural Resources (BGR)) recommended salt rock as an ideal host rock for a deep geologic repository (DGR), and in 1963, the Federal Institute for Soil Research proposed final disposal in rock salt formations for further exploration.

In the course of two multiphase selection processes, the Federal Government looked for salt structures for the purpose of final waste disposal and for a site for a WMC (Radioactive Waste Management Center – reprocessing, fuel element production, conditioning and disposal concentrated at one site) including a repository. Geological exploration work at the sites mentioned was suspended in 1966 and 1976

accounting for protests from parts of the local population. Despite numerous and constantly voiced opinions, the decision reached in February 1977 to construct an WMC, including a repository, at the Gorleben site in the Land of Lower Saxony was systematically made on the basis of a selection process founded on objective technical and scientific criteria [1]. There is no foundation to any accusations claiming the selection process was influenced by policy makers which could have resulted in Gorleben being a "preselected" site. There were public protests against the project but the project did have its supporters, particularly at a municipal level. It can also be said that the Gorleben repository project was revolutionary at its time in terms of public participation, including the general population and participation at a municipal level.

A definitive statement on the suitability of the salt dome can only be issued once the exploration work has been completed. This was supposed to require around five more years once the moratorium has been lifted.

40 years of repository research and over 500 successful research projects provide the basis for implementing a safe and secure repository for high-level waste in rock salt as a host rock. From1965 to 1995, research and development work for the final disposal of radioactive waste in salt formations was carried out at the Asse II mine, a former salt mine. Against this backdrop, low- and medium level waste was also deposited until 1978. The focus of the various research projects included investigating the interaction between radioactive waste and the salt formation as well as various emplacement technologies.

OVERVIEW OF GERMAN R&D FOR HIGH LEVEL WASTE

Even though approximately 100 years of experience of mining in salt rock was already available in Germany at the start of the repository program, and thus also notable information on the salt rock behaviour, it was noted that specific knowledge is necessary for the purpose of High Level Radioactive Waste (HLW) disposal.

The predecessor of the BGR was established in the 1958 as an important partner and consultant to ministries and industry for geotechnical issues, like evaluating the stability and suitability of underground cavities, in particular in terms of long-term safety assessments of waste repositories. Inter alia, BGR researchers have developed special testing equipment for investigating rock properties and used it to perform creep tests on salt samples to determine the effective micro-mechanism deformation laws. In-situ tests are used to supplement the laboratory tests. Accordingly, BGR founded a new field of research – salt mechanics – within the field of rock mechanics in the mid-1960s.

In 1965 the former Asse mine was acquired by the Studiengruppe Tieflagerung radioaktiver Abfälle (Study Group on Deep Disposal of Radioactive Waste), a group at the Research Centre in Karlsruhe, with the aim to perform research projects based on existing knowledge, but tailored to establish a knowledge base relevant for radioactive waste disposal in salt and derived from realistic conditions. The initial research program comprised three main areas and included, beneath others, the following topics [2]:

- Geophysical assessment of the rock characteristics in the Asse mine, which are relevant for the rock stability and the suitability for disposal:
    - Mounting of a metering point mesh and regular survey of the mine to determine rock movement;
    - Determination of the pressure resistance of the rock and examination of the rock stability of the salt pillars;

- Observation of the rock behaviour under the influence of heat and pressure;
- Observation of a potential change of pressure resistance under the influence of radiation;
- Measurement of permeability in the laboratory.

- Evaluation of disposal technologies of Low and Intermediate Level Waste:
    - Experiments on sealing artificial caverns in salt rock;
    - Examination of ventilation technologies;
    - Tracer experiments on the distribution of radionuclides in mining filled with saturated brine;
    - Fouling and corrosion experiments with wastes in the presence of salt;
    - Corrosion experiments with structure materials.
- Issues of conditioning and emplacement technologies for high level waste and spent nuclear fuel:
    - Design of a conditioning plant;
    - Development of underground transport vehicles and repackaging equipment;
    - Design of deep geologic repositories.

These areas have constantly been revisited, enlarged and filled with important R&D projects. Besides generating knowledge and experience for the underground handling of Low Level Radioactive Waste (LLW) and Intermediate Level Radioactive Waste (ILW) which can also be used to transfer general considerations to the operation of a Repository for HLW, experimental programs focussed on the influence of temperature on the salt rock, on the influence of radiation on the salt rock, and on the development of technologies for backfilling and closure of DGRs. In the following a selection of important tests are briefly summarised:

- From 1981 to 1986, The “Brine Migration Test” was jointly performed with the US Department of Energy (DOE). In this large-scale test strong Co 60 sources and electrical heaters were used to study the combined influence of radiation and heat on rock salt. The results were very encouraging and proved the suitability of rock salt as host rock for disposal of HLW and spent nuclear fuel.
- The BAMBUS study (Backfill and Material behaviour in Underground Salt Repositories) was carried out as final step of the more general “Thermal Simulation of Drift Emplacement” (TSS) test, which was designed to study in detail the thermal and mechanical impact of heat generating waste onto the host rock and the backfill material. The TSS test involved POLLUX casks mock ups in two parallel emplacements each heated with a thermal power of 6.4 kW over a time of nearly nine years. The BAMBUS project was aimed at improving the understanding of the behaviour of backfill and salt in a repository in rock salt by examining the material which was used for backfilling the POLLUX mock ups.
- The “Active Handling Experiment with Neutron Sources” project (AHE), which ran from 1991 to 1995, was devoted to study the effects of neutron and gamma radiation backscattering from the underground vault walls. In this project, co-financed by the European Commission, the French waste management and disposal agency ANDRA was involved among other foreign parties. The aim was to verify by means of in-situ measurement the forecasts of occupational dose burden to future repository operators during underground waste handling and emplacement.
- The “DEBORA” project, running between 1991 and 1999, was devoted to demonstrate the functioning of the seals that will close the boreholes used to dispose of vitrified waste canisters.

Since 1979 projects had been carried out aiming at the development of a concept for a DGR to a stage, which would allow full licencing of a repository. A reference design had been developed which was later further developed to different alternatives. Nuclear licencing involves, that only proven technology can be used, which in turn is also shown to be state-of-the-art. Since respective technological solutions were not available, specific equipment had to be developed first and then qualified to comply with the above mentioned requirements. Therefore, a demonstration test for shaft transport of heavy loads was performed

proving the technical feasibility of shaft hoisting equipment with a payload of 85 t, including essential machine components and parts, as well as demonstrating safety of the transport process considering especially radiation protection. Similarly, handling tests for drift disposal as well as vertical disposal in underground boreholes aimed at demonstrating the safe handling, horizontal transportation, and disposal of the disposal casks. The experiments were built in a 1:1 scale in a mock up environment, but with real equipment. Up to 2000 test runs had been performed per test showing the reliability and safety of the technical components.

In parallel to the development of a conceptual design, the assessment of the Gorleben site began. The above ground exploration comprised mainly hydrogeological and geo-physical assessments, seismic measurement, drilling to the surface of the salt dome as well as deep drilling, and pilot drilling for the shaft. Below ground exploration started in 1986 with sinking of the two shafts. Until the suspension of the activities in 2012 the exploration area 1 had been mined and the site has been extensively assessed with view to the geological mapping of the salt dome in Gorleben and its homogeneity, with view to presence and origin of hydrocarbons, and with view to the chemical and physical properties of the local salt rock.

When the first moratorium on Gorleben ended in 2010, a comprehensive study named VSG (Vorläufige Sicherheitsanalyse Gorleben – Preliminary Safety Analysis Gorleben) was initiated to summarise systematically the state of knowledge about the Gorleben site, from the geology over the conceptual design including the technology to the performance analysis. In regard of the ongoing discussion in Germany the work didn't aim on a suitability statement for Gorleben, but just on the summary and the potential to transfer the experience and knowledge to other repository projects. The project finished beginning of 2013 and was extensively discussed at the WMS 2013 (see e. g. the introductory presentation in [3]).

Programmes for other host rocks

In Germany, there has been interest in having a backup solution already for a long time in case a repository in rock salt cannot be implemented and Germany has to resort to granite or clay host rocks. In addition, studying alternative formations was deemed beneficial for the work on salt, for it would facilitate evaluating the advantages and disadvantages of this host rock. Consequently, since the beginning of the 1980s, granite increasingly became the focus of investigations as potential host rock for a final repository of radioactive waste, followed by work on clay from the mid-1990s. At first, German R&D organisations were in an observing position rather than in an active role, but more application oriented work started for granite at the end of the 1990s and for clay in 2001. German research and development institutions have been and continue to being involved in several international research projects and performing tests in foreign Underground Research Laboratories (URLs).

There are several studies, e. g. prepared by the BGR, reviewing the suitability of clay and crystalline rock. In addition, approaches have been developed to transfer methodologies from salt to other host rocks. Due to its potential availability, generally speaking, in Germany more activities and projects are related to clay rather than aiming on crystalline rocks as potential host rocks for a DGR, and, therefore, the programme for a DGR in clay is further developed then for a DGR in crystalline rock. Since 2011 the project ANSICHT (Methodik und Anwendungsbezug eines Sicherheits- und Nachweiskonzeptes für ein HAW-Endlager im Tonstein – Methodology and Application of a Safety and Verification Concept for a HLW Repository in Clay) – similar to the VSG – is aiming on summarising the state of knowledge for a generic DGR in clay in order to identify the up to date achieved level of quality and completeness of information and methods to assess the safety of such a repository.

So far the following results have been achieved:

- Long term projections for two regions;
- Host rock specific safety concept;
- Two conceptual design considering retrieval and recovery option;
- Generic backfilling and sealing concepts;
- Safety assessment methodology;
- Features, Events, and Processes catalogue for the first region;
- Definition of reference scenario; and
- Methodology for integrity verification and definition of the data base.

Worldwide there is not much experience of mining large facilities in clay. Hence, it again is of great value that inside the organisations of BfS and DBE substantial know-how is bundled due to the operation and erection of Konrad. Konrad is a former iron mine, where the iron is mainly present in oolite form surrounded by clay and clayish rocks. Thus, the Konrad mine offers similar advantages to the clay programme as the ERAM does so for the salt programme.

SITE SELECTION ACT OF 2013

In 1998, a coalition of the Socialist Party of Germany (SPD) and the Green Party had been elected in Germany for the first time for the Federal Government. From the very beginning of his term the Federal Minister for the Environment aimed on stopping all nuclear activities in Germany. Part of his policy had been to object Gorleben's suitability to host a GDR against the prevailing opinion amongst experts. Consequently, in 1999 he implemented a study group (AkEnd – Arbeitskreis Auswahlverfahren Endlagerstandorte) and tasked it to develop an approach for site selection independent of the geology and without any prejudice of any region in Germany. Initially 18 experts from the areas of geo-sciences, social sciences, chemistry, physics, mathematics, mining, repository technology, engineering, and public relations, supported by representatives of BMUB and BfS, had been assigned to the study group. By the end of 2002 they presented their results. While confirming deep geologic disposal as the only reasonable option for HLW disposal, they proposed a stepwise process for a site selection, with defined technical and societal decision criteria for moving forward from step to step.

Before the finalisation of the work of AkEnd the Government and the nuclear power plant operators came to an agreement on the future of nuclear power, which included that the Gorleben site shall continue to be the preferred site for a DGR for HLW, as long as its suitability is not disproven. Hence, the results of the AkEnd have not had an immediate effect on Germany's HLW program, but they form part of the basis for current discussions.

After the German Government made undone the nuclear phase-out in the autumn of 2010 it decided in summer of 2011 again to stop the use of nuclear energy for electricity production. This included the request for a repository for HLW, the decision on which shall be based on a national consensus between politics and public. Subsequently, after long negotiations the new site selection act (Gesetz zur Suche und Auswahl eines Standortes für ein Endlager für Wärme entwickelnde radioaktive Abfälle und zur Änderung anderer Gesetze – „Standortauswahlgesetz", StandAG) was put into force on July 27th, 2013. The act shall enable the search for a site which ensures the highest possible safety over a period of one million years. Thereby, the Government dismisses the plan to further explore the Gorleben salt dome, but to keep it as a potential site until either in the process of comparing sites Gorleben is deselected or its suitability is disproven.

To enable the site selection process, new criteria shall be developed and the overall organisation of the HLW programme shall be assessed and potentially adapted. This shall be done until the end of 2015 by the Disposal Commission, with the possibility to extent the process once for half a year. In 2023 sites shall be identified for underground exploration and in 2031 the decision shall be made for the final site selection.

The Disposal Commission is supposed to be a so called pluralistically assigned body with 32 members from politics and different public interest groups. The commission consists of eight representatives from the Federal Parliament, eight representatives from the states, eight scientists and two representatives from each of the following societal groups: workers unions, churches, industry and environmental organisations. In order to especially allow for representation of Gorleben critics, the Disposal Commission is led by two heads, who alternately lead the meetings.

Due to its decisive role in the site selection process the Disposal Commission should have been implemented directly after the enforcement of the StandAG. The representatives of the unions, churches, and the industry had been nominated without any substantial delay, while the environmental organisations initially declared to not participate at all. The members which had to be nominated by the Governments were identified after the Federal elections in September 2013. The decision on the two heads took until the beginning of 2014. Only then also the environmental organisations nominated their representatives. The constituting meeting took place on May 22nd, 2013. Since then, the commission has met altogether for seven times. Within the first year of its existence the Disposal Commission declares itself to be in a learning phase, i. e. working rules are defined and relevant basic information is gathered before in its second year the Disposal Commission can approach its main remit, the development of proposals for the following issues:

- Basis for decision whether to analyse scientifically alternative concepts to the direct disposal of HLW in DGR;
- Criteria for the site selection respectively exclusion;
- Criteria for error correction;
- Requirements on the organisation and approach for site selection and evaluation of alternatives; and
- Requirements for ensuring transparency.

To ensure a site selection process based on a scientific foundation and to ensure a transparent approach a Federal Office for Nuclear Waste Management (Bundesamt für kerntechnische Entsorgung – BfE) was established as a new supervising authority. Further remit of the BfE is to inform the public timely and throughout the entire site selection process by means of so called public dialogs to enable an open and pluralistic dialog. It also will be responsible for setting and collecting the financial contributions for the costs of the site selection programme. The BfE is subordinated to the BMUB and shall have the supervision upon the site selection tasks of the BfS, which also is subordinated to the BMUB.

According to StandAG, the BfE should have been implemented immediately after enforcement of the act. At the same time the need for the BfE at such an early time was questioned from many sites, mainly because most tasks and responsibilities of BfE refer to the time after the Disposal Commission has finished their work and the actual site selection process has commenced. That would postpone the need for the BfE to after 2015. Furthermore, it is one of the tasks of the Disposal Commission to review the organisation for the radioactive waste disposal program in Germany. A potential result could be that the

BfE would not be the appropriate body for the foreseen purpose. On the other hand, the argument went, the BfS has to be operational right from the beginning of the site selection process, i. e. staff has to be recruited and suitably trained. Since the BfE is also supposed to support the Government in administrative issues concerning radioactive waste disposal in Germany, the Government finally decided to follow StandAG.

Due to the above mentioned discussions the BfE was implemented with a delay of more than a year and started its activities on September 1st. In order to not prejudice any decisions, the BfE is commissioned with the support of the Government only. At the moment, it is concerned with the evaluation of costs related to keeping the exploration mine Gorleben in its current state. Furthermore, the authority is led provisionally only by the head of the Department for Central Functions, Funding Instruments and Structural Funds at the BMUB, and it is also provisionally based in Berlin at the BMUB. With regard to its currently downsized scope of responsibilities the approved staff is limited to the necessary size for performing administrative tasks such as preparation of fee bill. Any job advertisements shall be submitted to the Disposal Commission for information.

IMPACT OF SITE SELECTION ACT ON THE GERMAN HIGH LEVEL WASTE RESEARCH AND DEVELOPMENT PROGRAM

As indicated above as early as in the 1980s the objective originated to gain knowledge on other host rocks than salt and to develop methods to transfer knowledge and technologies from the cumulated experience to new applications. The pressure increased steadily since the end of the 1990s and finds its culmination in the current work of the Disposal Commission, which is not only supposed to question the approach for site selection, but shall also assess alternatives to deep geologic disposal as a safe answer for the HLW issue, even though DGR still is generally accepted as the only viable option. There are some single statements favouring long term storage mainly because of political reasons.

In light of the increasing request for enabling the transfer of specific knowledge and methodologies to general approaches the German R&D community responded to the request and moved from sole salt research to also include other topics, and also produced comprehensive studies to summarise the state of knowledge. VSG is a typical recent example for salt, which found its way into the respective project ANSICHT which refers to clay as a host rock.

Nevertheless, in Germany a coherent research and development policy for radioactive waste disposal does not exist, but different R&D programmes are currently running and regularly updated in order to align the R&D activities with the needs of the country. Principally, coordination of R&D for radioactive waste disposal in Germany is split into two main categories, site specific R&D coordinated by the BMUB (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit – Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety) and site independent R&D coordinated by the BMWi (Bundesministerium für Wirtschaft und Energie – Federal Ministry for Economic Affairs and Energy).

Concerning site dependent R&D the last noteworthy project had been the above mentioned VSG. Current activities at the sites are related to the development of specific technologies needed for the operation rather than R&D work. A peculiarity resulting from the decision to not prejudice any region in Germany to host a DGR is that on the web pages of the BMUB and the BfS all information on Gorleben including R&D reports is deleted apart from the announcements to reduce activities on site to a minimum.

The current site independent research programme is the continuation and update of the following research programmes, which started already more than 15 years ago:

- Research programme for disposal of hazardous waste in deep geological formation (1997 – 2001) (Forschungsförderung zur Entsorgung gefährlicher Abfälle in tiefen geologischen Formation (1997 – 2001);
- Priorities of future R&D work regarding the disposal of radioactive waste (2002 – 2006) (Schwerpunkte zukünftiger FuE-Arbeiten bei der Endlagerung radioaktiver Abfälle (2002 – 2006));
- Priorities of future R&D work regarding the disposal of radioactive waste (2007 – 2010) (Schwerpunkte zukünftiger FuE-Arbeiten bei der Endlagerung radioaktiver Abfälle (2007 – 2010)).
- Priorities of future R&D work regarding the disposal of radioactive waste (2011 – 2014) (Schwerpunkte zukünftiger FuE-Arbeiten bei der Endlagerung radioaktiver Abfälle (2011 – 2014)).

During 1997 to 2001 the research programme focused on R&D projects implemented in host rock salt formations and also, but with lower intensity, preliminary studies in clay and argillaceous and crystalline rocks were carried out. Due to the Federal Government's in 2000 announcing to phase out of the use of the nuclear energy, the research programme during the period 2002 to 2006 focused on R&D emphasising "alternative host rock". About one half of the projects and the funds were related to clay or indurated clay host rocks, while the other half was split among the subjects salt rock, crystalline rock and interdisciplinary research (e.g. safety analysis). Finally, during the period 2011 to 2014, the focus was on R&D dealing with pending issues concerning the disposal of radioactive waste in salt rock. In parallel to this work, the scientific and technical knowledge for the disposal of heat generating waste in clay was increased substantially. Issues related to the disposal in crystalline rock had lower priority, since in the course of previous scientific investigations, only limited regions suitable to host a DGR were found in Germany.

The results of the previous R&D works confirmed the feasibility of a DGR for HLW in a rock salt.

On that basis the objective of the current R&D programme is defined to providing scientific and technical basis for the implementation of a repository for heat-generating radioactive waste and spent fuel. This includes the continuous development of the state of the art of the science and technology for the disposal of radioactive waste.

Specifically, the scientific work in regard to salt formations is being performed in a results-oriented way. Due to the already existing advanced knowledge on these formations, in many of the related R&D themes only some remaining work is required. R&D regarding the disposal of radioactive waste in clay formations prioritises international activities focused on the state of the art of the science and technology which brings in-depth work in this kind of repository projects; while work on specific components of repositories in crystalline formations (e.g. geotechnical barriers) is being carried out with lower priority.

A direct response to the development of the StandAG had been the foundation of German Association for Research on Waste Disposal (Deutsche Arbeitsgemeinschaft Endlageforschung - DAEF). The objective of this independent working group is to promote the research and development in the field of the radioactive waste disposal, cooperating closer between its members. The association works, among other things, to obtain and to develop the technical expertise regarding the R&D on waste disposal repositories.

The association would also especially like to promote and to intensify the technical exchange between researchers, for example, by hosting conferences and workshops. Finally, it is supposed to serve as a knowledge pool for the work of the Disposal Commission.

The members of the DAEF comprise main German R&D organisations in regard to DGRs. The BMWi, the BfS, the BGR and the Project Management Agency Karlsruhe Water Technology and Waste Disposal (PTK-WTE), participate as guests.

CONCLUSIONS

Programmes for disposing radioactive wastes generally do last very long. This is especially true for disposal of HLW in DGRs. To develop a site to a stage where it can host a DGR involves many steps, all of them involving high efforts in terms of financial means, expertise, and R&D activities. Hence, responsible organisations have a tendency to minimise the number of sites as quick as possible.

On the other hand, two major risks are effecting the development of a site: First, the safety of the whole site can only be definitely assessed once the mine is entirely erected. Secondly, changes of political or societal opinions can heavily impede the site development despite its evident suitability. These risks can materialise at any time during a project. In such a case a new risk arises of losing a substantial portion of created knowledge which can cause a big delay of the programme and high additional costs.

The latter risk can be mitigated or its consequences at least alleviated by regular reviews of the state of the knowledge and by developing methods for the transfer of approaches from one project to another. Furthermore, it is advantageous to keep investigating alternative concepts to the currently preferred one at least on a low level. These mitigation activities enable a smooth transfer to a new concept if necessary without any unnecessary delay for developing a new working basis.

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