Three Decades Development of a HLW and SF Repository in Germany - The Way ahead - 10500

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ABSTRACT

As early as on February 22, 1977 a site for a deep geological repository mainly for heat generating waste was selected in Germany in the framework of a complex site selection procedure. The host rock is salt; the site is a salt dome near the village of Gorleben, at the shores of the Elbe River in Northern Germany. Repository development included first site exploration from the surface starting in 1979, and after 1986 exploration mine construction. In parallel, a large-scale R&D program was carried out aimed at having available as required the science and the technology needed to license and later operate the repository. A focus point of the program was the development and full scale demonstration of all necessary technologies and equipment, which were not state-of-the-art at that time. The federal election in September 2009 rendered a new government with a more positive attitude towards nuclear power, which is considered a transition energy source but indispensable for the foreseeable future. With the elections the political blockade of the German repository programs has finished. Currently, first steps are being undertaken for a swift end to the moratorium on the site exploration. The future work shall be closely accompanied by stakeholder involvement, and shall be based on an update of the repository concept to be carried out before and concurrently with the site exploration work.

INTRODUCTION

In the years 1973/1974, in view of the rapid expansion of nuclear electricity generating capacity in the country, the selection of a site for an integrated nuclear waste management center was a major issue for the German Federal Government. In line with the ambitious nuclear energy policy at that time, which anticipated a large number of power plants and a closed nuclear fuel cycle, the integrated waste management center (NEZ in the German acronym) was to centralize at a single location all the facilities of the nuclear fuel cycle back-end.

The site should on the one hand be capable to host an industrial-size reprocessing plant and its ancillary facilities, which implied requirements in regard to infrastructure, distance to the power plants, availability of qualified personnel, etc. On the other hand the location had to be above or in the immediate vicinity of a suitable site, which would host the repository for all kinds of radioactive waste, but especially for the heat-generating HLW resulting from the spent fuel reprocessing. Correspondingly, the site suitability studies were to pay special attention to the site capability to host a repository.

At a previous time the decision had been made that disposal of all kinds of waste was to be carried out in deep geological repositories, and that in particular heat generating waste was to be disposed of in a salt formation. There are a large number of such formations, potentially suitable to host a repository, under the Northern German plains. Salt and potash mining has been carried out there for longer than a century, so that plenty of knowledge on the geology of the salt formations exists, and long experience in constructing and operating mines was available. On the other hand, the preference of this host rock limited geographically the possible repository locations basically to the two northernmost states, namely Lower Saxony and the much smaller Schleswig-Holstein.

THE GORLEBEN SITE SELECTION

In 1973 the Federal Government, represented by the then Ministry of Research and Technology contracted the company *"Kernbrennstoff-Wiederaufbereitungs-Gesellschaft"* (KEWA) to carry out a site selection for the integrated waste management center (NEZ). In the framework of the so-called KEWA-Study [1] a site selection process in three phases was carried out, considering all the territory of the then Federal Republic of Germany (West Germany).

In a first phase a large area review with regional studies and preliminary evaluations of candidate areas was carried out, the *"Landkreise"* (Rural Districts) being the smallest considered unit. In the second phase regional studies were conducted, aimed a identifying and setting up a ranking of most promising site areas. The Gorleben site was excluded at this early stage from further consideration because the rural district of Lüchow-Dannenberg, to which Gorleben belongs, was included in a map of recreation areas as important for local recreation and this was one of the exclusion criteria used.

The second phase rendered a total of 10 candidate areas with potential for siting the NEZ. The geological, hydrological, and meteorological data and information used in these two phases were taken from existing sources, i.e. no dedicated site survey was carried out. Finally, in a third phase an expert evaluation by expert organizations and specialized companies was carried out, again based on existing planning information. An important source was a geological study [2] conducted by the company KBB GmbH (Hanover) with an inventory and evaluation of salt domes in Northern Germany.

At the end of phase 3 a ranking of four candidate sites was presented, all of them in Northern Germany since sites there were in principle considered better than those in the south, namely the sites 1 Börger (salt dome Wahn, in Lower Saxony), 2 Ahlden (salt dome Lichtenhorst in Lower Saxony), 3 Faßberg (salt dome Weesen-Luterloh in Lower Saxony), and 4 Lütau (salt dome Juliusburg in Schleswig Holstein). This later one was not considered any further due to its location too close to the border of the former German Democratic Republic (East Germany). In later phases the work of KEWA focused on detailed studies of the candidate sites. Additionally, the Gorleben site was included in such studies in 1976, as meanwhile the exclusion criteria "recreation area" had been discarded. In its interim report [3] KEWA clearly stated that the Gorleben site was the most favorable one from all considered sites.

The Government of Lower Saxony in its role as the host state for the integrated waste management center carried out in the following time a site selection on its own responsibility based on the previous work of KEWA for the Federal Government. A project team charged with this task in 1976 carried out a site selection process in three phases. An important condition was that the NEZ should be built at a site determined by the deep geological repository. The selection criteria, published in the minutes of a meeting of the Environment Committee of State Parliament [4], correspond to criteria still used at present.

In the first phase 140 sites were considered and a first set of 23 selected for further analysis. After application of exclusion criteria 13 sites were chosen for continued consideration. The analysis then focused in aspects as safety and environment, site geology, site location and infrastructure and economical aspects. At the end of phase 3 four site remained the mentioned salt domes of Wahn, and Lichtenhorst, Gorleben and a further site Mariaglück (salt dome Höfer). The results were submitted to the cabinet of ministers in the Lower Saxony Government for its consideration in December 1976. In a fourth phase finally Gorleben was selected. The salt dome Wahn was discarded because it is partially located under a training ground of the federal army, the salt dome Lichtenhorst because it is in a priority and reserve area for water supply to Lower Saxony's capital city of Hanover, and the salt dome Höfer because it had already been used for mining. On February 22, 1977, finally, the German Federal Government confirmed the selection of Gorleben by the Government of Lower Saxony as the site for the NEZ and thus for the deep geological repository.

Fig. 1. Aerial view of the Gorleben site.

DEVELOPMENT OF THE GORLEBEN SITE AND REPOSITORY TECHNOLOGY

The council of the heads of government of the Federal Republic of Germany and of the Federal States in a ground-breaking decision of September 28, 1979 [5] established the basis for the German waste management concept. The council welcomed the decision by Lower Saxony, to permit the construction of a repository at Gorleben in case the site exploration and the exploration mine development prove the suitability of the site for waste disposal. Therefore, the site exploration and exploration mine development was to be swiftly carried out.

Site survey from the surface started shortly thereafter, and led to drilling of a large number of exploration boreholes down to a depth of about 270 m, aimed at obtaining information on the overburden and on the layers directly above the salt. Furthermore, a large number of hydrogeological wells were drilled in the surroundings of the dome to study the hydrogeological conditions in the area. Exploration from the surface included detailed, precision leveling of the area on top and around the salt dome, seismic survey, and an extensive program of evidence collection and preservation to determine the environmental situation of the area prior to the development of the repository facility. Finally, four deep drilling well were sunk into the flank area of the repository down to more than 2000 meter, and provided valuable information on the salt structure necessary for the planning of the exploration mine. Two further shaft exploration boreholes were sunk at the selected positions for the two access shafts that were later sunk there.

In 1983 all the data from the surface exploration required for a preliminary site suitability evaluation was available. In an extensive interim report by the responsible governmental bodies, the German Geologic Survey, BGR, and the then Federal Institute for Physics and Metrology, paved the way for the underground survey by stating the presumed suitability of the site to host a repository. In view of the excellent surface

survey results, which strongly supported the presumed site suitability, the exploration mine was designed and constructed so that important and costly elements as the access shafts and the surface and underground infrastructure could later be used as part of the repository without major alterations and refurbishment. By that means, transformation of the exploration mine into a repository after licensing could be rapidly carried out optimizing the use of economic resources. A sort of review concerning the development of the Gorleben Project and proposals how to proceed was performed by the Federal Ministry of Economics and Technology (BMWi) and was published 2008 in a brochure [6].

After some preparatory work, construction of the exploration mine by DBE started in 1986 with the excavation of two shafts in the central part of the salt dome. After 1996 the infrastructure rooms at the exploration mine level of 840 m were swiftly excavated and equipped. Thereafter, the excavation of drifts and galleries around the "*Erkundungsbereich 1"* (EB1 Exploration area 1) was started. After a change in the Federal Government in 1998 there was a change in the waste management policy for political reasons, leading to a moratorium of the site exploration since November 2000. Until this time, some 400,000 m³ of void space had been excavated in the framework of the exploration mine construction. Figure 2 displays the current status of underground mine construction.

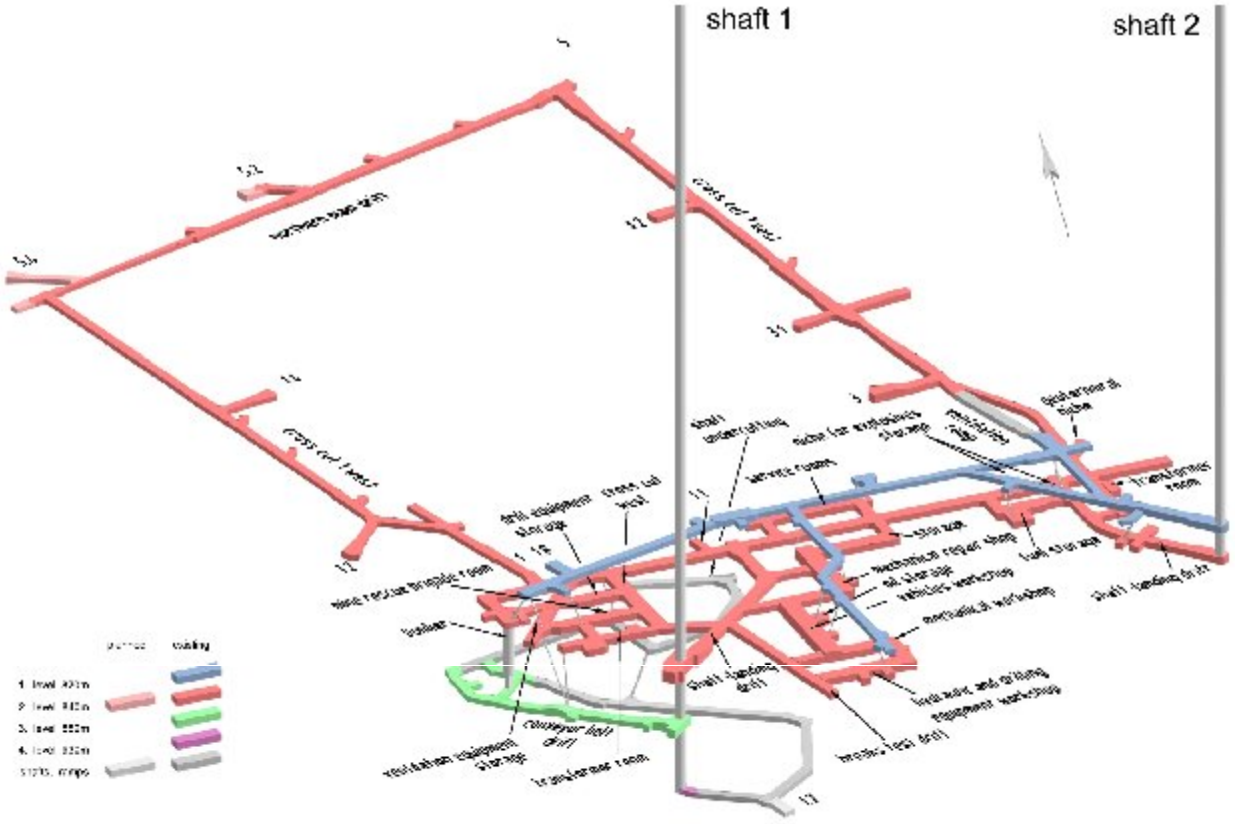

Fig. 2. Layout of the present underground mine construction of the Gorleben site.

The Moratorium that was to last as a minimum for three years and as a maximum for 10 years was adduced to provide time for studying questions the new Federal Government wanted to have resolved before continuing site development. Although the question had been resolved by 2005 and the results published in a report, the Moratorium was not lifted and the exploration was not continued.

In spite that the Gorleben site had been selected by elected government bodies fully in line with democratic legitimacy principles, and after investing 1.3 billion Euros over 20 years in the site development, the Ministry of the Environment (BMU) designated in 1999 a commission to develop a set of criteria and a procedure for selecting a new repository site starting from scratch. The results of the so-called AkEnd commission were published in 2002, but implementation failed since there was no agreement inside the Federal Government and with the Federal States about conducting a new repository site selection, and therefore the necessary legal basis was not passed by parliament. In 2005 a new coalition government was inaugurated, but the parties in the coalition failed to reach an agreement on the future development of the Gorleben repository project. However, after the inauguration of a new administration in October 2009, a new policy is held out in prospect.

Concurrent with the site development, the technology for waste disposal has been developed to technical maturity and demonstrated in 1:1 scale. Among others a pilot conditioning plant in which the spent fuel and the vitrified HLW will be discharged from the interim storage casks and loaded into the final disposal cask or container was designed and built at Gorleben, adjacent to the repository site (see Fig 1, on the upper left corner). The facility is currently fully operational but has not yet been hot commissioned since the repository development has suffered substantial delay. At the same site also interim storage facility for HLW and spent fuel with a capacity of up to about 4000 tons of heavy metal was build and is currently in operation to provide time for the decay heat of the waste to decrease before disposal. The facility currently contains some 1200 tons of HLW in the process of aging.

From 1985 till 1995 the R&D program Direct Disposal of spent fuel was successfully performed. The goals of the subprograms: spent fuel conditioning and cask development, demonstration tests, conceptual design of the disposal systems (System Analyses), and laboratory tests were achieved and finished on schedule. One of the subprograms concerned emplacement and handling techniques. [7] The technology for the shaft transportation of heavy casks containing spent fuel or vitrified HLW down to the disposal level was to be also developed and demonstrated, as it was not state-of-the-art before. Furthermore, a rail bound waste handling and transportation system was developed and tested, including all ways and means needed underground for the drift disposal operations (the reference concept), including the waste emplacement machine. In more recent times, in a further series of equipment design and demonstration projects, an optimized alternative for the borehole disposal of spent fuel and vitrified HLW have been developed and intensively tested in a series of demonstration tests, so that currently two alternative technologies exist for operating a repository in a salt formation. In a separate paper presented to this conference the equipment development program is comprehensively dealt with [8] and therefore these matters are not repeated here. An example of the machinery developed is shown in Figure 3.

Fig. 3. Picture of the equipment testing and demonstration facility.

In recent years significant attention has been given within the R&DD program of BMWi to activities that have implications and are of importance for the optimization of concepts and a future safety case. Among others it is worthwhile to specially mention the ISIBEL Project. In this joint key project performed by the German Geologic Survey, BGR, the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), and DBE TECHNOLOGY, a comprehensive, novel approach for a so-called safety proof concept to dispose of spent fuel elements in vertical boreholes in a rock salt repository is being developed [9, 10]. With these key projects an important step has been done to bring forward the conceptual, methodological and technical state-of-the-art being the basis to demonstrate the long-term safety of a HLW repository in rock salt.

THE WAY AHEAD

In view of the above, and in spite of the politically motivated stop of site exploration in the past ten years, it is clear that with the Gorleben repository project Germany still has in place one of the most advanced repository programs. Currently, with the construction of the Konrad deep geological repository for non heat generating waste and by decade-long mining experience in salt valuable experience is being obtained and available in the country on the industrial aspects of geological repository construction. Already in the year 2000-agreement between the Government and the electricity utilities to phase out nuclear power use there are some important statements dealing with Gorleben

- The Government confirmed that up to that time there are no scientific findings pointing at the non-suitability of the Gorleben dome to host a repository for heat generating waste.
- Data acquisition from the installed monitoring devices and some needed work were continued as necessary to secure the site later use as a repository.

In addition, the agreement implies that after clarifying the open questions, which happened before 2005, survey at Gorleben will continue and that at the latest in 2010. Correspondingly, and irrespectively of what the future of nuclear power use in Germany might be, after the removal of the political blockade by the Minister of the Environment in the last years, the way forward is finally open.

The German administrative procedures prescribed by the Nuclear Energy Act to license a deep repository, the *"Planfesstellungsverfahren"* (Plan approval procedure), does not anticipate active public participation until near the end of the process. In spite of the very proactive support of the village of Gorleben to the repository project, public acceptance needs to be improved to the extent possible. Obviously, ways and means need to be implemented to ensure that at least the population without a completely rejecting attitude has a stake in the future work. In spite that a formal framework for such public involvement is not part of German law, strong efforts need to be made to achieve the widest possible degree of consensus within the local population. At the same time it is necessary to remain aware that a certain minority will keep strongly opposing the repository project, regardless of the actions taken.

The initial moves on the Gorleben project continuation have not been as swift as expected. But this is not surprising, for in the initial weeks after the new government's inception the Copenhagen conference had to be prepared, and climate change has, as expected, currently a much higher priority in the agenda of the responsible Ministry of the Environment, BMU. Nevertheless work is ongoing

- to ensure that the future work will be periodically peer-reviewed by independent, international experts to guarantee that the program is steadily conducted according to the best international practices and in line with the most advanced state-of-the-art,
- with activities that a public review commission is established with the widest possible participation of all stakeholders in the Gorleben region and beyond, to serve as a vehicle to inform the public on

comprehensive and timely basis, in such a way that the needs and interests of the stakeholders shall be accounted for as far as possible in the review work,

- with an actualization of the Gorleben repository conceptual design that shall be carried out in the near future, in order to serve as guide for the underground exploration work.

With this, it appears now possible that a statement either confirming or rejecting the suitability of Gorleben to host the German repository for heat generating was can be achieved within a few years.

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