SUMMARY AND MAIN RECOMMENDATIONS

REPORT N°4 - October 1998

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° 4 corresponds to audits held between September 1997 and June 1998. Many important aspects have already been studied in the report on reversibility, which the Commission was requested to do by the Government, and handed over in June 1998. This report and the recommendations formulated in it have been unanimously approved by the Members of the Commission Nationale d'Evaluation (C.N.E.) and was handed to the Government in October 1998.

For this report n° 4, the Commission has assessed the evolution of research on the three areas of the law and focused particularly on the appropriateness of the scheduled research programme compared to the objectives set by the 1991 law and to the patterns of the industrial strategy that could be envisaged at short and long term and presented during the audits (chapter 3), also on the specific research related to each of the three areas of the law (chapter 4) and on the inventory of long-life high-activity waste (chapter 5). The report also includes the follow-up of research subjects and recommendations presented in the previous reports.

The coherence of the research explained in the scheduled programme compared to the requirements of the 1991 law and the industrial strategy has been assessed from presentations made, synthetic documents given by the actors of the law and the synthesis prepared by the Direction de la Technologie of the MENRT as well as the strategy of EDF presented on January 8, 1998 at the C.N.E. The Commission made this assessment in reference to government orientations recalled by the interministerial Council of February 2, 1998 and to strategic orientations expressed in the report of the parliementary Office concerning the assessment of the scientific and technological choices from June 11, 1998.

Research relevance on the three areas of the law

The need to continue the research vigourously and **evenly*** **on the three areas planned by the 1991 law** seems to be maintained in the scheduled research programme which has been presented to the Commission. In particular, works explained to the Commission exclude a high active waste (category C) separation-transmutation alternative in regards to final storage : in other words, the question of « everything or nothing » cannot be asked on this subject in a simplistic manner. It is already obvious that we shall not be able, under reasonable conditions, to realize a 100% transmutation of the long-life radionucleides (such as the cesium-135 for instance). The « everything » seems to be out of reach. Is it redhibitory and therefore do we have to decide the « nothing », that is to say leave out the research concerning the area 1 of the law in favour of area 2 and 3 ? This would obviously be contrary to the very reasons which led to the relaunching of the separation-transmutation strategy, and to the progress of the works presented which show how area 1,2 and 3 complement each other.

The objective is, let's say it again, a significant reduction of the long-term radiological inventory of waste, in order to reduce the possible health impact on future generations, for periods of time which today seem difficult to modelize. The reduction of volumes represent an industrial and commercial asset, which can be taken advantage of for storages, but is it a specific objective of the separation-transmutation strategy ? It is likely, and probably acceptable to consider that advanced separation processes and added operations on waste will produce secondary waste of the A or B category which, globally, could lead to an increased volume of ultimate waste.

The Commission considers that one should avoid opposing the area 1 of the 1991 law (separation-transmutation) to the area 2 (reversible and irreversible storage). To modify the balance between the three research areas, or grant a strong priority to the area 2, feasable within time limits that can be fixed, compared to the area 1 which has a schedule submitted to the uncertainties of the success specific to advanced research, would mean ruining the balance between the three research options, as it is planned by law, in order to allow the legislators to state in 2006 with maximum scientific data. On the contrary, the initiative taken by Public authorities and

* which does not necessarily means an equal annual budget.

research organisations to strengthen the area 1 through the development of research on innovative transmutation options, namely on a hybrid system demonstrator discussed at a European level, and by the AEC to strengthen efforts on the area 3 of the law (containerization and long term interim storage) go along the lines of the recommendations presented in the previous Commission reports, to dispose of all the options open by the law.

Calling the area 1 of the law into question could, on the other hand, be issued from the questionning – even if in parts - of the phase which comes just before it, that is to say the reprocessing phase. The hypothesis of the direct disposal of a sizeable tonnage of spent fuel containing plutonium in particular, and coexisting with a very advanced separation of this radionucleide over another part of spent fuels, would validate a simplified reprocessing of the entire quantity of discharged fuels.

Waste inventory

The Commission has devoted several audits to **the inventory of waste**, the packages specifications for disposal or storage, as well as the particular radionuclides contained in them. All the waste producers have established and given to the ANDRA categories B and C waste inventory forecasts for 2020 and 2070. Besides the ANDRA, as it does each year, has published the 1997 version of the national waste inventory, which makes a list of all the radioactive materials that exist in France, but without categorizing them explicitly.

The caracterization, the number, the volume and the content of waste packages are essential parameters that directly affect disposal and storage concepts. Moreover, these datas, even if they are preliminary, allow us to assess more correctly all the technical problems (thermic, radiological and chemical content, the confinement of radionuclides by the barriers, etc...) in order to tackle engineering, mining or surface problems, works dimensions, as well as safety analysis. That is why the Commission has always paid the greatest attention to this inventory problem.

The comparison between the 1996 (Ref ASQC-96-017A) and the 1998 (ASRE 98.031/A) inventory forecasts forwarded by the ANDRA to the Commission in May 1998 shows **significant discrepancies**. In particular, their comparison clearly displays a considerable reduction of the category B waste volume forecasted in 2020. The Commission tried to understand the reasons for these evolutions. Consequently, one can find in the tables 5.4 , 5.5 , and 5.6 of chapter 5, the evolution of the inventory for all the producers and per producer. The Commission did not succeed in matching the various values for 2020, or even choose one of them . For example, if the estimate of a 3000 m^3 yearly production of category B waste is correct, low assessments such as 49000 or 57000 m^3 in 2020, virtually imply that the present stock of this type of waste is non-existent, which is far from being the case.

As a result, the Commission very much regrets that the given inventories do not show in a complete, precise fashion and with the various radioactive categories, **the existing stocks to date, which represent the only objective base to make forecasts**. The subsequent evolutions can be justified by technological changes or old waste retrievals ; but then it is necessary to take into account a reasonable factor of success of these operations, and not base assessments on voluntaristic displays of objectives when we do not know up to what degree they will be reached. For example, the compacting of metal waste issued from electronuclear power plants can be considered as established, whereas the packaging of loose waste, or waste presently stored in various containers, must be assessed with caution and without neglecting secondary waste issued from repackaging. In this respect, the problem of downgrading B waste into category A waste admissible at the surface disposal Center of Aube (CSA) must be treated with the same circumspection.

Many sources of waste , already existing or foreseeable, do not seem to be taken into account in the inventories established by the actors of the law ; will they be able, before the year 2020 chosen for the inventory, to generate waste that would not be admissible in category A, therefore that could not be surface-stored at the CSA ? One can note in particular :

- the dismantling of reactors and plants already interrupted (UNGG, research ...),
- waste resulting from Superphenix shutdown,
- the dismantling of the COGEMA plant in Marcoule,
- the retrieval of loose waste (trenches, silos, etc.).

In the same way, the assessment made for 2070 should take into account, at least partially, the dismantling of the reactors which will be shut down around 2020, of Superphenix, Phenix, etc..

The assessment of vitrified C waste seems much more coherent. However, we note that no fuel is listed in the 2020 assessment, whether we refer to non-reprocessed MOX or UOX fuel from EDF, various fuels and fuel samples from the AEC, or also those from atomic powered ships. This position is certainly justified since these fuels, most of them being spent fuels, contain products that are possibly reusable, particularly plutonium and uranium, and so are not ultimate waste in the sense of the 1992 law. However, it would be necessary to have at our disposal a specific inventory of these fuels for a first assessment of the possible disposal or storage sites.

To appreciate the research concerning areas 1, 2 and 3 of the 1991 law, the main problem of the inventory is **the lack of a relevant assessment of what exists to date** listing together all the objects, either in service or not, being or including waste that cannot be accepted in the A category. We could then ensure a stricter connection of these data to the forecasts displayed for 2020. It is a complex investigation, for which the Commission has not the necessary means of action at its disposal, and which, anyway, does not fit into the mission that it was given by law. This does not minimize the problem whatsoever, and it is up to the Public Authorities to deal with it, with whom it may concern.

The extent of storage, whether reversible or not, within the 1991 law framework appears here for the first time. The rough estimate (500 to 1000 hectares), with the hypothesis retained by the ANDRA*, needs to be outlined. We clearly see in this assessment the appearance of the weight of spent fuel

* ANDRA report : influence of disposal time over storage extent – July 1998.

according to the heat they discharge, and particularly the weight of the MOX fuels if they were to be sent to direct reversible or irreversible disposal.

Follow-up of the Commission recommendations

As far as the **three areas of the law** are concerned, the Commission considers it has obtained **satisfactory factual answers** to most of its previous questionning or recommendations, even if some aspects such as the responsibility and the coordination of some research classified in the areas 2 and 3 **(containers, near field study)** could be improved in the sense of a better interaction between the actors of the law. In the direct line of the results achieved by the 1993 mission of mediation, research lauched by the CNRS on sociological aspects, should be intensified. Indeed, recent developments in Switzerland and Canada show that the « technical safety » of the projects does not, for all that, convince the public.

Plutonium recycling

In the field of action of the **area 1 (separation, transmutation)** the Commission explained in its report on reversibility that spent fuels and plutonium assuredly form ressources and not waste, while stressing the need to minimize stocks of plutonium for safety, radioprotection and non-proliferation reasons. In this respect, the EDF policy of flow equality goes along these lines. Is the hypothesis – mentioned during the audits - of placing on a long term interim storage a sizeable tonnage of spent fuels containing, besides minor actinides and fission products, the totality of uranium, plutonium and later their descendants, coherent with their more advanced elimination on an other part of the spent discharged waste ? It is up to the actors of the law to supply an anwer on this point. In the mind of the Commission, however, there is no opposition on principle between the development of research on area 1 and the formation of an important stock of spent fuels, inasmuch they are placed in reversible storage.

The Commission ponders over **the capacities of research** to bring a solution to the practice of an **intensive plutonium recycling** in **thermic reactors**. Indeed, this would follow the ineluctable course towards the increase in plutonium and minor actinides contents in the MOX fuels and would raise problems to which research might not be able to bring solutions.

Indeed, the quality of plutonium contained in spent MOX fuels deteriorates during the irradiation process in the reactor, consequence of a high plutonium-239 consomption, which is the main fissile isotope. Moreover, after being stored for several decades, most of the plutonium-241, the other fissile isotope, will have disappeared through decay in favour of non-fissile, irradiant americium-241. In other words, **plutonium does not age well**, and the reprocessing of stored MOX fuels, to extract this decayed plutonium from them, would not be particularly interesting, except in the hypothesis of the deployment of fast reactors in the next few decades. In this perspective, two other sources of plutonium would also be available : the one issued from current reprocessing of UOX fuels and the one from old UOX spent fuels. The Commission wishes to be enlightened on the scientific, technical and economical comparisons of these three possibilities.

It also states that the **recycling called " homogeneous " MIX** (recycling of plutonium in all the electronuclear plants on a uranium-enriched support) offers a priori better performances than the « heterogeneous » recycling done today, in terms of remaining materials and waste, as it was shown in studies presented by the CEA and the EDF : plutonium stabilization at lower levels and reduction of the amount of actinides in the waste. In this option, the fuel manufacturing capacity would be more important (1200 tons per year) but this fuel would **not be heavily charged in plutonium** (something like 2%), which bypasses problems linked to a high content (limitating factor of the number of recycling operations) and structure changes of the reactors. The Commission wishes to be presented with a detailled study of the impacts (ressources, disposal, storage, environment,etc...) of an hypothesis founded wholly or in parts on the homogeneous recycling of plutonium. In the same way, it recalls that **increased moderation** (RMA) in electronuclear reactors participate, to the detriment of power, to a global minimization of actinides in the cycle and in the waste.

Underground laboratories and area 2

In the field of **the area 2 of the law (reversible and irreversible disposal)**, the surveying works on the three sites suggested for the setting up of underground laboratories have been suspended since the opening of the public enquiries (beginning of 1997). They will start again only at the

outcome of the decision process and therefore there is nothing new for this report. The Commission evokes the urgency of this government decision concerning the choice of the sites, considering the time necessary for the building of the laboratories, the tests *in situ* and the interpretation of the results, which will have to be available in the year 2006, according to the December 1991 law. The Commission outlines the interest and the quality of the scientific days organized by the ANDRA in the three places concerned and which have gathered many scientists interested in the geological problems of each site. The ANDRA also pursued general studies concerning the area 2.

Among the studies with a fundamental character, the Commission again stresses that radionuclides retention by the various barriers and their migration-dilution in the geosphere are two essential parameters in order to guarantee disposal safety. Therefore it recommends to continue all the **geochemical studies** necessary to be able to **modelize** on solid bases the retention and migration-dilution mechanisms. In terms of packages, the Commission observes that research on glass materials keeps on progressing and wishes experiments to continue in order to encourage the concepts used in the **models** and **validate** the forecasts. As for bitumens, it also wishes studies to be pursued on the compatibility between packages and barrier materials, as well as on salt retention by the engienered barriers, the complexation capacity of the released organic matter and the pursuit of tests on bacterial damage. In the case of hydraulic binders, it is essential to better understand the mechanisms of concrete alteration when put into contact with the waters met in the sites suggested by the ANDRA ; the many research studies recently carried out on cement and concrete by the university, the CNRS, and industrial managers, would deserve a synthesis in order to orientate future programmes. Globally, the Commission considers that research on the qualification of matrices used for waste packaging, advances correctly ; it wishes the important efforts undertaken by the people responsible for areas 2 and 3 to be continued in narrow collaboration, **particularly for the study concerning containers and near field**.

Numerical simulation in safety analysis

The Commission would like to have at its disposal the overal plan envisaged for **computer simulation**, a vital tool in order to organize long-term risks into a hierarchy, validate concepts and carry out safety analyses. Even if important international works have already been done (PAGIS, EVEREST, DECOVALEX ...), these studies appear at present to be often overdiversified, often sub-contracted, once and sometimes twice. It would like the ANDRA to have the support of a team to control the development of a global software for the simulation of long-term nuclear waste behaviour in its environment. There are many skills needed : physics, fluid and rock mechanics, geology and geochemistry, mathematics (homogenization), numerical and computerized aspects (software engineering, parallel calculation). The supervision of sub-contracting can only be done by **a highly qualified team of people who would have these various skills** to ensure the integration of the various modules, their exploitation for experimental validation, and the improvement of the computer performances of the global software. One can note that the simulation in a geological environment with its own characteristics raises problems similar to oilfield simulations. Increased communications with oil specialists, and the concerned university teams, are recommended.

Packaging and interim storage (area 3)

Concerning **the area 3 of the law**, waste packaging in **new matrices** has known an important progress along the lines recommended in the previous years. The Commission encourages the pursuit of these research according to the orientations presented by their authors : vitrification, and particularly « direct vitrification of category B waste », concentrates ceramisation, new mineral matrices (glass crystallin, glass ceramic, ceramic materials, etc...). For all these matrices, a crucial point concerns their alteration by water which usually leads to the appearance of new phases at the interface level, the role of which must be clarified. Retention over a long period is an essential factor. Therefore we must ponder over a premature end to the matrice life which might suddenly be unable to ensure the confinement any longer.

The Commission is always in the expectation of technical information and a schedule concerning **old waste retrieval, processing and packaging**. Before anything, it pays particular attention to knowing the packages intended for storage or disposal, in order to establish an **inventory** as **complete** as possible. It would like these operations to be carried out without any delay, including **chemical toxicity** which does not seem to have been sufficciently taken into account. Finally, the Commission recommends that these studies on containers and overpacks be carried out by ANDRA and the CEA according to a programme structured in common, to cover all the aspects connected to areas 2 and 3 of the law, and to envisage a **packaging accepted for disposal as well as storage.**

The Commission has noted the programme of **long-term interim storage studies** launched by the CEA. In order to avoid that a storage, set up for several centuries, be forgotten and becomes *de facto* an irreversible surface disposal which would not have the safety conditions of an underground storage, the Commission recommends that the duration of such interim storage should not be planned, under any circumstances, to exceed the watch period for surface disposal of category A waste (300 years). Besides, the Commission suggests, if the Government retains the interest of a long-term interim storage, that a research should be carried out on sites susceptible to receive these storage centers.

Radiological and chemical risks

Some aspects of the **risks for human health** issued from long-term waste would deserve to be revisited. The Commission has noted that a certain amount of research concerning the biosphere is being developed both by the ANDRA and the IPSN, but it does not seem to directly involve specialists in radiotoxicology and chemical toxicology. The Commission believes that the fundamental aspects of radiological and chemical risks (cancers, genetic mutations, poisoning) deserve a deeper study and require specific research within the framework of the 1991 law : appendix 9 of this report is devoted to this and it wishes that the actors of the law integrate their research in the scheduled programme.

In the disposals and storages, we are facing a combination of **radiotoxic and chemical toxic products**. It is necessary to consider together criterias of either substances : the criteria that will have to be taken into account should be the most restricting of the two. The Commission recommends to establish at the earliest possible a chemical and radiochemical reference inventory and, after having chosen health criterias common to the chemical elements and to the radioactive isotopes, to realize a few simple exercices in order to compare the health impact of the suggested concepts.

International aspects

At an **international** level, we can note that the **first authorized geological disposal** is the one of the **WIPP**, New Mexico, **United-States**. Since May 13, 1998, it has been authorized to receive for disposal in a layer of salt, military waste similar to French category B waste. The WIPP should be accepting 175000 m^3 of waste over 35 years, and no reversibility of any kind has been planned. We can observe that this procedure is aiming at a category of waste which, in the Commission's report on reversibility (June 1998), was suggested for a geological storage.

In the **United-states** also, the exploration tunnel of the **Yucca Mountain site**, Nevada, is now finished. This site is intended for the disposal of spent fuel packages. It is situated in volcanic tuffs, 300 meters under a hill top and runs along 8 km. The tunnel measures 7.50 m in diameter and is equipped with a railway. Horizontally, we can get to it via a road. Five lateral « pockets » offer shelter for various experiments, particularly thermic ones. It corresponds fairly well to the subsurface storage concept, easily accessible horizontally, also suggested by the Commission in its report on reversibility.

In Canada, the government has published the conclusions of the **Environmental Board of Enquiry** to assess the generic concept of geological disposal in the Canadian shield granite, supported by many experiments in the Bonnet Lake underground laboratory (URL). Conclusions show that the concept is seen as safe on a technical level, but not on a social one. Therefore it is not accepted under the present conditions ; among the recommendations given, are those aiming at developping a plan to make the public participate, defining a framework to allow the assessment of the ethical and social dimensions of the concept, comparing various options, and finally creating a federal agency for radiocative waste management.

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To conclude, the research programme on radioactive waste management seems to have taken into account the major part of the phenomena involved. This programme covers an extremely wide scope and research is beeing carried out in many directions. The present report, through its volume, attests the quantity and diversity of approaches tackled by the various research teams. The weaknesses noted by the Commission in its assessment are, for most of them, being studied by the actors of the law. No major problem appear at present to be ignored within the current framework of our thoughts.