

SUMMARY AND MAIN RECOMMENDATIONS

REPORT N° 5 - June 1999

The assessment of research, according to the mission entrusted to the Commission by the article 4 of the law dated December 30, 1991, has been pursued. Report n° 5 corresponds to hearings held between September 1998 to May 1999. This report and the recommendations formulated in it have been unanimously approved by the Members of the Commission Nationale d'Evaluation (CNE) and was handed to the Government on June 21st 1999.

THE RESEARCH RELEVANCE ON THE THREE AREA OF THE LAW

As the Commission had noted in its report n° 4 (october 1998), we can now consider that research is being pursued equally on the three lines planned by the 1991 law. Of course, this does not necessarily mean the same annual budget for each of these lines, since the realization of an experimental device or of an underground laboratory can temporarily increase the amount of expenses on one of them ; the Commission is basing its judgement on a well-balanced progress in research works, which should produce, within the time limit set by law, a coherent final report as well as recommendations for future works.

Within the framework of government instructions, the Commission had, in June 1998, handed over to the government the report which it had requested concerning reversibility, together with its implications on disposal and storage. The decisions of the interministerial committees of February 2nd and December 9th 1998 have defined the principles of the right balance to be looked for between the three areas of the law. One can particularly note in them the interest granted to the transmutation possibilities by subcritical reactors (« hybrid » systems, area 1 of the law), the concept of storage reversibility and their specificity (« a close link should be established between the type of waste and the types of disposal or storage to be studied », area 2 of the law), as well as the problem of a prolonged storage, in view of a

possible processing of the spent fuels or of the high-activity waste (area 3 of the law).

The general appropriateness of the research to the objectives of the 1991 law and their coherence with industrialists' strategy, were confirmed when presentations were made on January 6, 1999. On one hand, EDF presented three successive phases for the management of its reactors in the century to come, while insisting on the obvious necessity for a utility to keep a high level of flexibility to adapt to technical, economic and statutory evolutions. COGEMA and FRAMATOME mentioned the feasibility and the availability of the various corresponding technologies. On the other hand, the actors of research, under the aegis of the Ministry of « Education Nationale », of Research and of Technology (MENRT), have, for the first time, presented in a common document the strategy and the research programme which represents an important progress according to the Commission's viewpoint. The Commission also considers that research must be able to offer, when the time comes, a fairly wide palette of technical solutions which would not restrain too much the future industrial choices.

However, the Commission draws our attention to a few points where the coherence of research with the spirit of the law or the industrial strategy could be improved, and on which it does not necessarily share the positions that were presented :

- the long term storage problem which, for EDF, is limited to about 50 years' storage after coming out of the reactors and which could go up to 300 years for the CEA ; the origin of this difference of approach may be caused by the nature of the waste that would be placed in those storages (spent fuel after previous storage in pools for EDF ; all types of B and C waste as well as spent fuel for the CEA) ; the Commission underlines that such a concept leaves a large share of the management of the final part of the cycle to future generations. The risk to neglect or even forget a very long term storage equipment is not negligible ;
- old waste retrieval that falls within the law and presently coming loose: for this, the CEA announced options that were chosen in the CEDRA interim storage project of Cadarache ; it is also developing new effective packaging

devices which could apply to this waste, because the effective retrieval of this loose waste is not obvious. COGEMA has decided on reference solutions according to processes that have been sampled industrially (cimentation, bitunization) and remains open to CEA processes as long as they are qualified in due time. Therefore it is essential that the process qualifications stemming from the CEA research be done according to a precise calendar which is compatible with the planned retrieval operations ; besides, these processes must lead to significant safety and possibly economic benefits ;

- the question of health hazards connected to the various modes of waste management is at the heart of the research which will be carried out on this subject. It concerns for example the relationship between doses of radiological of chemical nature and risks, for exposures which involve many generations, respecting the principle of precaution. The latest research presented to the Commission shows that scientific knowledge on the subject is still evolving and very much so, and that certain viewpoints will have to be revised and completed ; the Commission explains its views in the annex 7 of the report ;
- the Commission lends much weight to waste inventory that comes under the 1991 law, for it believes that knowing the characteristics of the packages to be disposed of or stored (dimensions, weight, thermicity, nature of the radionuclides) as well as their total volumes is a necessary condition so that both the experiments which will be carried out in the underground laboratories can be representative and therefore significant, and also for the development and feasibility studies.
- the document on research strategy and programmes does not touch on the question of the global responsibility of modelization, for the demonstration of disposal and long term storage safety.

The follow-up of the previous Commission recommendations

The two working sessions which have examined the recommendations follow-up have, in priority, favoured exchanges and allowed to provide clarifications on many points. In particular, all the recommendations written in the report N° 4 have received an answer. On the whole, the majority of

the recommendations have been taken into account by the actors of the law (chapter 2). Those that called for a more in-depth discussion on the part of the Commission appear in the body of this report.

Generally speaking, the bilateral or multilateral working meetings between the actors of the law, between the Commission and some or all of them, have brought about a convergence in the viewpoints on many aspects, even if a few subjects of divergence of scientific opinion do subsist like waste inventory or modelization, which will be dealt with in a separate chapter (chapters 4 and 5) ; the other items of the evaluation and the recommendations that refer to them will be assembled according to the three areas of the 1991 law (chapters 6, 7, and 8 respectively).

Waste inventory coming under the 1991 law

In its report n° 4, the Commission had noticed that the inventory and the 1998 forecasts were not satisfactory : particularly the values planned for 2020 did not seem to be coherent with the forecast made in 1996, nor with what we could know of the existing situation. The conclusions of the interministerial Committee of December 9, 1998 mean that we can now find a solution for this situation, thanks to the mission entrusted to the President of the ANDRA suggesting a reliable counting method which will be the basis to the inventory of what exists. Starting from that, it will then be possible to develop for the 2000-2020 and 2020-2070 periods which correspond to the main steps chosen by EDF to replace its facilities as well as by the ANDRA for the beginning and the end of operating the first repository. Following the declarations of the Commission, the producers have made this inventory more precise ; the Commission contributed to this through auditions and discussions.

The lack of coherence found by the Commission in its report n° 4 stems indeed from two main causes. First of all, the obligation that the waste producers had to supply forecasts for 2020 and 2070 did not include any inventory of what existed already. Secondly, in order to make these forecasts, the various producers had adopted fairly different attitudes concerning the waste that is not conditioned, which represents about half of B waste: in some cases, they limited themselves to existing techniques or to new

processes for which the industrial demonstration had already been done; others have used the potential result of current research to limit their volume thanks to an appropriate conditioning, or were able to change part of their waste into waste of A category receivable in surface storage; the compatibility of these with the standards of surface disposal, and especially with the radiological capacity of the site, remains to be demonstrated.

Finally, the waste from the dismantling of old facilities during the periods of time from 2000 to 2020 and from 2020 to 2070 does not seem to have been taken sufficiently into account in the 1998 inventory. This is also true for the problem of secondary waste, created by the repackaging of old waste. Both will tend to produce large volumes of B waste, which will increase an inventory that is already loaded, and A waste which might fill a fair volume of the only surface disposal center available at present in the Aube « Département », or of its radiological capacity.

Modelization and numerical simulation

Numerical computer simulation is a powerful tool for collecting knowledge in a coherent and complete way, within an operating framework. It is the normal complement to experimentation, and becomes indispensable when the latter is impossible in its space and time globality, which is the case for high-activity, long-life waste storage. The Commission continued its assessment of the needs and of the state of progress in this field, aiming to obtain a simulation tool able to carry out technical and safety demonstrations for the disposal draft that will have to be submitted to the Public Authorities in 2006.

Many aspects have been talked about, including very varied specific fields (physics, chemistry, mechanics, geology, etc..) often difficult to modelize : the actors of the law fulfill their role efficiently in this sector. But there does not seem to emerge a truly global organisation of the numerical simulation, nor a general strategy destined to integrate all the developed codes for a safety demonstration. It is vital, for the future of the research planned by the 1991 law, that one of the actors of this law should have a clear overview (and therefore should make a synthesis via a calculation code or a chain of coherent codes) and a long term planning orientated towards the creation of

a simulation tool with a higher scientific level, necessary for the validation of the disposal concept and for the safety demonstration in 2006. We must not wait until everything is analysed and modelized, to begin the simulation of the whole problem.

In other words, the Commission feels that the actors of the law are all aware of the importance of numerical simulation for geological storage safety and long term waste disposal. But it does not look today as if the objectives are clearly defined and as if it exists a credible long-term plan in order to elaborate complete and coherent tools, validated by possible experimentation, and the capacity for the public authorities to answer within the time limits to radionuclides distribution according to time, in the geosphere and the biosphere concerned, for a given concept of geological storage or disposal. The coupling of the codes especially is enormously difficult : climatology has been at a virtual standstill for a few years because of a similar problem, when it became necessary to couple two environments, oceans and atmosphere. Indeed, geological disposal will entail the coupling of four : package, engineered barrier, relevant geosphere and biosphere. This situation could lead us to miss first the 2001 deadline between organisations and even the date of 2006.

In these conditions, the Commission recommends to establish for the simulation, a clear long-term plan, with steps and meetings in order to make national and international comparisons on the efficiency of the various models ; to prepare precise, open and international calls for tenders, that can provoke the arrival of new teams ; to decide who will integrate modelization research in a code or a series of codes who will collect the data and who will be responsible among other things for the simulation of the experiments carried out in the underground laboratories. It appears necessary to rapidly select a central and distinguished scientific supervisor, surrounded by a small top-level team of people, able to follow and collect all the codes.

It would be desirable to call upon these teams in large private and public laboratories (EDF, IFP, INRIA, CNRS and Universities...), which already detain the necessary specialized competences, as well as those teams in countries facing the same problems.

The research on separation and transmutation - Area 1 of the law

The research led on area 1 of the law first focuses on more advanced separations, particularly on elements that contain isotopes which could entail a risk in the future. Those can then be either transmuted in a flow of neutrons in basic or innovating systems (separation - transmutation : S-T) either packaged in new matrices in view of disposal or storage (separation - conditioning : S-C). Separations are therefore a prerequisite to the implementation of these two options.

New families of molecules have made it possible to clearly improve the performances of minor actinides and lanthanides separation, as well as cesium extraction. The results of the research led in the « ACTINEX » programme on actinides separation and long life fission products are thus very encouraging.

The CEA is starting to refocus its research on separation by pyrochemistry towards the treatment of irradiation targets in relation with the so called « double stratum » transmutation process. In it, the first stratum consists of critical reactors producing energy and recycling plutonium, and the second stratum of hybrid systems incinerating minor actinides and some long life fission products.

Transmutation by hybrid systems aroused the interest of some industrialists who are taking part to the research association called GEDEON. Besides, several European countries are presenting common propositions in that direction, within the 5th PCRD framework.

The basic research on hybrid systems is, on priority, directed on the problems connected to the accelerator and the interfaces with the target and the reactor. Problems of materials are given added attention, and there is a first element of research on the accelerator which is the IPHI injector project at Saclay by the CEA and the IN2P3. This leads the Commission to make a strong recommendation so that a major effort be made on the IPHI project.

The research for underground laboratories and geological disposal - Area 2 of the law

The government decision taken on December 9th 1998 has given a new impulse to underground laboratory research to be carried out in the Jurassic clay in the site of Eastern France. The laboratory objectives will have to be clearly defined in the specifications which will guarantee the conditions in which the work will be carried out, compatible with the scientific quality of the observations, the operations that will have to be carried out either before, or in parallel (initial state of the site, control drilling, possible geophysical complements), the experiments to be made in the underground laboratory, and the schedule of the whole. Although it is aware of the tightness of the latter (it is the Commission itself which drew everybody's attention on this point), the Commission is plainly putting first the obligation to acquire solidly established data before respecting the schedule.

The ANDRA has decided to set up a research scientific and operational organisation, including a follow-up committee placed under the authority of its Scientific Council, as it had been recommended by the Commission in its previous report. The Commission is pleased by this initiative which will make it possible to have major scientific personalities participate to the works, and to draw the best scientific and technical benefit from this investment.

The government decision is also requesting the ANDRA to look for an appropriate site for a second laboratory in a granitic ground free from a sediment cover. This organization has immediately put into place, with the collaboration of the BRGM, an inventory of the granitic formations susceptible to meet this requirement. This task, the progress of which is regularly passed on to the Commission, takes into account the whole of the scientific progresses achieved on the knowledge of granitic massifs since the 1983 inventory. These new data are considerable, thanks to a large number of research projects going from the Ph.D thesis to a programme called « Géologie profonde de la France » (« Deep rock layers geology of France ») and the making of the national geological map. The Commission fully approves the approach that has been followed, which is both objective in terms of scientific criteria for making a choice, and leaves plenty of room for

concertation. It will formulate a specific evaluation as soon as it receives the intermediary report of this programme. However, it appears hardly plausible that an underground laboratory in granite could lead to a sufficient scientific exploitation for the year 2006.

The Commission also heard the ANDRA on the initial options concerning the development of waste storage coming under the law and on the associated safety exercises. There is no doubt that a first definition of the possible packages that could be placed in a future disposal is becoming urgent, firstly for the same reasons which are mentioned in the chapter devoted to the inventory : the representativeness of the underground laboratories and of the experiments which will be carried out there ; but also merely on the account of the acceptability of the packages as it is envisaged by the actors of the law. For instance, if a volume reduction at the time of the packaging does not lead to an approval as it is, but requires a specific containerization leading to a significant increase of the volume to be stored, we can fear to lose the benefit that was expected from such an operation. The same is true if the downgrading of the B waste appeared to be impossible .

Another important point concerns the modelization of the « far field », where it seems indispensable to stimulate fundamental research in order to have the tools and the teams when the background problems will have been solved, failing which the 2006 deadline will be put in jeopardy. The assessments given and the improvements wanted in the modelization chapter are here of utmost importance.

The research on conditioning and long term storage - Area 3 of the law

The research carried out in these fields have seen a significant increase in volume, combined with a strengthening of their structuration and orientation, as early as last year, following the government instructions. The Commission notes that the effort has been pursued throughout the current year ; however it wishes to see various gaps filled in. In particular, the programme should give more weight to subjects of general interest (containers and content, the long term behaviour of the matrices), the specific constraints caused by reversibility, the speciation of the radionucleides that are possibly released.

The Commission in this statement tried to clarify notions that are often not well defined in the present stage of studies, as it is the case namely for those words describing the constitutive parts of a waste package : the Commission invites all the actors of the law to come to an agreement concerning the definitions to be given.

As far as confinement matrices are concerned, the effort has been shared out on one hand between the existing matrices (glass, bitumen, ciment) and on the other hand, the new matrices (apatites, zirconolites, thorium phosphate, etc..). The forming of the NOMADE research group should facilitate a concerted development between the CEA and the CNRS and University teams directed to new matrices in promising fields such as specific glass, glass ceramic environments and ceramics.

The packaging processes for the making of new packages or the possible retrieval of existing packages, have been the subject of promising technological studies : waste incineration, cold crucibles with direct induction in the material to be melted, plasma torch, with the possibility of direct vitrification. These technologies could also allow to improve or simplify existing processes. The Commission follows with interest these developments and wishes to be kept informed, particularly concerning the repackaging of the B waste packages, and the retrieval of the old COGEMA and CEA waste.

The research on the long term behaviour of matrices and packages is concentrating on establishing the alteration mechanisms and on representing their long term resistance through predictive models. The Commission notes the remarkable effort made by the CEA on the studies concerning the resistance to alteration of the R7T7 glass which however must be pursued. The lixiviation of the uranium oxide and of the UOX spent fuels are fairly well known ; as for the MOX fuels, the results are less complete.

Long term storage over several decades is common practice, in France and abroad. Operations of retrieval have already been carried out without any major problems by the CEA and the COGEMA, but others could raise some difficulties. The Government, in its conclusions on December 9th, 1998

requested the CEA to carry out research on long term storage, while leaving the options open for research. Two lines are possible to store waste or spent fuels beyond 50 years : extend the time of storage through a succession of limited periods, at the end of which an expertise of the site and of the containers is carried out and allows for an additional period ; alter the existing industrial concepts (storage, container) to prolong their life span and achieve the confinement of waste in one go for several centuries.

In this perspective, twelve concepts have been suggested. The Commission recommends that, in an in-depth study, the specifications applied to packages should take into account both the transport and long term storage conditions, as well as disposal conditions in a geological environment, in order to limit package retrieval. (for instance coming from the results of the research on transmutation), or a deep disposal (necessary thermic and radioactive decreasing). Besides, it recommends that the risk to abandon a storage facility should be taken into account in the decision process.

The Commission repeats also the ambiguity that still remains on the finality and the duration of long term storage, as it is understood by EDF and the CEA, (respectively for fuels alone, and during 50 years for all fuels and waste over a 300 year period). Generally speaking, the extension of disposal limits raises the problem of the saturation of equipments, a problem that has already been met in the United States. In France, the reprocessing operation tends to reduce the volume of spent fuels. But, could the use of MOX fuels in all the units capable to receive them lead to a similar saturation situation in the next decades ? On the whole, the link with an operator would make the taking into account of the operating constraints easier as soon as the initial phase of the research is undertaken.