

TECHNICAL, NORMATIVE AND SOCIAL ASPECTS OF THE SITE SELECTION PROCESS FOR RADIOACTIVE WASTE REPOSITORIES

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ABSTRACT

In force since 2001, the Federal Law 10.308 states, in article 37, that the Comissão Nacional de Energia Nuclear – CNEN should start studies for the implementation of a final radioactive waste repository, “in the shortest timeframe technically feasible”. Nevertheless, not only technical aspects have to be taken into account to accomplish with this schedule, but, also factors of political, economic and social nature. In this paper, the importance and impact of public acceptance aspects are discussed, as well as the methodology of site selection for radioactive wastes repositories, and proposals to accommodate the emanated criteria from the existing legislation. Additionally, practical results from the international experience in the implementation of such deposits are presented.

1. INTRODUCTION

1.1. Context

Brazil has a regulatory framework to address the management of radioactive waste produced within the country. Among others, the Federal Law 10.308, from November 20, 2001, defines “sites selection, construction, licensing, process, supervision, costs, compensation, civil responsibility and guarantees concerning radioactive waste repositories and establishes other procedures”. In particular, this law states, in article 37, that “the Comissão Nacional de Energia Nuclear should initiate studies for the site selection, design, construction and licensing to start the operation, in the shortest timeframe technically feasible, of a final radioactive waste repository in the national territory”. However, up to now, only some activities related to the overall radioactive waste management process have been implemented.

Nowadays, the Brazilian environmental protection agency (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis - IBAMA) requirements for the Angra 3 NPP (Centro Nuclear Almirante Álvaro Alberto - CNAEA) licensing process include the implementation of a long-term solution for all radioactive wastes produced during the CNAEA power plants operation. These IBAMA conditions should be complied with by Eletrobrás Termonuclear S.A. (Eletronuclear). Therefore, before the start of Angra 3 operation, a final repository for low and intermediate radioactivity level wastes from CNAEA plants must be set up. Concerning the spent fuels, it is important to highlight that a final decision whether or not to reprocess these materials was not taken yet and currently they are not considered as radioactive wastes. Therefore, they should be stored in a long-term storage facility for spent fuels, until there is a definition of their final destination.

Except for wastes from uranium mining and enrichment operations, all the other radioactive wastes generated in the country are currently being stored in storage facilities operated by the CNEN Research and Development Institutes and the CNAEA power plant. The only radwaste final repository in the Country is located at Abadia de Goiás – Goiás State, and was built to disposal radioactive wastes from a radiological accident.

The implementation of radioactive waste repositories, in general, and particularly for low and intermediate level wastes, is a process that requires detailed planning of actions at short, intermediate and long-term time-scales. The main steps of the short term actions are the definition of the current and estimated inventory of radionuclides to be disposed at the repository, the choice of the type of repository to be designed and built and the installation licensing procedures. As to this last task, the main activities are site selection and licensing, by the nuclear and environmental regulatory agencies.

Recent international experience has demonstrated that success of a repository implementation process relies much upon on the procedures adopted during related activities, particularly with respect to the consideration of the impressions and beliefs of the stakeholders in the planning and pre-operational phases of the repository implementation.

In this context, the so-called “social license” is considered a key question. This emerging, abstract concept, is difficult to define, but it is usually related to the general conception of identifying the demands and expectations, concerning a business enterprise, coming from neighborhoods, environmental groups, community members and other members of the civil society. Obtaining the social license requires from companies a change in perspective. The aspects of their operations will be constrained to meet society expectations and to avoid activities that the communities deem unacceptable.

The importance and impact of public acceptance aspects are discussed in this paper, as well as the methodology for site selection of repositories. It is also discussed, proposals to accommodate the emanated criteria from the applicable legislation and the practical results from the international experience in repository project implementation. The paper begins with a discussion of the international experience in the implementation of repositories, evidencing the social communication and studies of the public perception. It follows a discussion of the current CNEN and IBAMA legislations, applied to site selection of repositories, and the proposal of procedures for accommodation of the guidelines for the formal licensing, regarding the social licensing.

1.2. National and International Experience on Radioactive Waste Repository Site Selection

The Abadia de Goiás Repository is a well-documented national experience in site selection for LLW and ILW repository. Built from a demand for the final disposal of wastes from the Goiânia radiological accident, the process was initiated in 1988 and followed the methodology pointed in the CNEN-NE-6.06 Regulation Act [1]. The U.S. Nuclear Regulatory Commission, also, recommends a site selection process based on four stages, in which the detailed study level is progressively increased, starting from region of interest to candidate areas, then candidate sites and, finally, proposed sites [2].

Other methodologies for site selection are being used in other countries, with different criteria for focusing on the quest for the most appropriate local for a repository installation. The distance from radioactive waste generators is one of the major employed criteria. In the United Kingdom, the low level radioactive waste management policy recommends that the proximity principle must be applied, as a reference position, during a repository site selection, to avoid excessive costs during the waste transport, even though, for some types of waste, this principle should be taken into account together with a specific risk evaluation [3].

In Canada, a deep geological repository for low and intermediate radioactive waste is planned to be installed close to the Bruce NPP, operated by the Ontario Power Generation (OPG). Technical, social and economical studies, as well as environmental impacts, when constructing the repository at this site, have been developed by a consultant company, as requested by OPG and the municipality of Kincardine, where the Bruce nuclear plant is installed. The repository installation process is at the licensing phase and the beginning of construction is estimated to occur in 2013 [4].

Beyond these cases, the installation of repositories nearby nuclear sites is still being considered in site selection processes of Drigg (United Kingdom), Centre de la Manche (France), Rokkasho (Japan) and Olkiluoto (Finland) [5].

Based on previous failure experiences in site selection, for many countries, public involvement aspects are nowadays taken as a baseline to improve their chances of success, in particular for spent fuel and high level radioactive waste disposal. The case of the Hungarian site selection of a repository for the LLW and ILW generated at Paks NPP can be mentioned as a good example of a foreseen change.

In 1978, a site selection process was initiated, following the best practices recommended by international agencies and based on a purely technical approach, and the site of Ófalu (Baranya region) was chosen in 1987. Due to a combination of the "not in our backyard" position and a growing antipathy for governmental initiatives, which were considered as being dishonest by local communities, the chosen repository site was complete and irremediably rejected. Popular pressure culminated with the construction license being denied by the environmental licensing authority, despite all attempts of reassuring the project safety.

In 1993, the site selection process was re-developed and re-started, now based on public involvement. Close cooperation with municipalities and truthful public communication was considered a high priority, side-by-side with the environmental and radiological safety aspects of the project. In 1996, a decision was made to proceed with further investigations, aiming the installation of a geological repository in granite, nearby Bátaapáti (Tolna region).

During a referendum in 2005, the majority of the 90% of the consulted population voted favorably for the repository construction, and the decision was later confirmed by local governments. Eventually, the construction license was issued by the entitled authority and entered into legal force in June 2008 [6,7].

2. METHODOLOGY PROPOSED FOR SITE SELECTION OF REPOSITORIES IMPLANTATION

CNEN-NE-6.06 Regulation Act defines the requirements to be complied with in the site selection process for radioactive waste repositories. According to this regulation, the site selection and local definition should be carried out selectively and sequentially, according to the following phases: (i) region of interest, (ii) preliminary areas, (iii) potential areas and (iv) candidate sites. This process is solely based on technical criteria.

However, the international experience, accumulated in the last decades, demonstrates that consideration of local, regional and national group's interest and their involvement in the project is highly important to achieve public acceptance. This would make the undertaking feasible, and should be regarded as essential in all phases of the project.

In view of the above, a hybrid methodology is here proposed for the site selection, that would cover both, the existing technical requirements and the criteria for the effective participation of the civil society. In this way, it is expected that a social consensus may be reached regarding the implementation of a final radioactive waste repository.

In the proposed methodology, radioactive wastes from mining and uranium ore processing were not considered, neither the wastes generated by non-nuclear facilities, referred to as NORM (Naturally Occurring Radioactive Materials). In the subsequent sub-items, the main aspects of this methodology are briefly described. In Table 1, a synthesis of the methodology is presented.

2.1 Phase I – Region of Interest Definition

The first task to be accomplished in the site selection process is the Region of Interest definition. Considering the lack of general premises for the Region of Interest definition, the following major aspects were considered:

- Legal (conformity with regulations and applicable legislation);
- Environmental (the repository environmental impact should be minimal and acceptable);
- Technical and safety related (established in regulations and concerned legislation);
- Location (near the main generating centers to minimize accident risks and costs related to the radioactive material transport);
- Social-political.

Table 1: Synthesis of the proposed methodology for Site Selection of the Brazilian Repository of medium and low level radiation wastes.

| Phase | Phase I: Definition of the Region of Interest (RI) | Phase II: Studies in the Region of Interest (RI) | Phase III: Studies in the Preliminary Areas (PA) | Phase IV: Studies in the Potential Areas (POA) | Phase V: Studies in the Candidate Sites (CS) |
|---------|---|--|---|---|---|
| Action | To present alternatives for the RI and send them to CNEN directors choice, jointly with a list of pros and cons of each one. | To apply on the RI a Cartesian selection using indubitable exclusion criteria, e.g. risk of seismic events, flood due to dam break, and others. | The list of PA is: (1) sent to the Social License Group, which will do the interaction with the citizens of the selected municipalities, in order to perform a public acceptance work; (2) sent to the group of technical selection of Potential Areas - POA , which will apply subjective criteria of selection (Technical Criteria of Hierarchization or TCHi). | The list of POA is: (1) sent to the Social License Group, and (2) also sent to the group of technical selection of Candidate Sites – CS , which will apply new subjective criteria for Site Selection TCSi. (3) It will also be done the compatibility of the CS list with the so-called nuclear municipalities and with the voluntary municipalities. | Characterization of the sites |
| Tasks | <ul style="list-style-type: none"> • Definition of the criteria to establish the RI alternatives; • Map delimitation of the RI alternatives; • Pros and cons list of each RI alternative; | <ul style="list-style-type: none"> • To hire experts; • Definition of the parameters; • Acquisition of geological bases, among others, software and equipments; • Application of the exclusion criteria (ExCT) | <ul style="list-style-type: none"> • Input of the Complementary hierarchical bases (regional geology, highways, etc); • Definition of the TCHi (criteria, parameters, weights, etc.); • Application of the TCHi | <ul style="list-style-type: none"> • Preliminary visits; • To hire experts; • Acquisition of complementary bases; • Definition of the Technical Criteria for Site Selection TCSi; • Application of the TCSi | <ul style="list-style-type: none"> • To hire the companies who will perform the site characterization. |
| Results | RI approved by CNEN | A list of not excluded municipalities (Preliminary Areas – PA) | A list of municipalities (Potential Areas – POA) | A list of the Candidate Sites (CS) | Candidate Sites (CS) characterized in a detailed scale |

Taking into account that the three first items will be considered in the subsequent phases of the site selection process, the Region of Interest was admitted to be defined in function of two basic criteria:

- (i) Proximity with the main waste generating centers. There are numerous advantages in choosing regions with basis on this criterion, highlighting aspects such as security, radiological safety and economic, with time reduction in the waste transport through public roads. In fact, this was one of the criteria adopted for the Abadia de Goiás Repository site selection.
- (ii) Voluntary municipalities to host the repository.

The largest waste generating sources are located in the southeastern region. Based on this, the region of interest may be defined considering the following hypotheses:

(A.1) Maximum distance to the largest waste generating sources existent in the country.

The region of interest is outlined from overlapping of equally distant areas to the waste generating sources, considering security and radiological protection criteria, plus time scale and maximum velocity admitted for the waste transport, from the generating center to the repository [8,9]. This alternative enables the insertion of the location of the already existing nuclear facilities in the site selection studies. This would include municipalities with a history of nuclear fuel cycle activities, leading, much probably, to a better public acceptance of the enterprise and, consequently, a minor difficulty to obtain the social licensing. From a technical point of view, there is the advantage of cost reduction for the characterization of the areas, due to the existence of local and regional advanced studies. Another favorable aspect to be considered is the perspective of future nuclear power plants installation in the southeastern region.

The lack of definition concerning the location for new nuclear plants in the southeastern region, predicted in Federal Government energy plan, may lead to the selection of a site distant from these future facilities, which may result in higher costs for the waste transport. Nevertheless, this vagueness, associated with the uncertainties on the construction schedule for these new NPPs due to the present world economic scenario, would not turn unviable the application of this criterion.

(A.2) Maximum distance to the main waste generating source in the country.

The main waste generating source in Brazil is the Central Nuclear Almirante Álvaro Alberto (CNAAA). In order to limit the region of interest around CNAAA, the following hypotheses were considered:

- (i) the waste transport to the repository will be done during the day;
- (ii) the time spent in the waste transport from CNAAA to the repository will be, at most, 8 hours;
- (iii) the velocity of the vehicle transporting the wastes will average 50 km/h;
- (iv) as a consequence of the roads sinuosity, a correction factor of 0.5, related to the non-linear route, should be applied for determining the area radius.

Considering the above hypothesis, a region comprised by a circle with up to 200 km, centered at CNAAA, is founded. This alternative presents the same advantages and disadvantages of

the previous option (A.1) but, in this case, the social actions opposite to the undertaking may be weaker.

(B) Voluntary municipalities to host the repository.

The application of the voluntary municipalities criterion to host the repository, presumes, evidently, the explicit agreement by the local authorities, condition that claims for many previous actions by the entrepreneur, aiming a straight, clear and transparent communication with the public. The voluntary municipalities would compose, in a smaller scale, the Regions of Interest, in this case not necessarily formed by continuous areas. This alternative would possibly be a facilitating agent to obtain the social license, task considered the most time-consuming and painstaking in the process for definition of the repository site.

In face of the uncertainty related to possible voluntary municipalities and the necessity of the construction of a LLW and ILW repository in a short time-scale, the Region of Interest defined according to the proximity to the present largest waste generator, is seen as the most feasible choice.

2.2 Phase II – Studies in the Region of Interest and Definition of Preliminary Areas

Studies within the Region of Interest should be done using a few area excluding criteria, highly relevant, in accordance with CNEN-NE-6.06 Regulation Act, generating a list of technically suitable municipalities, potentially candidates, which would compose the Preliminary Areas. Among these criteria, could be cited the risk of seismic, the potential risk of flood and occurrence of dam outbreaks (either from hydro-electrical plants, supply reservoirs or even from any type of waste dumps). For this phase of the study, geo-referred bases should be used, at scales of 1:1,000,000 to 1:100,000.

2.2 Phase III – Studies in the Preliminary Areas and Definition of Potential Areas

Countries which have already developed site selection activities for the construction of a national repository, or are already in a more advanced stage than Brazil on this issue, consider that the stakeholders involvement should be achieved since the initial phases of the site selection process. In case this may not occur, it is suggested that the social consulting, the involvement and participation of the stakeholders should start at least in phase of definition of potential areas. The municipalities accepting to remain in the site selection process will compose the Potential Areas, which, later, will be object of geological, physiographic, environmental and economic studies, aiming to evaluate their adequacy to the technical conditions required by the site.

2.3 Phase IV – Studies in Potential Areas and Definition of Candidate Sites

In this phase, it is necessary the establishment and application of selection criteria more specific than those applied in the previous phases, so that CNEN 6.06 requirements be met or even exceeded. In this context, for each of the selected sites in the previous phase, priority work will be developed regarding the following topics: a) topography; b) geology; c) hydrology; d) hydrogeology; e) climatology; f) social-economic; g) ecology and h) land title,

occupation and destination. The public acceptance work should proceed, with emphasis in upgrading the information related to the involvement and participation of the stakeholders, evaluated in phase III.

In this phase, the detail scale (1:10,000) and surveys to primary data acquisition should be preferably used. The final territorial extensions, in this selection phase, will consist of individual polygons. Based on these studies, the Candidate Sites should be selected.

2.4 Phase V – Studies in the Candidate Sites and Final Definition of the Repository Site Localization

The final definition of the repository site localization should be carried out from the characterization of the Candidate Sites, considering factors such as ecological, social-economic, geological and physiographic. Based on the obtained data, technical and social criteria will be proposed for the final choice of the repository site. In this phase, work should be developed using primary and secondary data, covering, among others, the following topics:

a) detailed topographic survey; b) radiometric survey; c) pedological survey; d) weather measurements; e) drilling of wells; f) geotechnical survey; g) geophysical survey; h) laboratory analyses; i) radiation exposure critical pathways; j) geochemistry; k) ecological studies; and l) hydrological and hydrogeological detailing. For each Candidate Site, a site characterization report should be prepared, containing the consolidation of the results obtained from the different studies.

Decision-making related to the final choice of repository site localization is characterized by the aggregation of numerous and different types of information, problem-solving complexity, uncertainty associated and target multiplicity - many times conflicting due to the presence of multiple interests. Frequently, there is not a solution to best satisfy all the actors involved; therefore, decision-makers should establish the criteria for analysis, judgment and decision. In this sense, the use of appropriated computer software to assist the designed authorities could be quite useful.

Finally, it should be highlighted that the social consensus, as to the repository site location, is a relevant factor to be pondered in the decision-making process. Despite the fact that other factors (environmental, economic, and so on,) are fundamental in the site selection process, the non-acceptance by the public may result in the non-viability of the entire project.

3. CONCLUSIONS

Although the national legislation points that the site selection, for the construction of radioactive waste repositories, should be done in phases, in an incremental complexity order and in compliance with exclusively technical criteria, the simple application of this legislation cannot secure reaching the social license. The difficulties to obtain the social license will be much enhanced without the civil society participation in the process, with real risks of turning the entire project into a failure, as it has occurred in other countries. The methodology here proposed preserves adherence to the present country's legislation, besides adding the possibility of an effective involvement of all stakeholders in the process. It is

important to note that activities related to the social involvement must be planned to adhere to the schedule of the overall process.

It is recommended that recent international trends in the site selection process for LLW and ILW repository be considered during the next review of the CNEN 6.06 Regulation Act.

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