RADIOACTIVE WASTE MANAGEMENT IN THE CZECH REPUBLIC

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Abstract

Radioactive waste and spent nuclear fuel are generated in the Czech Republic as a consequence of the peaceful use of nuclear energy and ionising radiation in many industries, particularly in the generation of nuclear energy, health care (therapy, diagnostics), research, and agriculture. The current extent of utilisation of nuclear energy and ionising radiation in the Czech Republic is comparable with that of other developed countries. The Concept of Radioactive Waste and Spent Nuclear Fuel Management is a fundamental document formulating government and state authority strategy for the period up to approximately 2025 (affecting policy up to the end of the 21st century), concerning the organizations which generate radioactive waste and spent nuclear fuel. The Concept puts forward solutions to provide for the disposal of waste in compliance with requirements for the protection of human health and the environment without excessively transferring any of the current impacts of nuclear energy and ionising radiation utilisation to future generations. The Concept was approved by the government of the Czech Republic in 2002. According to the Concept high level waste and spent nuclear fuel generated at the Dukovany and Temelín nuclear power plants will eventually be disposed of in a deep geological repository. Such a repository should commence operation in 2065. Work aimed at selecting potentially suitable sites began in 1992, but the final site has not yet been determined. In compliance with the aforementioned Concept, the Radioactive Waste Repository Authority (RAWRA) is responsible for finding two suitable sites before 2015. The current stage of evaluation covers the whole of the Czech Republic and includes detailed criteria and requirements. Based on the latest findings RAWRA suggested six potential sites for further investigation at the beginning of 2003.

1 Introduction

Radioactive waste and spent nuclear fuel are generated in the Czech Republic as a consequence of the peaceful use of nuclear energy and ionising radiation in many industries, particularly in the generation of nuclear energy, health care (therapy, diagnostics), research, and agriculture. The position of nuclear energy in the Czech Republic is determined by the Energy Policy of the Czech Republic. In 2008 nuclear power is expected to make up about 31% of the total electricity production in the Czech Republic. This ratio shows the importance of Czech nuclear power plants in the energy balance of the state. In the Czech Republic at present, four pressurized water reactor units of the VVER 440/213 type are operated at the Dukovany NPP, with a total installed capacity of 1760 MWe. Two other pressurized water reactor units of the VVER type with a capacity of 1000 MWe each, are currently in full power operation at the Temelin NPP. In addition other nuclear facilities exist in the Czech Republic such as research reactors, spent fuel storage facilities and radioactive waste repositories.

The radioactive waste management system in the Czech Republic has a long history. Significant amounts of radioactive waste had already been produced as early as at the beginning of the 20th century when the exploitation of uranium and radium began. In 1959 a nation-wide system of transportation and disposal of radioactive waste produced in the research, medicine, industry and other non-energy branches was created. The Institute for the Research, Use and Production of Radioisotopes was responsible for managing the system. The system included three near surface LILW radioactive waste repositories: Hostím (now closed), the Richard repository near the town of Litoměřice opened in 1964, and the Bratrství repository, near the town of Jáchymov, opened in 1974. LILW from the operation of nuclear power plants has been disposed of at the regional repository situated at Dukovany since 1995. This repository is also designed for LILW from the future decommissioning of both nuclear power plants.

The radioactive waste management system in the Czech Republic changed significantly in 1997 when a new law on the peaceful utilisation of nuclear energy and ionising radiation came into force (the Atomic Act). Since that time the Czech Republic has all the preconditions in place for achieving a comparable level of security, reliability and economic efficiency of its nuclear facilities and waste management system to that of the European Union countries. Upon the adoption of the Atomic Act, the State took over responsibility for radioactive waste disposal and the Radioactive Waste Repository Authority (RAWRA) was established as a state organisation to provide for activities pertaining to the disposal of radioactive waste and spent nuclear fuel. In compliance with the Atomic Act, existing radioactive waste repositories became, as of 1st January 2000 the responsibility of RAWRA. As a result, the state has assumed responsibility for the disposal of radioactive waste. The processing of radioactive waste into a form suitable for disposal, except for the processing of spent nuclear fuel to be carried out by RAWRA, remains the responsibility of radioactive waste producers. In 2001 RAWRA, together with the Ministry of Industry and Trade, which coordinates activities in the nuclear field as part of the government's economic and energy policy, prepared the Concept of Radioactive Waste and Spent Nuclear Fuel Management in the Czech Republic.

2 Radioactive Waste Management Concept

Radioactive Waste Management Concept (the Concept) serves as a basic document on which the long-term strategy of the government will be built with respect both to those organizations generating radioactive waste and those bodies and institutions otherwise involved in radioactive waste or spent nuclear fuel management. Hence, in the long-term, the Concept also provides guidance for the activities of RAWRA. The Concept's purpose is to come up with generally acceptable ideas concerning the management of radioactive waste and spent nuclear fuel in the Czech Republic, ideas that are strategically justified and scientifically, technologically, environmentally, financially, and socially acceptable. The document provides a general system framework for decisions to be made by those bodies and organizations responsible for radioactive waste or spent nuclear fuel management.

Last but not least, the Concept provides a source of clear information on the long-term strategy of radioactive waste and spent nuclear fuel management. The Concept is intended for all the institutions and individuals involved as well as for the general public. The design of the Concept relies on an analysis of the up-to-date development and professional estimation of future trends in the peaceful utilization of nuclear energy and ionizing radiation. The Czech government approved the Concept after discussions on the environmental impact assessment portion of the Concept (SEA) in 2002.

3 Low/Medium Level Waste Disposal

As previously mentioned, three near-surface repositories for low/medium level waste are in operation in the Czech Republic: Dukovany, Richard and Bratrství; waste of this type has also been disposed of at the now closed repository at Hostím.

3.1 Dukovany Repository

The Dukovany repository is situated at the Dukovany nuclear power plant site and is the biggest and most modern of all the repositories in the Czech Republic the construction and safety of which are comparable with similar facilities in Western European countries. Since 1995, drums containing radioactive waste from the Dukovany plant have been disposed of here, but it is also earmarked for the disposal of waste from the Temelin plant. The total repository volume of 55,000 cubic meters (approx. 180,000 barrels) is sufficient for the waste from the operation and decommissioning of both power plants.

3.2 Richard – Litoměřice Repository

The Richard repository is situated on the site of a former limestone mine. The repository has been in use since 1964 to store institutional waste. The total volume of the adapted underground space exceeds 17,000 cubic meters; the waste repository capacity making up about half of this figure. Based on extensive performance and safety analysis, it can be stated that the entire locality complies in the long-term with all radiation protection and nuclear safety requirements.

3.3 Bratrství – Jáchymov Repository

This repository is designed entirely for waste containing natural radionuclides. It is situated in a converted uranium mine; the total volume is over 1,000 cubic meters. The repository was put into operation in 1974. The mine is situated in water-bearing crystalline rock; a drainage system with run-through retention pits has been built round the mine and drainage water is monitored.

All the repositories are operated and monitored by RAWRA in compliance with the relevant permits issued by the State Office for Nuclear Safety and in the case of mines, in compliance with licenses and permits as per mining regulations. Based on the current production of radioactive waste, the capacity of the repositories is sufficient for several decades. According to the Concept no new repositories for LILW are planned; the existing capacity of repositories will be used to the optimum extent and their expansion will be considered if necessary.

4 Management of High Level Waste and Spent Nuclear Fuel

Intermediate-level long lived waste and spent nuclear fuel after it is declared as waste is potentially the most risky category of radioactive waste. This kind of waste is currently expected to be deposited in a deep geological formation. Repository containers are being designed for the direct disposal of spent nuclear fuel or processed high-level waste and suitable structures and insulation materials are being analysed. The techniques for spent nuclear fuel and high-level waste processing and the production of repository containers and insulation materials will be further developed and final selection made when the geological and hydro-geological conditions at the site of permanent disposal are known. According to the Atomic Act, the storage and shipment of spent nuclear fuel and high-level waste is the responsibility of waste producers. Currently spent nuclear fuel, after temporary storage at reactor pools, is kept in specially designed storage containers. Dual-purpose, transport-storage containers are used in the Czech Republic. Such storage techniques are accepted industry-wide and are considered to be high standard proven technology. The condition of storage containers is continuously checked and assessed. The behaviour of spent nuclear fuel during storage has been verified by long-term experiments.

International opinion considers the disposal of high-level waste and spent nuclear fuel in a deep geological repository (DGR) as the most realistic option. The objective of the DGR for high-level waste or spent nuclear fuel is to provide for the permanent isolation of such materials from the environment without the intention of later removal. The principle of the DGR is based on passive safety (i.e. no further human supervision). The repository system consists of a number of barriers, i.e. a combination of engineering (artificial) and natural (geological) barriers.

Internationally, magmatites (especially granitoids and basaltoids, as well as ultra basics have been studied), clay formations, rock salt formations and tuffitic rocks have been examined as host environments for a DGR. The potential construction of a DGR as well as its safety has been verified in all these rock environments. It is expected that a DGR in the Czech Republic will be built in granitic rocks. The repository will accept all the radioactive waste that cannot be disposed of in near-surface repositories, spent nuclear fuel after it is declared as waste or HLW in case of reprocessing, long lived or high level waste from the decommissioning of nuclear power plants or high-level waste or spent nuclear fuel from other nuclear sources.

The project for the building and operation of a DGR is carried out in stages and consideration of the potential construction of new nuclear reactors will be taken into account.

Development work on a DGR began in 1993 and further activities are proposed in several stages: the selection of candidate sites and of the structure of the engineered barrier system, proposal of the final site and corresponding design of the engineered structures, underground research laboratory and confirmation of the safety of the DGR by safety analysis, construction, operation and closure of the DGR. The final decision will ultimately depend on proof of the feasibility of a DGR in the Czech Republic. RAWRA has completed the regional mapping phase of site the selection process and six candidate sites have been selected for further study. According to the Concept, two candidates sites should be included in regional plans by 2015 and DGR operation is scheduled to commence operation by 2065.

4.1 Siting of a Deep Geological Repository

The siting of the DGR broadly follows IAEA Guideline No. 111-G-4.1, Siting of Geological Disposal Facilities. The area survey stage has been completed and six sites have been selected for the site characterization stage. During the area survey stage, pre-existing geological information was considered and number of reports containing descriptions of hundreds boreholes were evaluated. The majority of these reports are stored at Geofond, the central archive of geological information on the Czech Republic, which is part of the Czech Geological Survey. At Geofond, about 20.000 geological maps of different scales are stored, along with some 180.000 geological reports, which include descriptions of more than 550.000 boreholes. The evaluation considered a wide range of geological information and its applicability to site characterization.

Archive reports were evaluated from the following points of view:

- geology, tectonics, mineral deposits exploration;
- borehole drilling and description;
- petrology, mineralogy, geochemistry;
- geophysics;
- hydrogeology;
- hydrology and climatological situation;
- engineering geology and geotechnics;
- demography and conflicts of interest.

Beside the reports associated with the selected areas, some eight hundred reports containing information on seismicity and geodynamic movements were evaluated. Only high-quality information was considered. The largest number of reports was those concerning hydrogeology and engineering geology.

There are many relevant siting requirements contained in legislation and these have to be included in an appropriate way in the program of geological activities. Among numerous laws, the following contain the most essential requirements for geological activities on siting:

- Mining Act (No. 44/1988);
- Geological Act (No. 62/1988);
- Act on Environmental Impact Assessment (No. 100/2001);
- Act on Land Planning (No. 183/2006).

All the above-mentioned acts have been amended during the past few years and are accompanied by several special government decrees or regulations. These legal acts set out in detail which stage of the work needs to be reached and which particular data and information are necessary for a decision or permission for further activities.

The State Office for Nuclear Safety has issued Decree No. 215/1997 Coll. on the Criteria for the Siting of Nuclear Facilities. This decree was issued in conjunction with the Atomic Act and respects the recommendations of the IAEA and other international institutions. The decree defines 17 excluding criteria and 15 conditional criteria for the specific site. RAWRA developed additional criteria based on the specific technical and safety requirements of a DGR. These criteria have also been compared with available international practice.

Following the completion of a survey and subsequent assessment of the whole of the Czech Republic, geological research at six potentially suitable locations commenced in the second half of 2003 with the aim of collecting more detailed geological data to reduce the surface area of the individual candidate sites. Work carried out before 2004 was considered geological research (in terms of Act 62/1988, on geological work practices) for which no special approval was required.

The “Geological and Other Work Required for the Assessment and Reduction of the Surface Area of Potential Sites for a Deep Geological Repository” project was completed during the year 2005, as planned. The project involved the following:

- compilation of geological information through indirect methods (aerial geophysical measurements and satellite photographs), field reconnaissance and the study of historical geological documentation; the information obtained allowed the surface area of the six potential sites to be reduced in order to facilitate the next stage of geological investigation;

- preparation of preliminary feasibility studies for each site to identify those sites where a surface area of the required size would be available for the siting of a deep geological repository whilst, at the same time, respecting all other statutory obligations and requirements;

- the design and installation of RAWRA’s geographical information system (GIS), including the input of data relating to the project and handover to RAWRA.

The technical part of the project including field reconnaissance was completed in 2004. The interpretation of the collected data was performed, final reports prepared and the creation of the geographical information system completed in 2005. A peer review of the final reports consisting of about 1300 pages and a number of appendices was carried out by four independent experts in early December 2005. Work carried out during the year successfully resulted in the reduction of the surface area of each of the sites to be subjected to further geological investigation.

A preliminary feasibility study has been conducted for all the candidate sites the aim of which was to summarise and interpret all the information available at the current stage of the project. Since data relating to deep underground rock masses was not available, the study was concerned only with the surface area of each candidate site, its connection to the existing road or railway network and other infrastructure, conflicts of interest, risk analysis and comparison of capital intensity. The conclusions of the study show that all the candidate sites provide the required surface area. This is a key finding which will allow work on all the candidate sites to continue.

However, in view of the overwhelmingly negative public attitude to the project, RAWRA has suspended geological work at the sites until 2009. This time period will be used to identify conditions acceptable for both the Government and the local communities concerned so that work might continue.

Communicating with the public is a significant part of RAWRA's responsibilities. RAWRA staff members make efforts to be available to the public and to communicate technical information, they hold public meetings in all selected sites. RAWRA's effort is aimed at creating public trust in the technical soundness of the siting process.

4.2 Design of a Deep Geological Repository

The DGR programme comprises the preparation of a general design, including proposals for and the verification of the long-term behaviour of the engineered barriers (disposal containers, sealants and back-fill materials). RAWRA currently follows an approach aimed at building and increasing general knowledge of the individual repository system components' behaviour and performance mainly through the active involvement of subcontractors in various international projects. In addition to exploiting foreign research into the construction of a DGR, domestic research will also play its part. Thanks to the participation of Czech institutions in projects of the 6th and 7th EC general plan for science and research and thanks to various bilateral contacts and international cooperation, the effective accumulation of knowledge is assured and the development of domestic research firmly established. It is intended that international cooperation will be maintained in future years. Ongoing projects on research into back-fill and sealants and the determination of methods for the evaluation of engineered barrier materials will continue in the future.

The projects worked on in the general plans of the science and research play a key role in the field of research and development. For RAWRA the results in the field of the RAW management of the already finished projects of the 5th general plan (namely FEBEX II, PROTOTYPE REPOSITORY, CONTAINER CORROSION, COBECOMA, IN-CAN PROCESSES, SFS, BENIPA, BENCHPAR, BIOCLIM, BioMoSA, SPIN, PADAMOT, RETROCK) and of the projects of the 6th general plan (namely NF PRO, FUNMIG, ESDRED, PAMINA, EUROPART, RED-IMPACT, ACTINED) are particularly important. Moreover, a long-term project for the updating of the DGR reference design will be commissioned, the aims of which will include updating the DGR budget, the incorporation of the latest domestic and foreign R&D knowledge, a complex assessment of DGR safety and the preparation of this documentation for assessment by the State Office for Nuclear Safety and relevant international agencies.

A final decision on the suitability of a disposal system will be based on a thorough safety analysis based on the characteristics of the host rock formation and on an evaluation of the behaviour of the engineered barriers and will incorporate foreign experience and advanced computer modelling techniques.

Data for such a safety analysis will also be obtained from the examination of natural systems with properties approaching those of a future repository (natural analogues). Data obtained from the analysis of the behaviour of natural analogues will also be used for the validation of models used in predicting long-term repository behaviour.

In addition to preparing a programme for the construction of a geological repository, RAWRA supports, in compliance with specific aims set out in the Concept, the involvement of research institutions in the development and application of new technologies for treatment and conditioning of RAW and for the advanced reprocessing of spent nuclear fuel.

5 References

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