

STATUS OF SITING A HIGH LEVEL WASTE REPOSITORY IN FRANCE

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ABSTRACT

Radioactive waste generated by industrial activities have been managed in France for many years, and industrial solutions have been implemented for low-level and short-lived waste. This waste is stabilized in solid matrices and sent to near-surface disposal facilities, first the Manche center and, since 1992, the Aube center.

High-level long-lived radioactive waste is the subject of research to lay the groundwork for decisions on a waste management system which guarantees safety for man and his environment. These investigations have been conducted since 1991 under a law which set three research directions:

- separation and transmutation ;
- reversible or irreversible disposal in a deep geological repository ;
- waste conditioning and long-term storage.

The first alternative as well as waste conditioning are accordingly concerned with the waste of the future. Long-term storage is basically only considered for a timescale much shorter than the lifetime of the radionuclides present in the waste. Among the 3 research directions, disposal in a geological repository appears today to be the possible choice for existing waste. Barring a satisfactory alternative, it will also be the solution for the waste of the future. Research into the reversible or irreversible disposal of high-level long-lived waste in deep geological formations is carried out in France by ANDRA, with the assistance of various partners, institutes and research organizations.

High-level long-lived waste from the nuclear power generation cycle in France is stabilized by reprocessing. After the uranium and plutonium present in the spent fuel are separated, the minor actinides and fission products are stabilized in a silica glass matrix. The hulls and endpieces, which were formerly immobilized

in cement grout until 1995, are now compacted. Disposal studies demand the development of inventory models reflecting the quantities and grades of waste which will have to be disposed of at a given date. These models can be used to design the disposal structures and to evaluate long-term safety. They are prepared on the basis of existing waste and on future production hypotheses. To offer an idea, a simple model presumes the continuation of current production, both in quantity and grade, until 2040. The typical volumes considered in this model are:

- about 7600 m³ of vitrified waste ;
- about 80,000 m³ of intermediate level waste ;
- about 25,000 m³ of unprocessed spent UOX and MOX fuel.

Besides this simple model, other models, assuming no reprocessing after 2010, or total reprocessing, are also being investigated. The different alternatives for repository design are considered, with proposals of modular concepts offering relative simplicity of design, as well as architectural flexibility. The studies of the relevant disposal concepts cannot be conducted in generic terms. They demand the identification of the sites for which the development of concepts can fully exploit the actual geological characteristics. Methodological studies will nonetheless serve to identify the necessary basic research guidelines, and to characterize the sites from the angle of a preliminary idea of the requirements they will have to meet.

The rest of the presentation shows the lessons drawn from the first siting attempts, the research process carried into practice, its progress and first results, and the future outlook.

I. FIRST, AN EVALUATION MISSION

A first program of geological surveys on four different sites, each one in a different type of formation (granite, shale, clay, and salt), was suspended in 1990 due to public opposition. The highly sensitive subject of radioactive waste disposal was then re-examined by a Member of Parliament, Christian Bataille, on behalf of the Parliamentary Office for Scientific and Technological Decisions.

After many talks, hearings, meetings and assessments, his report concluded that three factors merited serious consideration in such a sensitive area:

- responsibility,
- transparency (openness and accountability),
- democracy.

Responsibility implies the duty to manage the waste produced by our electric power generation without leaving the burden to future generations. Transparency means dialogue to develop solutions which are acceptable to the different parties. This involves information and explanations on all the programs, results and choices proposed. Democracy clarifies the roles and assignments of all the players concerned.

It is the duty of the scientist to assume responsibility for scientific endeavor, of the politician to decide on a process, of the local or regional official to foster progress on field programs, and of the waste generator to provide the means for the successful implementation of waste management policy, the production of clearly defined, properly characterized waste. And the responsibility of the waste manager to conduct R&D to find the ways and means to manage and dispose of the waste packages in compliance with safety rules keeping sanitary and environmental impacts as low as possible or reasonably achievable.

In accordance with these concepts, Christian Bataille brought a bill before the Parliament, leading to a debate and a vote. The law of December 1991 sets the framework for research on long-lived high-level waste management, defines the roles and responsibilities of each party, and guarantees the rights of communities faces with intrusive research.

II. THE SELECTION OF FOUR SITES

After the law of 1991, the government has given a mission to the same deputy, Mr. Christian BATAILLE, to select some sites upon which some preliminary

geological surveys may be achieved. After the interruption of the first program of geological surveys, a few years ago, it was a very difficult task ; so, Mr. Christian BATAILLE has first explained in a press meeting the meaning of the law and has asked for departments to be candidates for underground laboratories.

There were about 20 candidates. In each case, Mr. BATAILLE visited the department, met the elected officials, the professional organizations and the environmental protection associations. Then, he proposed to the government to keep four sites which combined favorable geological as well as political and social conditions :

- a clay formation in the Meuse department,
- the same clay formation in the Haute-Marne department,
- a granitic site in the south of the Vienne department,
- a clay formation in the Gard department in Marcoule.

III CHECKING THE VALIDITY OF THE SITES

Preliminary surveys began in early 1994 with the aim of validating the sites through surface investigations. The first two sites were first combined because of the similarity and continuity of the argillite formation, and called the Est site. A thick siltite formation was also discovered at Marcoule. The suitability of the sites was assessed according to criteria stipulated in Fundamental Safety Rule RFS.III.2.f, which sets the guidelines for achieving the goal of deep geological disposal guaranteeing long-term safety for man and his environment.

- The East site

The East site is located on the margin of the Paris Basin, a sedimentary basin intensively investigated and hence well known. The Callovo-Oxfordian formation selected consists of argillites. It is 130 m thick and its average depth is about 500 m.

First, the underground laboratory will serve to assess the influence of the vertical variability, clearly expressed at different scales, on the transfer parameters, thus requiring the construction of two ascending and descending galleries to intersect a significant portion of the formation.

Secondly, further information will have to be provided on the role of the Callovo-Oxfordian formation in the functioning of the hydrogeological system during the last million years.

Finally, in view of the thermo-mechanical properties of these argillites and their creep capacity, the retrievability conditions will have to be clarified (types of underground structures support, possible layout of a repository).

- The Gard site

The Gard site corresponds to the northwest margins of the South-East Basin. The preliminary surveys discovered a formation of close-packed impervious siltites dating from the Vraconian, up to 400 m thick under Marcoule. This formation was folded in the Pyrenean phase (the level difference is about 700 m between south and north).

The architecture of the URL will account for the thickness of the host formation, its homogeneity and its structuring. Thereby it comprises two experimental levels.

The upper one will be at -560 m and focused on potential damage caused by hydric or thermal disturbances due to the low porosity and the high rigidity of the layer.

The lower one at -690 m will be the starting point of a South-North gallery about 1 km long, in order to observe the facies variation and identify any fracturing at the base of the formation. This gallery will help to know if the folding induced changes in the stress field and any properties anisotropy. It may also allow to measure the distribution of ions in solution in the interstitial water and then to assess the diffusion process on a large time scale (several 10 My).

- The Vienne site

The Vienne site lies on the Poitou Sill between the two great French sedimentary basins, at the junction between the Massif Central and the Massif Armoricain. The formation selected is a Hercynian granodiorite formation. The 160 m thick sedimentary overburden helped to identify the major faults which were active up to the Tertiary, but, conversely, concealed the lower scale fracturing. The underground laboratory is the only means to explore the fracturing extensively.

The first step will be initiated as soon as the access shafts have been built. An appropriate system of hydraulic and geochemical measurements in boreholes will help to monitor the disturbances induced so as to estimate the connectivity of the hectometric fractures network.

The second step on the construction of three exploration galleries, which are oriented in direction of major structural elements, will be used to observe the structuring of the blocks lying between these fractures and to properly measure the physicochemical properties of the groundwaters, in order to better know their origin, age and chemical exchanges.

Migration tests will then be carried out in these blocks, at their boundaries and in the hectometric fractures, in order to confirm the assumptions of the distribution of the containment functions between blocks and hectometric fractures.

Since the three sites met the requirements of the Fundamental Safety Rule, setting criteria for long-term stability, water content and pressure head, ANDRA filed applications in mid-1996 for the construction and operation of three underground laboratories. The files include a detailed presentation of the sites, danger and impact studies, description of equipment, work feasibility studies, and the experimental program. The applications have been under examination for more than a year.

IV. INTEGRATION ON THE SITES

During the same period, and based on the lessons drawn from earlier siting attempts, a consensus and partnership between ANDRA, elected officials and communities is probably the ideal arrangement. This can only be achieved if the goals and programs are, first, openly and fully presented, and, secondly, explained. Two channels have been used for this: direct communication, and via the local authorities.

The measures provided by law have been applied: structures for dialogue and exchange organized at each site, local Information Commissions made up of representatives of the State, elected regional officials, environmental protection associations, unions and professional organizations, and the applicant, ANDRA. The Commissions have been meeting regularly since 1994, around ten times a year.

A second interesting aspect of site integration is support for local economic development projects. According to the law, budgets allocated by ANDRA are managed by Economic Development Associations set up at each site by the regional authorities. For each site expected to host an underground laboratory, budgets of about 10 million US\$ per year have to be shared among projects in preparation.

IV. THE LAW OF 30 DECEMBER 1991

The French law of 30 December 1991 put operations smoothly on track. The law sets a fifteen-year framework for conducting radioactive waste management research. It established three research directions to assess various alternatives for waste management:

- first, the investigation of partition and transmutation of the long-lived radioactive elements present in the waste: this topic is addressed by the French Atomic Energy Commission (CEA, Commissariat à l'Energie Atomique);
- the second solution, handled by ANDRA, the French Agency for radioactive waste management, evaluates the options for retrievable or non-retrievable disposal in deep geological formations, particularly through the creation of underground laboratories;
- the third addresses immobilization and conditioning processes, as well as long-term near-surface storage: this is also managed by the French CEA.

But beyond setting guidelines for research, the law also defines a clear framework specifying the duties of each party, setting goals and a major rendezvous at the end of the fifteen-year research period. At that time, the Authorities, having examined the research results, will be able to express their preferences with regard to long-lived high-level radwaste management.

The roles of the different players are clearly identified. The missions of the politicians, producers, researchers and waste managers are clearly delineated. An external control system has also been set up. Executive control is mainly exercised through the Safety Authority and its technical support. Legislative control is exercised by the Parliamentary Office for the Evaluation of Scientific and Technological Choices. And the National Evaluation Commission set up by the law makes a

scientific assessment of the research programs and results. It holds hearings on the three research directions and reports to the executive and legislative authorities. It advises the politicians about scientific and technical developments and checks that adequate resources are allocated to each avenue. The Commission publishes an annual assessment which in turn serves to guide further program adjustments.

The concept of reversibility was introduced by the law and has sparked specific studies. Requirements associated with reversibility must be reconciled with those of long-term containment, and structures allowing for reversibility must be designed. Reversibility is a precautionary factor affecting the decisions taken for the coming decades.

V. PRESENT STATUS

The applications for permits to build and operate three underground laboratories were scrutinized from mid-1996 to end 1997. The examination phase provided for technical opinions from the Safety Authority and the administrations in charge of the subsoil and the environment, public enquiries on the three sites, and the consultation of the territorial authorities, communes, Départements and regions.

At the technical level, the ad hoc group of experts with the Safety Authority ruled in favor of continued investigations from underground laboratories on each of the three sites.

The public enquiries elicited nearly 2000 questions which ANDRA has answered systematically. On completion of their mission, the enquiry Commissions submitted a favorable report on each of the sites.

The communes in a 10 km radius concerned by the installation of the underground laboratories voted 85% in favor of continued investigations. In the Départements directly concerned, the votes tallied 84% in favor. At the regional level, 49% of elected officials voted against the underground laboratories.

What is the situation today? The public inquiries took place in 1997 and their conclusions were given at the end of last year. Moreover, the government received the opinion of experts from the safety authority. At the beginning of this year, on the second of February, following an interministerial meeting, the government asked further information on reversibility which has been a great question during all the public inquiries. So, the National Evaluation Commission submitted, last June, a

report on reversibility to the Government, which should take its decision in the nearby future.

VI. PROSPECTS AND CONCLUSIONS

Surface investigations conducted from 1994 to 1996 demonstrated the favorable characteristics of the sites selected in terms of the Fundamental Safety Rule. This led to the permit procedures for underground laboratories. Breakthroughs in knowledge are expected from access to the geological formations from the underground laboratories, to demonstrate the suitability of the formation to accommodate a high-level long-lived radioactive waste repository.

All the experiments have to be prepared meticulously, given the short time remaining before the 2006 rendez-vous. International cooperation has provided ANDRA with the preparatory framework. The experiments should be prepared with the assistance of our Swedish, Canadian, Swiss and Belgian colleagues, thanks to their own methodological installations. The granting of the permits will set the stage for the next phase of investigations on sites for which the target level of knowledge lies far beyond the methodological research, since it is closely linked with the developmental process of the repository concepts.

The law of 30 December 1991 inaugurated a working method according to which, over and above purely scientific issues, a consensus must be reached with the local communities. This method bore its first fruits with the candidate sites volunteering to host underground research laboratories, and the permit procedure under way for their installation and operation. Yet 2006 is a long way ahead, and the next step is to obtain the underground laboratory permits.

The simultaneous initiation of several sites is a huge responsibility. Most of the experiments planned to solve new problems will demand special methods and specific technologies for French and foreign teams alike. International cooperation on the French underground laboratory project will help combine thought and effort for mutual benefit.