CO-OPERATION BETWEEN SLOVENIA AND CROATIA IN THE LOW- AND INTERMEDIATE LEVEL RADIOACTIVE WASTE REPOSITORY PROJECT

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ABSTRACT

The paper describes the LILW repository project development in Slovenia and Croatia from the viewpoint of co-operation of national agencies for radioactive waste management - ARAO in Slovenia and APO in Croatia. The project performance, as well as the co-operation itself, are based on the fact that NPP Krško, sited in Slovenia, is the joint venture facility of both countries, which are consequently obliged to find a proper solution for final disposal of operational and decommissioning radioactive waste generated by the plant. The main aspects of the project development in both countries, such as LILW repository site selection and characterisation, development of repository conceptual design, performance of safety analysis, radioactive waste characterisation, economic evaluation of the project, radioactive waste transportation, licensing, public acceptance, etc. are presented in the paper. Based on separate descriptions of the project development in Slovenia and Croatia respectively, the main aspects of co-operation between ARAO and APO are elaborated.

1 INTRODUCTION

The performance of the low- and intermediate level radioactive waste (LILW) repository project in Slovenia and Croatia is based on responsibilities of both countries for the Krško Nuclear Power Plant (Krško NPP). Since the project has methodologically been conceived in somewhat different ways in the two countries, there are some differences between Slovenia and Croatia in the present status of the project development. In general, the project is composed in both countries of a couple of correlating activities, such as site selection/characterisation process, development of technologies and basic design, performance of safety analysis, radioactive waste characterisation, economic evaluation of the project, radioactive waste transportation, licensing, public acceptance, etc. The project began in both countries some ten years ago and has presently reached the results as it is described below.
The goal of this paper is to emphasise some details of the LILW repository project, as it has been undertaking for last 10-15 years in Slovenia and Croatia respectively, and to put some light to co-operation of two national agencies - the Agency for radwaste management (ARAO) in Slovenia and APO in Croatia - in the frames of the project development.

2 PROJECT DEVELOPMENT IN SLOVENIA

2.1 Site Selection Process

In 1993 Slovenia experienced an unsuccessful site selection process for LILW repository due to strong public opposition. All activities connected to the siting were stopped at that time and a serious reflection on site selection approach was made. In 1998 ARAO started with a new site selection approach to identify location for surface or underground LILW repository.

The chosen mixed-mode approach is very flexible, guarantees high public involvement and can be easily adapted to specific conditions and circumstances. In first phase, desk investigations and rough technical screening of the national territory are performed. How detailed the screening is depends from country to country, but usually the tendency is to retain a larger number of potential sites. This phase is then followed by the negotiation phase with local communities identified in previous, pre-selection phase. Only if the negotiations are successful and further steps agreed with the local community, is the first phase followed by more detailed research including field investigations to assess the suitability of the potential location.

The decision of local community to participate, or withdraw their participation at any stage, must be respected throughout the whole project. Therefore, it is very important to stimulate the local communities by financial compensations, rents or other benefits to participate in the siting process and finally, if the suitability of the location in their community is confirmed, to host the repository.

The communication with the local community/-ies will be established in accordance with ARAO’s plans through an independent mediator who will conduct the negotiations between the community and the investor. The mediator represents the link between the two parties and facilitates the communication and negotiations between the investor and the local community. It is believed that such an institution can significantly contribute to a successful conclusion of the site selection process, especially if he/she would have sufficient public credibility and adequate authorisation for negotiation.

The proposed combined procedure for LILW repository site selection in Slovenia has considered also the IAEA recommendations and is divided into four stages, which are schematically presented in Figure 1.

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Figure 1: Scheme of combined site selection process.
The first stage, conceptual and planning stage of the mixed mode siting approach, has been prepared and defined until the end of 1999. Different aspects of site selection, technical and social, were considered. The use of recommendations (geology, seismicity, water, population density, natural resources, land use) on siting and methodology for ranking of the areas according to their suitability for LILW repository were defined. The forms of public participation and involvement together with communication activities programme which identifies main communication goals and target groups have been prepared.

In the second, area survey stage, the suitability of the Slovenian territory for a surface or underground LILW repository is examined through desk investigations. Therefore a comprehensive geological database with information on lithology, hydrogeology, tectonics and engineering-geological data has been prepared. By means of GIS (Geographic Information System) technology the Slovenian territory has been assessed with regards to geological suitability of land in which natural properties were investigated. As a result potentially suitable areas for LILW repository from geological point of view have been identified. Preliminary results, which were achieved in 2001, show that around 45 % of entire Slovenian territory is geologically suitable for surface or underground LILW repository. The potentially suitable areas together with the site selection procedure for LILW repository are planned to be included in the National Physical (Regional) Plan for the period 2000-2020 [1].

At the areas of interest the contacts with local communities and municipalities will be established through the mediator. Depending on the results of the negotiations further investigations of identified areas will be performed by using recommendations, which identify other properties of land such as land use, population density, natural resources and others. Through the evaluation of identified areas and with the agreement of local communities further field investigation of potentially suitable locations will follow. According to the most optimistic scenario the final site will be selected and confirmed until 2005.

2.2 Repository Conceptual Basic Design and Preliminary Performance Assessment

Parallel to the site selection project several correlating activities, such as development of technology and basic design, performance of safety analysis, radioactive waste identification and economic evaluation of the LILW repository project have been initiated.

As an information on a fundamental technical solution and economic aspects conceptual design of the LILW repository is being developed. Due to the small amount of long-lived LILW compared with short-lived (around 98 %) the repository design is limited to short-lived LILW only. While decision on repository type will be made during the site selection process, both alternatives - surface and underground (either up to several tens of meters under the surface or tunnel type) - were considered. For both repository types the basic conceptual design was prepared for generic location, limited to four types of most probable geological environment in Slovenia and disposal facility.

The conceptual design for the surface LILW repository is similar to the French or Spanish approach with restriction to only 10 disposal units-vaults, while the amount of waste to be disposed of is approximated to 17,000 m³. It includes also too different extent treatment and conditioning facilities on site. The underground disposal system consists of underground facilities in which the transport and disposal of conditioned waste is carried out, combined with surface waste acceptance, conditioning and treatment facilities. Two alternatives of access to the disposal units were considered: horizontal access in the plastic rock (tunnel type of repository) and vertical access in the hard rock. Beside the general presentation of the technical solutions of disposal operation, both conceptual designs also include technical description of the whole disposal system, a list of activities and equipment in the facility, cost assessment and visual presentation of the facilities.

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Parallel with the site selection and repository technical system determination, a performance assessment of repository radiological impact on the environment and on population has started for generic location, using the methodology recommended by the IAEA. The Slovenian assessment team, which was organised and joined in 1997 by the ARAO agency, prepared some basic studies in order to clarify the objects of the performance assessment and safety analysis (PA/SA) procedure: the assessment context, the input parameters on system and waste and the timeframes for the assessment [2].

Following basic information on PA/SA, in 1999 the first preliminary PA of two safety cases (surface and underground) for generic LILW repository site was performed. All required data and description of generic location, waste, disposal system and assessment context, were prepared for two disposal concepts/siting options. The results of these calculations were optimistic and showed that the LILW repository can be built in such manner that its environmental impact will be negligible.

Within the last years, more work was done in this field. The assessment cases were re-developed and extended in light of the initial results obtained, with particular attention to the inventory to be disposed of (short versus long-lived waste) and the duration of the institutional control period. A systematic, generic list of all-possible features, events and processes (FEP list) predictable for surface or underground LILW disposal in Slovenia was prepared. Recommended and selected were the most reliable scenarios for LILW disposal in normal and altered evolution conditions. A comprehensive relation’s base of parameters, significant for surface and underground disposal, was also prepared. Verification of the proposed conceptual models was done with more powerful and accurate computer codes for the surface repository over an aquifer of lower water permeability and underground repository in a plastic rock. The modelling took place in three successive steps:

- the near field modelling, run by PORFLOW computer code, giving the mass fluxes and concentrations of radionuclides leaving the waste nearest area
- the geosphere modelling, first with hydraulic field and then with transport calculations for the whole mass flow entering the geosphere from the near field (GMS computer code) giving concentrations in groundwater as the result
- the biosphere modelling, taking as a starting point the radionuclide concentrations in groundwater and in the stream and calculating (by AMBER code) the final dose to the member of critical group. Calculations were run by AMBER code.

The results for both generic cases under normal evolution scenarios showed that there is a negligible dose influence to the member of the critical population due to the migration of radionuclides from the foreseen LILW repository. Further development of Slovenian PA/SA project was also supported by IAEA by providing technical and expert assistance through the Technical Co-operation Programme for the period 2001- 2002.

2.3 Pre-investment Project

In order to receive basic information on cost assessments of the entire site selection procedure and LILW repository construction, the ARAO prepared pre-investment project for two disposal options for generic location. It includes description of all planned activities for site selection and construction of surface and tunnel type of LILW repository together with dynamics of realisation, financial needs and costs evaluation. Uncertainty analyses were done for different technical and financial parameters, which could influence overall repository costs. The resulting document serves as a good basis for further site selection planning, financial comparison of different technical options and assurance of financial sources for future work.
3 PROJECT PERFORMANCE IN CROATIA

3.1 Site Selection Process in Croatia

The activities on LILW repository site selection in Croatia began in 1988. The site selection method and criteria were defined until 1991 and validated by Croatian Government in 1992. The official list of approved criteria was published in 1992 (Croatian Official Gazette ‘Narodne Novine’ No. 78/92).

The site selection consists of two stages: the first, site survey stage, terminating by inclusion of preferred (candidate) sites into the Physical (Regional) Plan of Croatia; and the second, site characterisation stage, aiming to define the final repository site through field investigations and other necessary actions. The complete selection process was periodically advised and assessed by the experts from the International Atomic Energy Agency (IAEA), so that some dozen of IAEA expert missions have been undertaken in last decade.

There were ten exclusionary criteria applied in the site selection process, i.e. in regional analysis of whole territory of Croatia, aiming to reject all areas which do not meet requirements defined by any of the involved criteria. These criteria are related to the following issues: flooding, earthquakes, faulting, rock types, slope dynamics, groundwater circulation, population density, present and planned land use types and protection of natural and cultural heritage. All potential sites which had been identified by exclusionary screening were additionally subjected to comparative analysis, i.e. the evaluation based on application of 28 comparative (weighting) criteria. By exclusionary screening 7 potential areas were found out in 1993: Petrova gora, Trgovačka/Zrinska gora, Bilogora, Moslavačka gora, Papuk/Krnjija, Psunj and Požeška gora (Figure 2). There were identified 34 potential sites within these areas in 1994 [3].

![Figure 2: Potential areas for LILW repository site in Croatia](image-url)
Almost all potential areas are mountainous regions composed of solid rocks (granite, gneiss). Geomorphologically they represent remobilised and exhumed massifs of the old Pannonian mass stretching generally beneath thick Tertiary and Quaternary sediments of the Pannonian basin in northern Croatia. From the geological standpoint, they are all (except Bilogora) typical horsts. A re-examination and correlation of these areas by the mentioned weighting criteria resulted in selection of four preferred sites. Thus, the potential sites of Trgovska gora (8 km²), Moslavačka gora (20 km²), Psunj (14 km²) and Papuk (8 km²) were proposed for further investigations in 1997. The survey undertaken in 1998 pointed to two of them (Moslavačka gora, Trgovska gora) as the most suitable ones. Finally, Trgovska gora was selected as the most perspective site and was after debate in the Croatian Parliament included into the Physical (Regional) Plan of Croatia in 1999 (Official Gazette 'Narodne novine', No. 50/99). Presently, we are preparing backgrounds for environmental impact study and a detailed programme of final site characterisation, that includes all on-site investigations necessary for the site confirmation.

### 3.2 Repository Conceptual Basic Design Options

Two basic LILW disposal facility types should be considered in Croatia: (a) a near-surface engineered burial /in vaults/ and (b) subsurface disposal /in tunnels/.

**A. Near-surface engineered burial in vaults.** A widely used option, expected to be the least expensive one and might relatively easily be modified to allow for waste retrievability. The disposal facility is designed to accept all LILW waste quantities from the NPP Krsko operation as well as from the plant decommissioning and from nuclear applications from Croatia. The packages of highly compacted waste in steel tube type containers (TTC) and steel containers with biological shield (MOSAIK), will be placed in reinforced concrete containers and then into concrete vaults. The vaults, set on or below ground level, consist of a concrete base and walls with an underlying drainage layer. The top is sealed with concrete, water resistant isolation, and covered with soil layers of alternating hydraulic conductivity, topped with vegetation.

**B. Sub-surface disposal in tunnels.** The disposal facility is also designed to accept all LILW waste quantities from the NPP Krsko operation as well as from decommissioning and from nuclear applications in Croatia. The packages of highly compacted waste in TTC and MOSAIK, will be placed in reinforced concrete containers (typically smaller than for the vault facility) and then disposed into tunnels. Although the waste will be covered by only few tens of meters thick host rock, the public perception might strongly favour the safety of this option. It would probably not require the additional period of passive institutional control. The sub-surface facility design consisting of tunnels should be set more or less horizontally into a hill slope.

Regarding the more probable option, i.e. the near-surface engineered burial in vaults, it should be added that all LILW is assumed to be disposed of in TTC, foreseen to be placed in reinforced concrete containers. The concrete containers are expected to be set in units for final disposal, with the final disposal area consisting of 10 units.

### 3.3 Public Involvement

APO is authorised in Croatia to manage the issues related to public participation regarding the radioactive waste repository project in Croatia. We want to have public involved in the matter through several specific types of communication, and have developed the following modes of direct and indirect public participation in the radioactive waste repository project:
permanent co-operation with mass-media in order to give continuous, full, precise, synchronous and honest information to the public
- well-organised research of public opinion related to environmental issues
- sponsorships related to environmental protection
- involvement of the public to improve all referring activities of the APO
- building trust with environmental groups
- close co-operation with respective scientific and research institutions and expert groups.

3.4 The Project Follow-up

The planned on-site investigations, that should give final confirmation (or rejection) of the Trgovska gora site for disposal of LILW, are based on three major groups of techniques: (1) geodetic methods /including mapping and remote sensing/, (2) geophysical survey /surface geophysics, geophysics in boreholes/, and (3) drilling /shallow and deep boreholes/. Taking into account all these activities, the planned project time schedule, indicating year of their completion, is as follows:

- Completion and validation of preliminary site characterisation 2002
- Allowance for access to the site (planning documents + physical access) 2003
- Detailed on-site characterisation: Phase I 2004
- Detailed on-site characterisation: Phase II 2005
- Site approval 2007
- Disposal facility construction 2009
- Repository start-up 2010

4 CO-OPERATION BETWEEN SLOVENIA AND CROATIA

As it is described above, the planned LILW repository in Croatia and/or Slovenia is intended to accept, above all, both the operational and decommissioning wastes being generated during lifetime of the NPP Krško. Since the NPP is Slovenian-Croatian joint venture facility, co-operation between Slovenian and Croatian sides during the LILW repository project development is necessary for successful realisation of the project. The co-operation itself began ten years ago, i.e. after national agencies for radioactive waste management - ARAO in Slovenia and APO in Croatia - had been established in the newly independent states of Slovenia and Croatia in 1991. This co-operation is mainly directed to the LILW repository project, but perspective it may be widened to other issues regarding e.g. decommissioning of NPP Krško, as well as other subjects related to management of radioactive waste.

The co-operation between ARAO and APO is presently directed mainly to the following subjects:

- periodically organised meetings (in general, twice a year) intended to achieve a satisfactory exchange of information on all issues important for the project realisation
- exchange of experiences in the field of site selection in order to optimise and harmonise the site selection and characterisation process including public involvement
- discussions on development of possible LILW repository conceptual designs to be applied
- detailed mutual informing on experiences in the field of PA/SA development
- joint participation at conferences and workshops (e.g. ABMER Workshop and Workshop on defining FEP list in 1999, IAEA Workshop on NPP Krško decommissioning in 2001, etc).
5 CONCLUSIONS

The LILW repository project is intended to solve problems related, above all, to manage and finally dispose of operational and decommissioning wastes generated by NPP Krško, but additionally to ensure final storage for LILW produced through diverse nuclear applications in Slovenia and Croatia. As co-owners of the NPP Krško, both countries are consequently responsible to find a proper solution for final disposal of radioactive waste produced by the plant. For this reason two national agencies for radioactive management - ARAO in Slovenia and APO in Croatia - were established by national governments after the countries had been proclaimed as independent states in 1991. The close co-operation between the agencies started immediately after their foundation, and is directed to all aspects of the project, such as the LILW repository site selection and characterisation process in both countries, development of the most convenient conceptual repository design, conduction of performance assessment/safety analysis for the repository, harmonising of public participation policy, etc. The agencies have established practice of periodically organising mutual meetings, and periodical joint participation on workshops and conferences. They have also developed a close co-operation with the International Atomic Energy Agency (IAEA) in Vienna. All these aspects seems to be of a great importance for a successful realisation of LILW repository project and initialise possibilities to widen the co-operation in future to other fields of radioactive waste management in Slovenia and Croatia.

REFERENCES

