The French Geological Repository Project Cigéo - 12023

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ABSTRACT

The French Agency for Radioactive Waste Management, ANDRA, was launched by law in 1991 to perform and develop the research programme for managing high level and intermediate level long-lived radioactive waste generated by the French nuclear fleet. After a 15-year intensive research programme, including the study of alternative solutions, an overall review and assessment of the results was organized, including a national public debate. As a result, the Parliament passed a Planning Act on radioactive waste management in 2006. Commissioning of a geological repository by 2025 was one of the most important decisions taken at that time. To reach this goal, a license application must be submitted and reviewed by the competent authorities by 2015. A detailed review and consultation process is, as well, defined in the Planning Act.

Beside the legal framework the project needs to progress on two fronts.

The first one is on siting. A significant milestone was reached in 2009 with the definition of a defined area to locate the underground repository facilities. This area was approved in March 2010 by the Government, after having collected the opinions and positions of all the interested parties, at both National and local levels. A new phase of dialogue with local players began to refine the implementation scenarios of surface facilities. The final site selection will be approved after a public debate planned for 2013.

The second one is the industrial organization, planning and costing. The industrial project of this geological repository was called Cigéo (Centre Industriel de Stockage Géologique). Given the amount of work to be done to comply with the given time framework, a detailed organization with well-defined milestones must be set-up. Cigéo will be a specific nuclear facility, built and operated underground for over a hundred years. The consequence of this long duration is that the development of the repository facilities will take place in successive operational phases. The characteristics of the first waste packages received will determine the work and the corresponding investments by 2025 on the repository site.

One of the main challenges will be to accommodate both activities of mining and nuclear operations at the same time and at the same location. From the technical standpoint, ventilation and fire risk cannot be managed through a simple transposition from current nuclear industry practices.

The reversibility demand also leads to concrete proposals with regard to repository management flexibility and waste package retrievability. These proposals contribute to the dialogue with stakeholders to prepare for the public debate and a future law which will determine the reversibility conditions.

New design developments are expected to be introduced in the application from the current studies conducted until 2014. The possibility of optimization beyond 2015 will be kept open.
taking into account the one hundred years operating time as well as the capability to integrate feedback gained from the first construction and operation works.

The industrial committed work aims to reach the application stage by 2015. The license application procedure was defined by the 2006 Act. Subject to authorization, the construction might begin in 2017.

INTRODUCTION, GENERAL CONTEXT

ANDRA became an independent agency in 1991 after already having had 22 years of experience in the field of radioactive waste management. As introductory remarks, we shall come back on the few guiding principles of ANDRAs’ activity, as introduced by the Research Law on Radioactive Waste Management passed by the Parliament in 1991. Not only did this law deal with high-level and intermediate-level long-lived radioactive waste, but it also defined a new framework for radioactive waste management, with a number of decisions which were also important for other activities of ANDRA. If we just quote the first article of this 1991 law:

«Article 1 - High-level, long-lived radioactive waste shall be managed in a manner that ensures the protection of nature, of the environment and of public health, and that respects the rights of posterity.»

The main concern for the Parliament, and also for the Government was and remains safety, for today and for the coming generations. The new wording in the following 2006 Planning Act covers not only high level and long-lived radioactive waste but as well «any radioactive material and waste». ANDRA becoming an Agency which is now independent from the radioactive waste producers, the message was that radioactive waste management cannot be only driven by industrial or economic concerns. An independent body is responsible for defining requirements to achieve safety, and waste generators have to fulfill those requirements. In the current process, a dialogue is organized between the waste generator and ANDRA to look for the most suitable ways to generate radioactive waste packages which can then be accepted at the disposal sites. The overall process is also controlled by our safety authority. It is important to remind that requirements, and thus waste acceptance, are not only defined from the waste characteristics but also from the disposal site characteristics that is its capability to ensure safety over time. This is one of the main reasons why we cannot transfer the waste acceptance conditions from one site to another.

ANDRA becoming independent reports directly to 3 ministries, the one in charge of energy, that for environment and last for research. This having been done, a strong message was given to the public that in all cases, the state will take care of the environment and public health, no matter what the nuclear industry does, especially given the timeframes for the radioactivity to disappear.

A second important point of progress introduced by the 1991 Research Law is the system for controlling radioactive waste management and for public involvement. A National Assessment Board (CNE) and Local Information and oversight committees (CLIS) were launched at the sites. The CNE assesses the research and study programmes on radioactive waste management, their progress and the results. Every year, the CNE transmits its report to the Parliament, and then makes it available to the public. It is important to emphasize that the Parliament not only passed a law but also provided the means for monitoring its decisions. The responsibility given to the CNE is not only restricted to the assessment but also includes the duty of expressing scientific and technical achievements into language which can be understood by the politicians and decision-makers. This marks the end of an older era when decisions were
exclusively made by the scientific or technical specialists. It is here clear that all citizens, politically represented by the parliament, are concerned and would like to understand and to take part in the decision-making process.

However it must also be kept in mind that there is also a local dimension, which is where the radioactive wastes are or will be disposed of. The level of concern, here, is different because the local public will have to live within the neighborhood of the radioactive waste. To organize the public involvement, Local Information and Oversight Committees (LCIS) has been set-up. Their mission is to oversee a general monitoring, information and consultation function with regards to the facilities for radioactive waste management. The CLIS may commission hearings or have independent audits performed.

The last point, and it was not the least of the concerns of the 1991 Research Law, is that a 15 year timeframe was given to perform research for high-level and intermediate-level long-lived radioactive waste management. Research would include not only the geological disposal but also the long-term interim storage option and partitioning and transmutation. Based on the results and on an extended consultation process, including a National Public Debate, a Planning Act was passed by the Parliament in 2006. The decision in principle was taken to dispose of the high-level and the long-lived radioactive waste in a reversible repository in a deep geological formation. The work performed so far was to progress on the geological repository project now called Cigéo, for Industrial Disposal Geological Center.

PRESENT STATUS OF CIGÉO

A license application for the reversible geological repository must be submitted in order for the review of the creation-licence application to start in 2015 and, subject to its approval, the commissioning of the new repository in 2025.

In late 2009, ANDRA submitted to the French government proposals concerning the implementation and the design of Cigéo. A significant step of the project was completed with the delineation of an interest zone for the construction of the repository’s underground facilities in 2010. ANDRA has launched at that time a new dialogue phase with local actors in order to clarify the implementation scenarios on the surface. The selected site will be validated after the public debate that is now scheduled for the first half of 2013. This debate will be organized by the National Public Debate Committee. In parallel, the State is leading the preparation of a territorial development scheme, which will be presented during the public debate.

The 2009 milestone also constitutes a new step in the progressive design process of the repository. After the 1998, 2001 and 2005 iterations, which focused mainly on the long-term safety of the repository, the Dossier 2009 highlighted its operational safety, with due account of the non-typical characteristics of an underground nuclear facility. It incorporates the first results of the repository-optimisation studies, which started in 2006 and will continue in the future.

The reversibility options for the repository constitute proposals in terms of added flexibility in repository management and in package-recovery levels. They orient the design of the repository in order to promote those reversibility components. They contribute to the dialogue with stakeholders in the preparation of the public debate and of the future act on the reversibility conditions of the repository.

The development of the repository shall be achieved over a long period, around the century. Hence, the designer will acquire additional knowledge at every new development of the project, notably during Phase 1, which he may reuse during the following phase, in order, for instance, to optimise the project. This process is part of the approach proposed by ANDRA in 2009.
pursuant to the reversibility principle.

**The repository Project**

Surface installations cover an area of approximately 300 ha and include nuclear facilities where waste packages will be received, controlled and prepared before disposal. They also include industrial workshops in support of excavation work and the maintenance, administrative buildings, one or several muck-stockpile areas, 40% of which will be reused for the closure of the repository.

Underground disposal zones are designed in modules in order to allow for a progressive construction of the disposal cells and the sorting of the waste according to their characteristics. Their footprint after about 100 years of operation is expected to be in the order of 15 km².

Surface/bottom connections are necessary in order to convey staff, disposal containers, materiel and materials for work activities, as well as utilities, including ventilation. Work-related transfers shall be made through the vertical shafts. In order to provide extra flexibility in the siting process, ANDRA studied the possibility of opening a linear ramp for package-transfer purposes, thus uncoupling part of the surface installations from the underground ones by a distance of approximately 5 km down a ramp with a 10% slope.

Fig. 1. Display of the potential decoupling of certain surface installations through a ramp (indicative concept of the repository after about 100 years in operation)

**The Implementation of the Repository**

Studies and investigations conducted by ANDRA until 2005 showed the feasibility of the repository in an argillite layer of the Callovo-Oxfordian formation that was investigated by the Meuse/Haute-Marne Underground Research Laboratory (URL), at Bure. A 250-km² zone was delineated around the URL where the results achieved on the argillite layer may be transposed.

Based on detailed further investigations results obtained between 2006 and 2009, ANDRA proposed a restricted zone (ZIRA) in the order of 30 km² for the implementation of the underground facilities of the repository, which corresponds to about twice the total expected footprint of the underground facilities after about 100 years of operation.

In March 2010, the government validated ANDRA’s proposed zone after having received the opinion of the French Nuclear Safety Authority (ASN) and of the CNE. The comprehensive 3-D
seismic survey campaign took place during the spring and summer of 2010, and the first results confirmed the absence of any faults, even minor, affecting the Callovo-Oxfordian formation in the ZIRA.

The government also took note of the wish of the Meuse and Haute-Marne Districts to establish a sustainable partnership for hosting the geological repository. ANDRA is requested to study the implementation of the repository’s ramp access in the straddling zone between both districts. In response, ANDRA has proposed to study such implementation over a zone located along the border between both districts, and close the Laboratory (Figure 2). Shafts are located perpendicularly to the underground facilities.

ANDRA is examining the modalities dealing with the insertion of the installations in their environment by taking into account the local expectations, such as the management of surface waters and of excavated muck, releases, landscape insertion, proposal of architectural sketches, worksite management, etc. Facilities and equipment to be developed for the construction and the operation of the Cigéo (transport infrastructures, location of the railway terminal, power and water supplies, dwellings, etc.) are being reviewed in the framework of an inter-district territorial scheme elaborated under the aegis of the Prefect of the Meuse District, as the co-ordinator Prefect of the project.

Fig. 1. Location of underground facility and siting scenarios for surface installations

**MAIN ISSUES**

**Industrial Issues**

ANDRA has set the following industrial structure for the project:

- the Cigéo shall be a non-typical nuclear installation designed to be built and operated for more than 100 years. Due to that long timescale, the decision was made to develop the repository structures by successive operating steps according to a flexibility approach (Figure 3). The structures achieved in the framework of the Cigéo’s Phase 1 shall consist of pilot structures.

- subject to approval, the purpose of the first construction phase shall be to ensure the disposal of the waste packages by 2025. The actual disposal of the first package will mark the transition between the initial construction phase and the operating phase. From that point onwards, all construction and equipment work for the new operating phases
shall be achieved concurrently with the nuclear operating activities of the existing sections.

- in its capacity as implementer and future operator, ANDRA shall ensure a strict technical control of the project throughout its existence. The Agency has reinforced its engineering skills (project management, design and handling of disposal packages, infrastructure engineering, economic assessment), by creating a specific division for engineering and the Cigéo Project, with a view to ensuring the operational guidance of subcontracts on “Studies” for which the first call for tenders was launched in mid-2011. ANDRA is also developing its skills in the field of underground operations with the internalisation of that activity at the Laboratory. Following the example of ANDRA’s Scientific Board, the purpose of the Industrial Committee, whose creation is under way under the aegis of the Agency’s Board of Administration, shall be to advise the Board on industrial choices and to assess the activities of the services involved.

Fig. 3. Progressive evolution of the Cigéo

The nature of the programme for the first operating phase and of the development scheme for the following phases requires the reception of the different waste packages to be planned in close co-operation with waste producers. In fact, the characteristics of the first packages to be delivered determine the functionalities of the surface nuclear workshops to be commissioned on the disposal site in 2025.

In 2009, ANDRA proposed a first approach of disposal scenarios. By making the best use of existing storage capacities, while reducing the new capacities to be created, the stream of stored packages may increase progressively once the Cigéo enters into service. Its level of industrial activity may then stabilise over time. It appears possible to organise storage activities through campaigns by waste-package families in order to facilitate operating conditions. Exchanges are under way with waste producers in order to precise those scenarios. Depending on the choices made, producers may have to develop complementary capacities for storage, destocking and conditioning, as well as transportation means on site, if current infrastructure and transport means are insufficient.
Safety and Security Issues

If the operational safety of the Cigéo, in its principle, is comparable with the safety of other existing nuclear facilities, the underground part of the facility includes non-typical characteristics that prevent from a direct transposition of practices. Underground installations have no equivalent compared to existing nuclear facilities in terms of volumes, and the underground environment limits accessibility. Managing the co-activity between underground work and nuclear operations must ensure the best worksite separation possible. With regard to fire-risk management, a dedicated regulation framework reference shall be established, due to the specificities of the project.

The solution involving a top-bottom connection through a ramp was further investigated, notably with regard to its use for the transfer of casks containing disposal packages. Feasibility studies relating to a cable-transport mode (funicular) or by a self-propelled carrier were conducted, thus leading the way to other opportunities compared to the solution involving cage transfer in a vertical shaft presented in the Dossier 2005.

In line with the recommendations of the Dossier 2005’s assessors, significant work was achieved in order to mitigate the risks associated with packages (reliability of engines, reduction of potential heights of fall, etc.). The possibility to simplify the ventilation mode of the useful part of the cell for intermediate-level long-lived waste (IL/LL) was investigated. The recommendations of the assessors of the Dossier 2009 orient the next studies to be conducted until 2015 concerning the analysis of operating risks, notably on the containment and management of fire risks.

According to the Safety Guide, “once the disposal facility is closed, the protection of human health and of the environment shall neither depend on monitoring nor on institutional control that may not be ensured reliably beyond a limited period of time”. That implies a sound understanding of the evolution of the repository (status of knowledge and of uncertainty levels) in order to make the repository as robust as possible against internal events (component failures) and external events (human intrusions, natural events) likely to occur over timescales exceeding 1,000 years. Every design evolution is therefore checked to make sure it has no impact on the long term hydraulic and transport performances of the disposal.

The design studies include a description of the disposal at closure. This gives a framework for simulations and long term safety assessment. ANDRA already implements a study and test program on seals, although these components will be implemented in several decades, for the closure phases. These studies may not prevent future evolutions of the repository design within an iterative optimisation process coupled with the periodic safety reassessments.

Reversibility Issues

The 2006 Act states that the reversibility of the disposal process should be granted, as a precaution, for at least 100 years, but without prescribing the actual reversibility conditions of the repository. Those conditions shall be set forth by a new act that shall be voted, after the review of ANDRA’s application and before the authorisation to issue the creation-licence for the repository through a decree to be issued by the State Council after the public inquiry.

The numerous exchanges that have already taken place with stakeholders show several potential motivations for the reversibility prescription, such as a constant control throughout the disposal process, the ongoing possibility to implement other management modes, the continuing availability to intervene in case of abnormal evolution, the possibility to retrieve...
packages should the recovery of their waste content ever become interesting, and the concern not to abandon the site.

The Assessment and Follow-up Committee for the Information and Consultation Approach (COESDIC), launched by ANDRA, and the Scientific Board have underlined the essential character of “the adaptability, throughout the project, of repository specifications in relation to future scientific, technological, economic and societal evolutions, that are unable to forecast as a whole for the time being”.

In response to those different expectations, ANDRA proposes a reversibility approach relying on technical measures designed to enhance the retrievability of waste packages and to ensure a stepwise decision-making process to control the disposal process. In order to facilitate exchanges with all stakeholders in France and abroad, ANDRA has proposed to set forth a retrievability scale in order to illustrate the progressive character of the disposal process and to establish a potential stepwise decision-making process corresponding to the completion of the different scale levels. The scale also shows that the “passive” character of the repository’s safety increases as the repository process progresses. Those activities are part of the Reversibility and Retrievability Project that has been initiated by the OECD Nuclear Energy Agency (NEA) and whose results were presented at the international conference organised at Reims, on 14-17 December 2010.

Fig. 4. Evolution of the retrievability and passivity of the facility compared to the scale of the OECD Nuclear Energy Agency (NEA)

**Economic Issues**

The current reference for the cost estimate of the repository was initiated on the basis of technical hypotheses (inventory, design options) and of the economic conditions of 2002. Under
those conditions, the estimated gross cost of the repository (non-updated expenses) in 2005 varied between 13.5 and 16.5 billion euros of 2002, spread over 100 years, that is, in the order of 1% of electricity-production costs. The estimate covers construction, operating and closing costs, together with all taxes. The working group that produced the 2002-2005 estimate had recommended to update it while taking into account the advance of the research work. The government has initiated an updating process for the repository’s cost estimates, in order to update the cost estimation for the public debate in 2013.

The costing of a project becomes finer as studies keep progressing. Hence, the cost of the Cigéo’s first phase should be estimated with a precision factor in the order of 20 to 30% in 2015. In order to provide the best estimate for repository costs at every step, ANDRA acquired specific tools and relies during the study phase on specialised engineering techniques. The purpose of the work, which is currently under way, is notably to identify both saving opportunities and technical risks.

ANDRA has also identified several action levers with a view to optimising the cost of the underground architecture, such as optimising the total drift length, the excavation timing and the cell length. Certain leads, whose feasibility is not yet confirmed, require further investigations. ANDRA has thus requested the authorisation to extend the Laboratory's operating life until 2030. The licensing procedure is under way and the Public Inquiry Commission has already granted its approval.

However, the 100-year operating life, the requirement to integrate experience feedback from the construction of the initial repository structures and the experimentation delays associated with certain progress leads imply that the optimisation possibility must remain open beyond the submission of the licence application. That flexibility prescription shall require the establishment of scheduled milestones in co-operation with ASN, during which the safety reference system shall be re-examined. Hence, as recommended by the CNE in its June 2010 report: “Since only a single structure is involved and since some of the technical options are still at the investigation stage, the creation-licence application shall reconcile the precision required by the administrative procedure and the necessary flexibility to meet the prescriptions involving reversibility and the integration of technical advances.”

CONCLUSION

The Cigéo Project is moving to an industrial project. In order to ensure its success, it must consider multiple issues associated with local insertion, industrial planning, safety and reversibility, while controlling costs. ANDRA, as the implementer of the project, acts as the guarantor for the search of a fair equilibrium among all those concerns. The project needs an open governance with clear responsibilities for each actor.

The external governance of the project reflects those different issues. The COESDIC has already pointed out that such a general interest project requires an open and clear governance. The different entities for consulting or involving the relevant stakeholders allow the various stakeholders to express their views. In its capacity as implementer and future operator, ANDRA is responsible for final choices, with important decisions pertaining to the government.

In its assessment report for 2010-2012, the Parliamentary Office for Scientific and Technological Choices (OPECST) underlined that such governance plays a crucial role in the climate of confidence that is now developing around the project.