

SUMMARY AND MAIN RECOMMENDATIONS

REPORT N°3 - September 1997

I. 1996-1997 WORK APPRAISAL OF THE NATIONAL ASSESSMENT COMMITTEE

During the period between July 1996 and June 1997, the National Assessment Committee has carried out 12 auditions of the actors of the law (ANDRA, CEA, COGEMA, EDF) and heard 4 experts : Carlo RUBBIA (CERN - Switzerland) on the first area of the law : "Separation - Transmutation", as well as Jean-Paul MINON (ONDRAF - Belgium), Claes THEGERSTRÖM (SKB - Sweden) and Colin ALLAN (EACL - Canada) on the problem of retrievability in the context of the second area of the law. Two auditions have been devoted respectively to the industrial strategy and the research strategy, but the two dates of these sessions (28th May and 23rd April 1997) permit only a first valuation of these presentations which will have to be studied in depth during the second half of 1997.

Several members of the Commission went to the United States to meet the government organisms which are concerned by nuclear waste management, and to Canada to meet the various authorities from EACL (Canadian Atomic Energy Limited) and visit the important underground laboratory research site in Manitoba (URL - Pinawa and Whiteshell Laboratories).

The Commission also devoted 9 plenary or part sessions to the writing of this document, which will be presented to the Ministries and the Parliamentary Office for Scientific and Technological Choices on 10th September 1997, then to the actors of the law then to the Press.

The assessment presented here deals with the three research areas as defined by law.

II. GENERAL CONSIDERATIONS

They concern the global research strategy and the general balance of the programs, the work to be carried out in the underground laboratories, as well as a first approach on retrievability.

The oral presentations made to the Commission show that the concerned public authorities and the various players in the nuclear field have thought things over together in order to clarify their industrial and research strategies. They also suggested priorities and time limits for research to be carried out before the year 2006. The Commission values their effort to debate hand in hand as well as to suggest directions for the whole downward part of the nuclear cycle. Because of the presentation dates of these strategies, recorded in documents which have not yet been finalised, the Commission will limit itself to comments dealing with research and will continue its assessment, based on texts, in its 4th report.

A. Research Strategy

The pluriannual research plan must obviously meet on one hand the requirements necessary to fulfil the missions set by the 3 areas of the 30th December 1991 law and on the other hand, the research requirements of the concerned industrialists, always within the context of the law.

As for the requirements of the organisms responsible for industrial operations we can say that the research program plan which was presented corresponds to what is required for the current operations, notwithstanding a few exceptions.

However, in spite of a visible effort of coherence in the criteria used in assessing the research relevance and priority, the exposed research plan shows through an ordered juxtaposition of individual programs, stemming from groups which are anxious to protect the future of their own projects. The Commission recommends to the Directors of these large organisms to ensure the real cohesion of efforts and technical choices.

A number of points would need to be more emphasized ; the Commission recommends to reconsider :

- the fate of existing and non containerized waste, which represents an important volume, especially sludges, and which will have to be taken back. The Commission is expressing doubts on the solutions that were quoted, without totally being won over ; adversely it would be desirable as far as possible, not to use the bitumization process, a technique that the La Hague plant has now abandoned, to embed sludges that have accumulated in silos, and to avoid reconditioning systematically waste that is already conditioned,

- the weight given to the research on long life fission products, which is relatively too weak (^{129}I , ^{135}Cs , ^{79}Se , ^{99}Tc , ^{107}Pd ...) as well as radioisotopes either the lighter ones (^{14}C , ^{36}Cl ...) or the ones capable of initiating a gas diffusion (^3H , ^{85}Kr ...) ; if we compare the volume of teams or budgets allocated to these subjects with those devoted to actinides, we see a gap situated between 10 and 100 ; these radionuclides however are the most likely to create the most serious problems during the first storage period, as it is shown in studies on the return to the biosphere carried out by the IPSN as well as by foreign countries ; therefore it would be advisable to put more efforts into the separation and the destruction of the reactors, the specific conditioning matrices, the chemistry and the geochemistry of these radionuclides ; the impact of the thermal problems connected to the average life fission products, like the ^{137}Cs and the ^{90}Sr , deserves closer attention since it largely conditions the influence of the disposal,
- the fate of iodine and cesium ; particularly if the chemistry now used in specific nuclear fields is well known, the chemistry and the biochemistry of the other fields must be taken into account, including the risks of transfer, of concentration along the food chain, as well as the toxicology of ingestion by man. A less acute problem is the one of tritium waste, even if it remains lower than the administrative authorizations, as well as the problems caused by the interim storage of tritiated waste (tritiated water, tritium, tritiated metals, irradiated graphites ...).
- The lack of a definition to this day and as far as we know, concerning the characteristics (dimensions, weight, etc...) of those packages that would be intended for future underground disposal, and the storage concept in vertical pits or in horizontal galleries, prevents us from really tackling the problems of mine engineering (diameter, height of the underground works, dimensions of the pit landing, handling tools) and therefore prevents us from assuring that the underground laboratories which will be dug, will be really representative of the future works ; we have here a crucial and urgent issue to which an answer should be given before the end of 1997,
- the fact that some tools and the procedures necessary for the characterization tests of old packages are missing, leads to postponing the definition of the storage concept,
- research that would be made necessary if it was decided not to reprocess part of the irradiated fuel, or to reprocess all these fuels at a different extraction rate ; the particular difficulties connected to the reprocessing of MOX fuels ; the possible conditioning of irradiated non-reprocessed fuels in view of an extended disposal period that could possibly end in storage.

Other points concerning the three research areas mentioned in the program plan need to be clarified :

- the links between reprocessing, long term fuel storage, simplified reprocessing which would leave more plutonium in the waste and specific plutonium conditioning, are not clearly explicit,
- the different types of research led in the context of area 1 and the one led in the other two areas; the first type aims indeed at widening the choice of possible solutions to the waste problems ; the second type, being a more applied research, corresponds to the need to provide the legislator with decision elements referring to geological disposal : in that sense, it must provide results,
- among the research studies on the first area, the distinction between those that fit mainly in the continuity of present technologies, and the result of which depends first on industrial choices, and those being innovative, often complex, which require an important, often fundamental effort of research with an unpredictable outcome.
- Research on innovative options, which deals with fuels as well as reactors themselves (mainly hybrid systems) is so complex that in the long and middle term it forces research organisms like CEA , CNRS and EDF to define a common research strategy and put together complementary competences and associated resources ; therefore we must in time envisage a federation of several European teams to study the performances and the technical aspects of these systems in term of incineration, and, if the case arises, to develop an upgradeable prototype allowing the coupling of various types of subcritical assemblies to an accelerator. An exchange such as this one, where each party (including C. RUBBIA and his CERN team) would bring its fields of excellence, would allow a multinational funding and probably a participation of the European Union, on the grounds of existing waste disposal.

In conclusion, the progress of knowledge should now allow the actors of the law to suggest sufficiently elaborated storage concepts, taking into account the various criteria of size (thermal, volumes, galleries or pits ...), safety, and coherence of these concepts with the other characteristics belonging to the downward part of the nuclear cycle (proportions to be reprocessed, separation and transmutation of some bodies).

B. Underground Laboratories

The Commission imposed on itself a strict duty of reserve as soon as the first public enquiry order is signed concerning the building and operating authorizations for underground laboratories (DAIE), and this while the enquiry is being carried out. The Commission has only met the survey-commissioners, following the notifications that they sent to its members.

We can note that the complementary geological and geophysical work recommended in our second report (June 1996) particularly the one dealing with geophysical modeling and the reinterpretation of seismic studies, has been done during the second half of 1996. These tasks have been executed with competence by ANDRA and made it possible to clarify certain points : the way various granitic masses are rooted in the Vienne "Département" and the continuity of the middle and upper part of the silt formation in Marcoule in the Gard "Département". In turn, these results allow a better understanding of the problems which will have to be solved when these underground laboratories are built, if the building authorization is granted.

For the site in Eastern France, complementary studies confirm the favourable assessment made on the capacities of the site. In Gard, the acquired additional knowledge contribute to a favourable assessment of the geological parameters in the pursuit of the program.

In the Vienne site, the hydrogeological and geochemical assessment of the new results prevent us from suppressing the reservations expressed before by the Commission. There are risks of the fluid circulation between granit and exploited aquifers which increase significantly the difficulties to qualify this site as disposal possibility, because of the lack of an appropriate storage concept specifying the geological barrier function. Moreover, it is to be noted that the disposal must be build in a kilometric area on a site made of hectometric blocks requiring then watertight barriers by faults crossing. The assessment of results makes us realize the existence of unavoidable negative aspects for underground disposal which bring the Commission go beyond up above the reservations expressed in the report n° 2 (page II and paragraph 6.1.3.2).

However, the granitic formations in some conditions may provide a possible alternative to storage in clay environments ; in particular some difficulties met on this site could be removed in a site where granit would be showing on the surface. The postponement of the schedule for the works in different underground laboratories will not be necessarily detrimental.

However, if these laboratories were to be built, one cannot avoid mentioning a delicate problem. Of course it sounds logical to imagine that the detailed engineering studies, the realization of the shell and maybe even certain specific aspects such as safety on the building site, could be entrusted to competent and experienced contractors. However it is essential that the people in charge of the experiments and observations which will be carried out in the laboratories should be closely associated to the development and realization of each building stage : the validity of the experiments and the significance of the results depend on it. But this requires a large number of engineers/researchers having both an in-depth knowledge in their fields and sufficient or even substantial knowledge in mining work. In Canada, for instance, the EACL maintains for one underground site only, about 70 people attached to the building and 60 in classic surface laboratories.

ANDRA must be able to ensure this double involvement : enlightened supervision of subcontractors on one hand, and the development/realization/follow-up of experiments carried out underground on the other hand. In this respect, it looks urgent to complete the teams and to take advantage of the time when the documents are being examined and when preliminary works are being carried out, to send each person in charge of experimentation follow a long term training in existing sites abroad, so that they can acquire the specific knowledge necessary for conducting work in underground laboratories.

We can indeed question the availability of competence, in the present situation, to run several underground laboratories at the same time.

C. Retrievability

Retrievability is mentioned in the law, and the Commission wished to be enlightened on this provision. It has heard extremely competent foreign experts on the subject. You will find in chapter 7 the Commission's preliminary comments on retrievability : duration, level of retrievability, according to the type of waste. The approach of the Commission does not aim at replacing the legislator, but it could help clarify the concept mentioned in the 1991 law. Consequences are obvious on waste conditioning, on storage concept and architecture. In this respect, it would be advisable to look openly for optimal solutions between long term interim storage and retrievability in geological disposal.

In the very long term, when the packages integrity cannot be guaranteed any longer, the concept of retrievability loses its very meaning. It would then be fit to envisage the retrieval of the residual radioactive products with the help of mining techniques adapted to the disposal particular environment.

III. RECOMMENDATIONS ON THE THREE RESEARCH AREAS OF THE LAW

Area 1 : Separation - Transmutation

The Commission formally records the research programs that she was presented with, and hopes that these programs will not remain isolated, each one for each team, but will form a whole that can be clearly defined and coordinated between the various partners, with priorities and an agenda that will cover the different stages of the global strategy. This applies in particular to radionuclides to be separated, and to their orientation towards transmutation or conditioning ; it applies also to research on innovative systems.

The fission products are treated lightly in present studies, in spite of their toxicity which is reinforced because of their capacity to migrate in underground waters. Even in Carlo RUBBIA's project, some residues from long life fission products are not really taken into account. If it appears impossible to free the necessary teams among the present participants to cover the subject, the Commission suggests to entrust it explicitly to other teams from French research organisms having the relevant competences. The latter would be responsible for integrating these programs in the priorities and in the general research agenda.

Many scenarios on plutonium and minor actinides recycling have been presented to the Commission so far. The Commission feels that time has come to advise CEA and EDF to concentrate on a few scenarios and study all the different aspects (safety, industrial and economic feasibility of the different stages including targets manufacturing and reprocessing, associated waste and their short and long term radiological impact).

In view of a wider collaboration on innovative systems as recommended above (paragraph II), and to ensure an experimental base adapted to the issues to be studied, the Commission wishes to be presented in 1998 with the first stages of the studies the point of which is to establish the interest and the feasibility of a subcritical reactor fed by a reactor of minimal thermic power, and designed first to examine incineration.

The chemical aspects of area 1 also deserve special attention :

- the separation of minor actinides, technetium and cesium in reprocessing is approached at the CEA according to a clearly defined strategy, the developments of which can be appreciated ; this research should be pursued with the will to reach a technical feasibility for the first deadline set in 2001,
- the program dealing with the making of incineration and transmutation targets and of their reprocessing, is less explicit ; the Commission recommends that the studies that have been started should be developed and deepened, but it also wishes to see that the coherence with the scenarios chosen for the global strategy is pursued and presented to its members,
- in order to accompany this research and the one recommended in a strategic context, it is essential to make the Atalante facilities available ; the Commission reiterates the item from its report n°2 recommending to keep to the date of its implementation.
- new problems are emerging for the chemistry associated to the incineration and transmutation of innovative systems, namely the manufacturing and reprocessing of metallic targets : a pyrometallurgic and electro-pyrometallurgic method with melted salts is being explored : this type of chemistry is explored abroad and at the CEA as a complement to hydrometallurgy ; CEA-DAM are experienced in the field of plutonium electrorefining ; the Commission recommends that this method should be explored, including on burnt materials

before vitrification ; it wishes to be informed on the experimentation possibilities that exist in France and the European and international collaborations with the organisms that have acquired experience in this field.

Area 2 : deep geological disposal

The specification choices for the packages which will be allowed in deep disposals (nature and characteristics of the container as well as the waste it contains) are dependent on the choice of storage concepts (for instance the engineered barrier) and the architecture of these structures, and vice-versa. That is why the Commission feels it is a priority that the concerned actors of the law communicate to its members their common position on the subject as soon as possible.

The main outlines of the research programs to be implemented in the underground laboratories have been presented to the Commission. Its members wish to hear the specific programs devoted to remove remaining doubts on fluid mobility in the rock matrix (depending on the case, compared importance of diffusion and "darcean" flows ; real meaning of the very low permeabilities which have been announced), and in the fractures (particularly in granit) ; and on the phenomenons connected to the solid - fluid interface (for which the "Kd parameter" is a very basic estimate).

These studies should help us to base modelization more firmly on physical laws, the field of application of which must be clearly defined and so establish the validity of calculation codes. In the second half of the year 1997, the Commission wishes to hear the results already secured and those that are expected from underground laboratories to validate, in fine, the calculations on radioactive elements migrating up to the biosphere and which come into safety analyses.

The Commission also recommends to pay particular attention to the study of some geochemical aspects, namely an investigation must be pursued on organic colloids and minerals present in natural waters, and their possible role in the transport of radionuclides ; in the sight of the information provided by natural analogs including Cigar Lake (Canada), Oklo (Gabon) and natural systems enclosing metals used in the alloys of containers. These studies must be continued.

Within the context of geophysics, the Commission recommends to follow recent developments of non destructive physical methods (high frequency radar) to identify and make a map of the cracks situated a few meters or ten meters or more outside the galleries. It recommends also in the perspective of a possible retrievability as planned by law, but which must not weaken passive safety, to experiment sensors for physical parameters in underground laboratories, and which would later be placed permanently in future disposals, to follow environmental evolution after observing the various stages necessary to close part or all of a disposal site.

The definition of the word source of packages and the definition of these materials forming the engineered barrier are now essential to tackle the studies and the modelization of the neighbouring field ; the Commission wishes to be presented with these definitions in reasonable time so that the numerical modelization could really start.

The scenarios on the return to the biosphere will have to be clearly explained and include the possible formation of organic derivatives through microbiological activity, and the possible concentration by plants and animals all along the food chain, in particular under the influence of a long term chronic contamination, and taking into account the specific characteristics of the retained sites.

Area 3 : Conditioning and interim storage

As far as conditioning is concerned, the importance of which has been stated for all the research programs of the second area, the Commission wishes first to be enlightened on the specifications retained or suggested by the actors of the law : the information it has been given so far goes from precise specifications ("individual "packages" in glass or other material) to the greatest uncertainty (containers or subcontainers which would bulk one or several packages). Such a situation cannot continue without assuredly being harmful to the work that will be carried out in the underground laboratories. Definitions of functions, materials, procedures, specifications... are necessary.

While it is waiting for these definitions and clarifications, the Commission can only renew insistently its previous recommendations to carry out research on traditional matrices :

- on the long term behaviour of nuclear glass, in comparison with the acquisition of new data on natural and anthropogenic analogs,
- on establishing the deterioration mechanisms of cement powder based materials, and the consequences induced on and by the packages near fields,
- on the confirmation of positive results presented on bituminized coating (good resistance vis-à-vis water and micro-organism aggression), and the implementation of similar studies for bituminized coating and mixed coating, other than those produced by the STE₃ from La Hague.
- regular information from the Commission on the progress of the long term qualification of these matrices is desirable.

- The Commission attaches much importance to prospective research on new matrices usable for various types of waste : vitreous, ceramics, phosphate or oxide matrices, some natural analogs of which have undergone several erosion and sedimentation cycles and remain unaltered since the Precambrian. In this respect, the Commission wishes to see the setting up of a coordination between the scientific teams working in the field of solid chemistry, and materials used in the end part of the cycle. The choice of possible matrices, announced for 1998, will have to be presented to its members, together with potential waste (old, present or future waste) that may benefit from them.

Finally, it is highly desirable to think over the duration, the objectives and the modes of long term interim storage of various types of waste, in order to achieve a coherent program and significant results for the date set in 2001. This thinking effort will have to rely on the experience acquired in France and abroad for the past few decades.

General comment

The Commission reiterates its recommendation on the need to develop a systematic publishing policy in the international scientific journals that have a reading panel. It recommends also that generally speaking public reports and reviews of a high scientific level show to the international community how France is anxious to fulfil its responsibilities in the downward part of the nuclear cycle and how capable it is to do it. In that sense, an international symposium organized on the initiative of the actors of the 1991 law, with the support of the relevant ministries, would be a sign of opening appreciated by all.

This concerns just as well safety, disposal and interim storage engineering aspects including partitioning transmutation conditioning, than research and development studies.