

## **Cigéo, the French Geological Repository Project – 13022**

Thibaud Labalette, Alain Harman, Marie-Claude Dupuis and Gérald Ouzounian  
ANDRA, 1-7, rue Jean Monnet, 92298 Châtenay-Malabry Cedex, France  
[Gerald.ouzounian@andra.fr](mailto:Gerald.ouzounian@andra.fr)

### **ABSTRACT**

The Cigéo industrial-scale geological disposal centre is designed for the disposal of the most highly-radioactive French waste. It will be built in an argillite formation of the Callovo-Oxfordian, dating back 160 million years. The Cigéo project is located near the Bure village in the Paris Basin. The argillite formation was studied since 1974, and from the Meuse/Haute-Marne underground research laboratory since end of 1999. Most of the waste to be disposed of in the Cigéo repository comes from nuclear power plants and from reprocessing of their spent fuel.

### **INTRODUCTION**

The planning act of 28 June 2006 [1] requires Andra to pursue studies and research with a view to selecting a site and designing a disposal facility, so that the licence application for the facility can be reviewed and assessed in 2015 and the facility can be commissioned in 2025 (subject to licensing). In 2012, the project entered its industrial preparation phase. The system project management consortium was selected by Andra. The studies are at present intended to provide the technical data necessary for preparing the public debate planned in 2013 and submitting the Cigéo construction licence application in 2015.

### **THE CIGEO DISPOSAL FACILITY PROJECT**

The overview of the Cigéo project is displayed on figure 1. The surface installations of the disposal facility include:

- nuclear facilities, in which waste packages are received, inspected and prepared before being placed in disposal cells;
- industrial workshops for tunnelling work support and for maintenance;
- administrative buildings; and
- one or more dump areas for stockpiles of excavated material, some 40% of which will be reused to close the disposal facility.

The surface area of the site is about 300 hectares.

The design of the underground part of the facility is modular to allow phased construction of the disposal cells and separation of the wastes according to their characteristics. After a hundred years of operation, it is expected to extend over some 15 km<sup>2</sup>.

Surface-underground connections are necessary for transfer of personnel, waste packages, equipment and materials for the works, and utilities, including ventilation. Works-related transfers

use vertical shafts. To allow greater flexibility in site selection, Andra has studied the option of a ramp for waste package transfer.

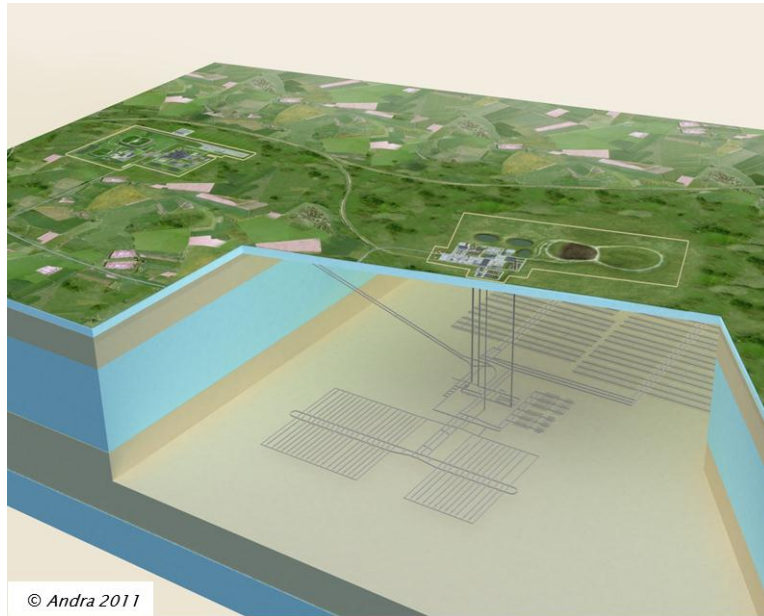


Fig. 1. Diagram of the disposal facility (based on the 2009 options).

## SITING THE CIGÉO PROJECT

The studies and research conducted by Andra from 1993 and up to 2005 demonstrated the technical feasibility of disposal in the Callovo-Oxfordian argillite stratum, and that safety could be achieved on the long-term. An area of 250 km<sup>2</sup> has been defined around the laboratory, within which the results obtained from the underground laboratory on this argillaceous stratum can be transposed.

In late-2009, after an additional set of investigations, including 2D seismic surveys, Andra suggested a limited area of about 30 km<sup>2</sup> to study the location of the underground disposal facility. Geological quality is a determining criterion in site selection. Andra also initiated dialogue with local representatives to identify the criteria related to regional development and to local integration to be taken into account in siting Cigéo.

In 2010, the government approved the area suggested by Andra, following opinions from the nuclear safety authority (ASN) and the national review board (CNE), and after consultation with the local information and monitoring committee of the underground laboratory. The results of the detailed 3D seismic survey of this area conducted subsequently confirmed the absence of even minor faults in the Callovo-Oxfordian geological formation.

The Meuse and Haute-Marne districts have expressed their willingness to enter into a long-lasting partnership to host the disposal facility. At the meeting of the high-level committee (CHN) on 27 February 2012, chaired by the Minister for Energy, Andra was requested to study the location of the disposal facility ramp entrance in the inter-district area defined on both the Meuse and the

Haute-Marne districts. Several options are currently under study for the siting of the surface facilities (figure 2). The final site selection will be confirmed in 2013.

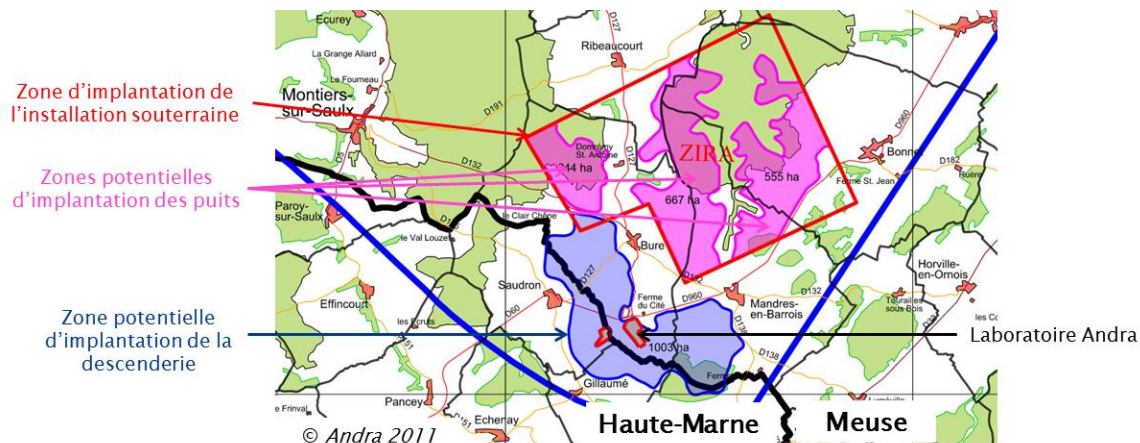


Fig. 2. Options under study for the siting of Cigéo.

The means for integration of the facilities into their environment are being examined by Andra, taking local requirements into account: management of surface water and excavated materials, discharges, landscaping, preliminary architectural drawings, site management, etc.

The developments and facilities required for construction and operation of Cigéo (transport infrastructure, siting of the local network and railway terminal, electricity and water supplies, housing, etc.) are being studied within the framework of an inter-district development plan prepared under the authority of the prefect of the Meuse, nominated as the coordinating prefect of the project, in collaboration with the local representatives.

To guide and advise it in its duty to inform and dialogue with the various stakeholders, Andra has set up an expert committee to monitor the information and consultation process, reporting to the Scientific Council of the agency.

## THE INDUSTRIAL AND ECONOMIC ISSUES

As a nuclear operator, Andra is responsible for the safety of Cigéo. Andra consequently has special responsibility for design choices and their implementation, as they are long-term commitments. The industrial organisation set up by Andra for the design stage consists of a system project manager and industrial architect, for the preliminary design phase (2012), accompanied by several subsystem project managers from 2013 for the basic design.

In the project schedule, the contractual design phases are linked with the statutory milestones. The planned timetable of the public debate is consistent with the industrial design schedule, the preliminary design leaving options open to consultation. The recommendations resulting from the debate will be taken into account in the basic design.

The project organisation is based on two references:

- the act of 12 July 1985 on the relationship between public project ownership and private project management, referred to as the MOP act, the provisions of which are applicable to the construction of buildings, infrastructure and industrial facilities, and
- general recommendation RG Aéro.000 40 used by Andra to structure and coordinate the project.

The organisation put into place by Andra aims to control project technical performance, lead-times and risks and to optimise costs while meeting the safety, security and reversibility requirements, taking into account the issues related to intellectual property of technological developments and to local integration of the project. Project reviews by external experts are organised at the main industrial design milestones of the Cigéo project.

An ad hoc industrial committee was set up by Andra in 2011. It submits opinions and recommendations to the Andra board of administrators on all issues related to the activity and the industrial projects of Andra, including the Cigéo project.

Cigéo will be an unparalleled nuclear facility, built and operated over a period exceeding a hundred years. This long duration leads to the construction of the disposal structures in successive operating phases, to provide flexibility. The definition of the programme of the first operating phase and definition of the master plan for construction of the subsequent phases require planning of the delivery of the various waste packages in close collaboration with the waste producers, Areva, the CEA and EDF.

The characteristics of the first packages to be delivered determine the functions of the surface nuclear workshops to be commissioned at the disposal facility in 2025 and the industrial needs at the current storage facilities, mainly La Hague, Marcoule and Cadarache, to be planned consistently with Cigéo. Transport of waste packages from the storage facilities to Cigéo is the responsibility of the waste producers.

Interface procedures between Andra, which is project owner and responsible for the disposal facility, and the waste producers, which are both beneficiaries and funders of the facility, are governed by a cooperation agreement, respecting the responsibilities of each party. This agreement also enables the Cigéo project to benefit from the operating experience feedback of Areva, the CEA and EDF.

The Cigéo cost estimation procedure is defined by the act of 28 June 2006:

- Andra proposes a disposal facility cost estimate to the Minister for Energy,
- the Minister requests comments from the waste producers and the opinion of the Nuclear Safety Authority on the Andra proposal, and
- the Minister fixes the cost estimate and publishes it.

The nuclear operators take this estimate into consideration to determine their radioactive waste management charges, as defined in article 20 of the act of 28 June 2006.

The current baseline for the estimated cost of the disposal facility was initiated in 2002 based on technical assumptions (inventory, design options) and of the economic conditions at the time. It resulted in 2005 in an estimated gross cost of the disposal facility (expenditure not updated) of between 13.5 and 16.5 billion euros under the economic conditions at the time, equivalent to about 1% of the cost of electricity production. This estimate includes construction, operation and closure costs and the taxes spread over more than a hundred years. It was drawn up based on a waste inventory corresponding to all production by the French nuclear fleet over forty years.

The government has undertaken the process of updating the estimated cost of the disposal facility with a view to fixing a new estimate of this cost. Andra will propose a new estimate at the end of 2013, based on the preliminary design and on the updated waste inventory provided by the waste producers. The new estimate will take into consideration the recommendations of the assessors and any changes incorporated into the project following the public debate.

The act of 28 June 2006 institutes a “research” fund, the resource for which is revenue from the “research” tax, and a “construction/operation” fund, the resources for which are the contributions of the basic nuclear installation operators, defined by agreements.

## **ISSUES RELATED TO SAFETY AND SECURITY**

In accordance with the safety guide drawn up by the Nuclear Safety Authority [2], “after closure of the disposal facility, protection of human health and the environment must not depend on monitoring and institutional control that are not certain to be maintained beyond a limited period”. This involves an understanding of the evolution of the disposal facility so that it can be made as robust as possible with respect to internal events (component failures) and external events (human intrusions, natural events) likely to occur over very long time-scales.

Extrapolated up to the final closure of the disposal facility, the technical solutions under study provide a framework for the simulations and long-term safety analyses of the facility. Andra is also starting a programme of studies and tests on the future seals that will be installed when the disposal facility structures are closed.

Although in principle the operating safety of the facility is similar to that of existing nuclear facilities, the underground part of the facility has atypical characteristics rendering straightforward transposition of existing practices inadequate: the volumes of the underground facilities available to accommodate nuclear activities bear no comparison with surface facilities; in addition, the underground environment limits accessibility. Management of concurrent activity between underground construction works and nuclear operations must separate the worksites as much as possible. Furthermore, there is no benchmark applicable without modification to management of the fire risk, given the specific features of the project.

The examination process for the Cigéo construction licence application is defined by the act of 28 June 2006. By dispensation from the rules applicable to other basic nuclear installations, the licence application is subject to a report from the national assessment board (CNE), an opinion from the Nuclear Safety Authority, the opinions of the local authorities and an assessment by the

parliamentary office for evaluation of scientific and technology choices (OPECST). The disposal facility reversibility conditions will subsequently be defined by an act.

Since 1996 the Nuclear Safety Authority, the Institute for Radiological Protection and Nuclear Safety (IRSN) and the standing expert group on waste regularly assess the work of Andra in terms of safety. Following the examination of the 2009 assessment, review meetings on the identified safety issues are scheduled between now and 2015.

## **ISSUE RELATED TO REVERSIBILITY OF DISPOSAL**

The act of 28 June 2006 stipulates that the reversibility of the disposal facility must be ensured, as a precaution, for duration of no less than one hundred years, but does not define the conditions of this reversibility. These conditions will be laid down by a new act, which has to be passed before the construction licence for the disposal facility can be delivered by decree by the Council of State, following a public inquiry.

The many discussions already organised with the stakeholders have identified several possible reasons for the reversibility requirement, including the possibility of monitoring the disposal process, retention of the option of implementing other management procedures, maintenance of a capacity to take action in the case of abnormal change, the possibility of retrieving packages if the waste that they contain becomes recyclable and, lastly, the concern not to abandon the site.

In response to these different requirements, Andra proposes a reversibility approach based on technical measures intended to facilitate possible withdrawal of packages and on a decision-making process for coordination of the disposal process.

To facilitate discussions with the stakeholders in France and abroad, Andra has proposed to define a scale related to the reversibility. This scale is shown on figure 3 and illustrates the staged character of the disposal process and can be used to define potential decision milestones associated with the various levels defined on this scale. The scale also shows that the “passive” character of the safety of the disposal facility increases as the disposal process progresses. This work is done as part of the Reversibility and Retrievability project set up by the Nuclear Energy Agency (NEA) of the OECD, the results of which were presented at an international conference held in Reims from 14 to 17 December 2010 and are published in [3].

## **RD&D**

The beginning of an industrial phase of the Cigéo project does not alter the need for Andra to maintain high-level research, development and demonstration (RD&D). RD&D work is still necessary in order to prepare the construction licence application for Cigéo, and then its commissioning. Consequently, the operating licence of the laboratory has been extended until 2030. In the longer term, the continuation of Andra’s RD&D work will optimise the new construction phases at Cigéo and the monitoring and closure systems that will be used. RD&D on waste, its conditioning and its disposal will contribute to both the safety and economic competitiveness of Cigéo, proposing optimisations throughout the operation of the facility, and to its reversibility, by opening the way to potential upgrades. To accomplish this, Andra will continue

to rely on resources and on a research organisation that are consistent with the national and international priorities in the field.

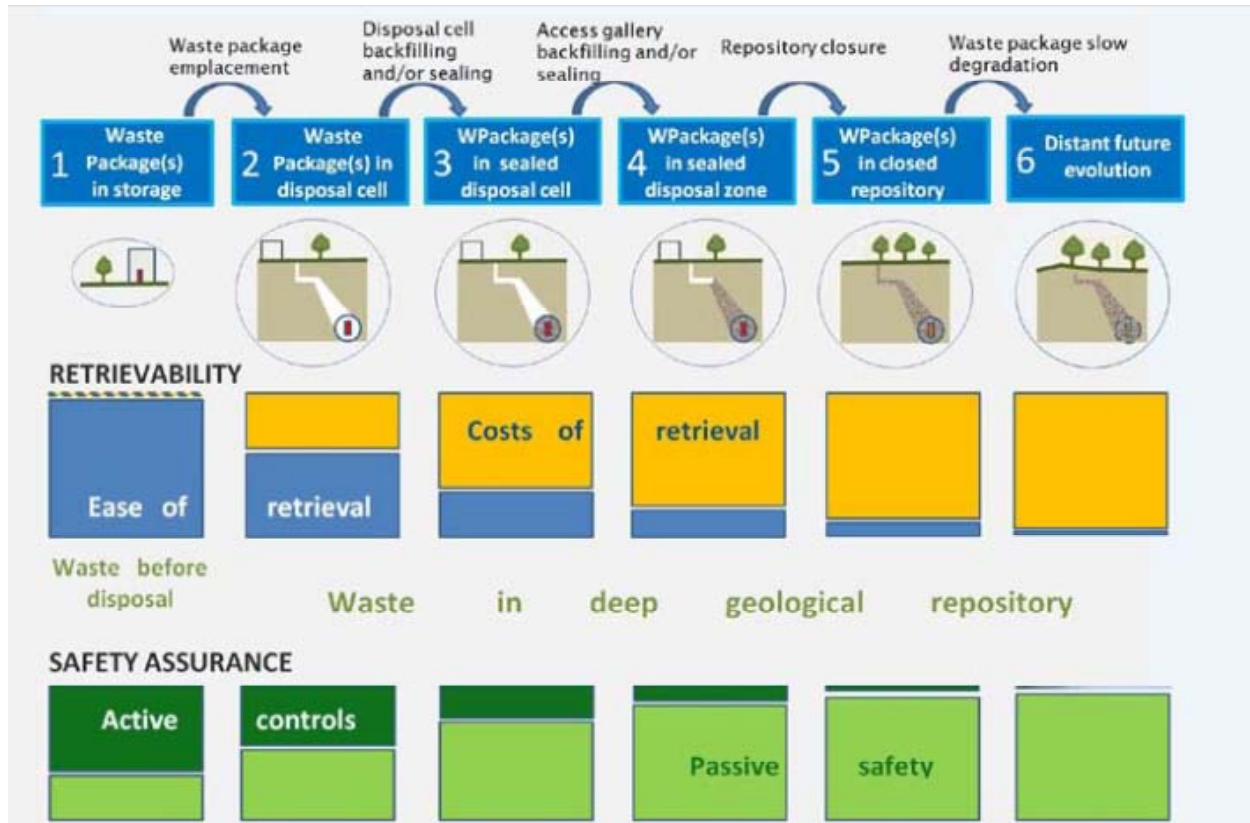


Fig. 3. Ease of withdrawal and passivity of the facility as a function of NEA scale level.

The Andra research work is coordinated with that of other RD&D bodies on the back end of the nuclear fuel cycle, in particular within the framework of the research monitoring committee. In parallel, Andra is participating in forecasting exercises in the nuclear field or in alliances so that it can position its scientific activities within the more general perspective of the national research and innovation strategy. Lastly, the European platform *Implementing Geological Disposal – Technology Platform (IGD-TP)*, through its strategic research agenda, provides a roadmap shared by the counterparts of Andra and the stakeholders for the next fifteen years.

The Andra Scientific Council guides the positioning of the agency in its national and international research environment, and then confirms its strategic choices.

Andra was also assessed positively in 2012 by the research and higher education assessment agency. The assessment measures the capacity of Andra and its teams to lead and direct the scientific and technical studies intended to fulfil the missions assigned to it by the government.

## CONCLUSIONS

These new developments in the Cigéo project are taking place in an international context marked by the Fukushima disaster, but also by the publication of European Council directive 2011/70/Euratom of 19 July 2011 [4] establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste and of the American Blue Ribbon Commission report [5], which recommend deep geological disposal as the reference solution for the most radioactive waste, while stressing the necessity of adopting flexible and adaptable procedures for the process of setting up such facilities.

At international level, the French approach is considered exemplary, in both political and technical terms. Like France, a number of countries have undertaken research on geological disposal. The concepts and the geological media chosen vary according to the country. Long-lived intermediate-activity waste from American defence activities has been disposed of at the Waste Isolation Pilot Plant (WIPP) disposal facility in the United States for the last thirteen years. Finland plans to commission its spent fuel disposal facility in 2020. The construction licence application for the Swedish disposal facility is being examined.

In order to be successful, the Cigéo project must resolve societal, safety and industrial issues. Andra is the guarantor of a fair balance between these different concerns. The external governance of the project involves the various protagonists and stakeholders linked with these issues, under the control of the government and of the assessors. In addition, Andra has in-house advisory and assessment resources, which contribute to ensuring the quality of its work.

The public debate on the Cigéo project will contribute to discussions on risk management, reversibility, local integration of the project, and environmental and health monitoring. It will throw light on the management of existing radioactive waste and waste produced in the future; 30% of the high-level waste and 60% of the long-lived intermediate-level waste for deep disposal have already been produced. The flexibility of the project (the underground tunnels are excavated as and when they are needed) and its adaptability to changes in the French energy system will be presented in the debate. This will provide linkage with the debate on the energy transition Andra will take the recommendations from the public debate into consideration to prepare the Cigéo licence application to be submitted in 2015.

## REFERENCES

1. Consolidated version of Planning Act No. 2006-739 Concerning the Sustainable Management of Radioactive Materials and Waste
2. <http://www.andra.fr/publication/produit/loi-VA-12122006.pdf>
3. Guide de sûreté relative au stockage définitive des déchets radioactifs en formation géologique profonde, ASN, (2008)
4. <http://www.asn.fr/index.php/S-informer/Actualites/2008/Gestion-des-dechets-radioactifs>
5. Reversibility of decisions and retrievability of radioactive waste, NEA/OECD (2012)
6. <http://www.oecd-nea.org/rwm/reports/2012/7085-reversibility.pdf>
7. Council Directive establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste, Directive 2011/70 EURATOM of the European council (2011)
8. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:199:0048:0056:EN:PDF>



WM2013 Conference, February 24 – 28, 2013, Phoenix, Arizona, USA

9. Blue Ribbon Commission on America's Nuclear Future, Report to the Secretary of Energy, 26 January 2012
10. [http://cybercemetery.unt.edu/archive/brc/20120620220235/http://brc.gov/sites/default/files/documents/brc\\_finalreport\\_jan2012.pdf](http://cybercemetery.unt.edu/archive/brc/20120620220235/http://brc.gov/sites/default/files/documents/brc_finalreport_jan2012.pdf)