NATIONAL SCIENTIFIC EVALUATION COMMITTEE

REPORT N° 7 - JUNE 2001

CONCLUSIONS AND PERSPECTIVES

In its previous report the Committee had made a midway research assessment on the management of high activity, long-lived nuclear waste. In this perspective, it has been showed that several research tracks seem capable to give concrete and applicable results within the time limit set by law. It particularly concerns the problems that fall within the province of a correctly carried out classical or mining engineering. The conclusions of the report n° 6 have been discussed with the leaders of the main organizations concerned: research centres, agencies, industrialists, authorities in charge, etc. after they were presented to the Government and the Parliament. Overall, they have been approved by our counterparts. It is therefore important to draw lessons from these discussions for the years that remain before the December 30th 2006 deadline, when the law planned to hand out a report on the whole of the research carried out in order to facilitate the decisions of the Public Authorities.

It may be noted that France, besides the United States, is probably the country that has carried out research and gathered information in the nuclear field, more than anyone else. However, the scattering of some research and the lack of physical realization of prototypes, particularly containers, are two weaknesses that result from a lack of research prioritisation and from the absence of a restrictive calendar, within the period of time set by the 1991 law. The result is the lack of information on the French effort in the phase coming after the cycle – excepting the industrial activities by COGEMA – both at an international level and at the level of the French population, which obviously participate to the deficiency of social acceptance.

The organization of research by the CEA relative to packaging and long term storage (area 3 of the law) has just been modified and presented to the CNE on April 25th 2001. It answers the wishes of the Committee, including separate projects for the packaging and the storage of C waste (high activity and long-lived), B waste (medium activity with long-lived radionucleides) and possible used, non-reprocessed fuels, as well as the making of prototypes and, above all, for each project, a binding agreement for a given date which may, in several cases, not wait for the year 2006. Finally, the setting up of shared working groups with the ANDRA has become a reality. The Committee is pleased by these major improvements in the research process.

The Committee also noted a real evolution of the projects by the ANDRA, even if it does not make explicitly the difference between the concepts of restrictive calendar and binding agreement. The Committee greatly wishes this evolution to continue and that this method of project management be completely taken into account by engineers and researchers.

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The results of our assessments make the Committee strongly wish that the organizations' leaders favour the four main following points**:**

First point:

First of all, there are the **containers**. These **are the only protection** on which rests the workers' and the neighbouring populations' safety, both during transport and storage periods (these being the only ones allowed by French Law), or during the exploitation of future reversible repositories, if they are authorized by the Legislator. The very concept of reversibility implies the integrity of the containers. Therefore it is highly recommendable that this problem be dealt with as soon as possible. The problem of containers has really been taken into account since the CEA is in charge of packaging and storage, and the ANDRA in charge of final disposal, and that they have increased their collaboration.

Obviously the historical diversity of the different types of waste, of their inventory in radionucleides, of their present physical state, does not permit to reduce the number of these containers to three or four, but certain well defined problems must found an appropriate answer within two or three years. The exhaustive inventory of this waste, on which we will go back later, should anyway supply at last a clear answer to the optimal number of types of containers to be considered. However, large amounts of waste, regularly produced during a past or present period, already allow us to designate **a small number of waste families** for which a type of container could rapidly been defined. Some of this waste has been existing for a long time and is *de facto* stored in "packagings" which, even if they do not wear the label of "container", make us doubt all the same, even worry when we consider the outer appearance of some of them. The loose residues from the bottoms of the silos also pose a problem that we should not leave unanswered much longer, and on which the Committee had already drawn the attention in its previous reports, and particularly in the report N° 4, quoting again the recommendations presented by the Castaing Commission (November 1982).

The Committee does not ignore the complexity of the problems, as well as the necessity to have the appropriate containers for the intermediate storage or final disposal, and vice-versa. However it feels that a country having the competence and the experience of France in the nuclear field cannot leave this situation last much longer. Indeed, **it deeply regrets** to realize that certain envelopes, considered by some as a final container, are not so by others, without knowing clearly anyway which position is the wisest, or which complementary envelopes are suggested for a future disposal, and if these are realistically compatible with a good classical engineering for a temporary storage or with a mining engineering for a final disposal. It is time to remedy this situation, and the presentation of the CEA projects in this field on April 25th 2001 permits us to hope that this phase has begun.

The containers destined to **B waste** and to **non-reprocessed used fuels** appear as a priority because of their large volume and the extremely varied state of these containers. This last comment is particularly true for B waste, in spite of their low medium activity compared to used fuels and C waste. Indeed, if some of them are packaged satisfactorily, **others obviously need to be repackaged**, finally others still come loose, awaiting to receive a proper packaging. The promise that has just been made by the CEA to present, for B waste, functional demonstrators in 2002, and **real size containers in 2004**, corresponds to reasonable deadlines for a good engineering. As for the part of used fuels that would not be reprocessed, it has now been decided to place the structures in an airtight case, which is itself put into containers destined to be stored; The Committee considers that it must also **be shown these containers in 2004**.

The fact that several other countries had already developed different types of containers could provide the possibility to take advantage of this circumstance to examine if one of them could provide a solution for one of these waste families, in the sense mentioned above.

A particular aspect concerns the possible switch from intermediate storage to final disposal. This operation will require the retrieval and handling of old containers, with possible risks for the workers. It is important to anticipate the most appropriate technical measures to be taken to ensure the safety of this operation. As far as possible, the containers to be used for final disposal should be the same as those for storage to avoid any repackaging. The fact that recently the views of the people in charge of these two lines of research had become closer, is encouraging. This switch should thus be made easier in the future.

Second point:

Storage facilities have existed for a long time, since the various types of waste, whatever their origin, are kept in places specially designed or not for this purpose. It is the same thing in the main countries with which we maintain a regular relationship. The Committee considers that the surface or subsurface storage design and the presentation of a concept design study depend, this time again, on

a good classical engineering in which the criteria of simplicity, easy handling and safety for the workers would naturally be engaged.

The wish, expressed by the CEA at the hearing of April 25th 2001, to present **a concept design study as early as 2002**, and to endorse a binding agreement in order to offer **real choices in 2006**, is a new and important element which clearly follows the Committee's recommendations.

It will be possible to rely profitably on industrial facilities either existing or being developed for the storage of **vitrified waste**, like E-EVSE at La Hague or HABOG in the Netherlands, both realized by COGEMA, even if the specifications must be finalized for a long term storage.

For **spent fuels**, long term storage has a dual objective, with different time scales: (i) The technical necessity to cool down that has to be done before a possible final disposal; (ii) the long term energy and environmental choices that will have to be made in France. Under water storage of UOX fuels does not pose any major problem, for periods of several decades, and could technically be renewable with a periodic renewal of the agreement from the safety authorities. The storage of first generation MOX spent fuels would be around one century. For the MOX fuels which would be considered as ultimate waste (second or third generation MOX if there is some ?), the duration of the storage is not estimated at present, but would certainly be a long term one (centuries ?).

The Committee considers that the required knowledge for a prolonged under water storage would be available in due course; however important scientific and technical research remain to be done before engaging into realizations.

Beyond a century, dry storage seems necessary to the actors of research, and requires important works. It has the advantage of passive cooling conditions in the long run, and increased confinement. An ambitious programme has been launched in 1998 by CEA and EDF and concerns the phenomena of cladding corrosion and the deterioration of UOX and MOX fuel pellets in water saturated or unsaturated atmosphere (PRECCI programme). The Committee fully approves of this research.

The **storage of medium activity B waste**, containing long-lived elements, is a **priority**, although this waste is by nature an ultimate waste material which is a candidate for final disposal: indeed we cannot envisage the valorisation or the transmutation of the products concerned, considering their low content in a considerable volume. Several times, we have insisted on the urgency of a conditioning (loose waste) or a reconditioning (old waste). This being done, we shall probably have to wait for several decades to obtain a possible final disposal, which demands an appropriate storage. B waste represents a global volume ten times larger than the volume of high activity waste and used fuels; besides, the state of their present packaging (or absence of it) leaves us perplexed.

One first realization within a short period of time, of a simple, convenient – active or not active - demonstration storage that could be visited, would possibly allow a rational storage of certain categories of waste for which there is an absolute urgency, and above all, combined to the presence of credible containers, it would show to the authorities, to the decision makers and to the public the conditions in which safety is ensured for the population. This is possible in a country like Sweden, and probably has an important role to play in winning over people's conviction on the feasibility and the social acceptance, which is the case in that country, whatever the decisions made on the future of nuclear energy.

It would be important to compare the possible respective advantages of surface and subsurface* storages: easy engineering and costs in one case; larger obstacle to deliberate human intrusion, less risk in case of an earthquake or an aircraft crash, at the price of a mining-type engineering, probably more complex and more costly, in the other case. We can note that Sweden, although situated in an area hardly seismic at all, has chosen a subsurface storage for its spent fuels, protected by a 30 meter high rock cover.

It would also be good to compare the respective advantages and disadvantages of placing in La Hague a prolonged storage of non-reprocessed used fuels or ensure this storage on the 20 nuclear power plant sites. The Committee underlines in the first case the availability there of an industrial experience and an easier supervision, low seismic risk, but the necessity to have transports ; in the second case, the latter are minimized in the short term, but with a higher complexity : the building of 20 long term storages, a specific supervision of these many facilities, greater risk of terrorist attack, increased risk of aircrafts falling because of the number of sites involved, diversity of the seismicity.

The relevance of a co-localization for a storage facility and final disposal site should also be examined in due course. In this respect, we must note that implementing the reversibility of a final repository poses the question of having the availability on the disposal site of a storage capacity capable to receive packages that would be retrieved from the repository.

Third point:

One vital element of information to clarify the nature and the extent of the works to be carried out for each family of waste is the availability of a realistic and precise inventory of high-activity or long-lived French waste that exists so far, as well as a provisional inventory of the same waste in 2020, since its existence is already predetermined. This information forms one of the basic elements for any research planned in the 1991 law. That is why the Committee has very much insisted on the fact that the

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preliminary inventories that had been presented were not easily interpretable nor were they very reliable.

On these grounds, the Government had given the President of ANDRA on May 6th 1999 the responsibility of establishing an inventory protocol so that the volume of each waste category could be perfectly identified, taking into account namely the extrapolation of this inventory in the middle and long term. This task has been carried out and presented to the Government, then to the Committee on May 4th 2000 ; the latter approved it.

The Commission deplores the fact that there has been no follow up to this task and that although having now the proper tool, the realization of the inventory has not yet begun, for reasons that have not been given to the Committee.

There is absolutely no doubt that this is a serious deficiency that has an impact on most research subjects touching on containers, storages and final disposals, and makes impossible any kind of precise prioritization of pollutions and risks. Even the number of necessary containers or the surface area required for storage and final disposal facilities cannot be assessed realistically in the absence of these data. It is for instance difficult to plan the sharing out of some dismantling waste between those which are or will be receivable for surface disposal, and those which, on the contrary, will fall within the area of the 1991 law. The making of the inventory would also have the advantage of listing the quantities of waste which have not found, to date, a long term management procedure (graphite for example) and nuclear waste without any perspective of use (depleted uranium, for example).

As for the inventory of national waste, this situation puts France well behind other European countries such as Sweden or the United Kingdom.

Fourth point:

The physico-chemical separations of the most radiotoxic elements also offer a field of competence where scientific feasibility has already progressed enough to expect before December 30th 2006 a demonstration of technological feasibility, supported if need be by an experimental demonstration unit. There again, the problems of chemical and realization engineering will have to be tested before the term of the law.

In the context of a precautionary philosophy, we can thus prepare a future when glass would not contain actinides any longer (except for the losses), since we shall know how to fission them, but only everything or part of the fission products, some of them being long-lived and capable of being also separated.

At the same time, it will be appropriate to formalize a provisional or final packaging process for the products from these separations that could be realized. The feasibility of specific conditioning processes will be acquired in 2006, but will probably still need some research in terms of process development (the research on glass has been carried out for 20 years).

As far as **transmutation** is concerned, the Committee recalls the constant effort that is being made on its various aspects, namely on the use of the present reactors to limit the production of actinides. It also notes the crucial point concerning innovative targets and fuels, indispensable to an effective transmutation. Many products and samples have been elaborated today by the CEA and are awaiting to be irradiated in a reactor.

In this context, the Committee wants to show its concern in front of the new delay announced for the re-starting of the Phenix reactor, now planned during the course of 2002.

Conversely, we observe various new actions, namely in the shape of « road map », in view of the realization of a hybrid system **demonstrator**, with fast neutron spectrum and with solid fuel. This path is considered as the most promising by the nuclear actors concerned by the actinide incineration, or even by certain long-lived fission products and we observe that the various partnership in the field of transmutation are only focusing on it today. It is the case in France with the motivation file for such a demonstrator and the associated basic studies, carried out in common by the CEA and the CNRS. It is also the case at a European level with the concrete propositions expressed in April 2001 by the ad-hoc work group and with the support brought by the European Commission for these activities within the framework of the 5th R & D European Programme. It is again the case in the United States where the « Advanced Accelerator Applications » (AAA) project is beginning to be substantially financed, and in Japan. These projects herald the possibility of the beginning of having a demonstrator work within 10 or 15 years, at least with classical fuels. But the basic technical options could be cleared before the 2006 deadline which could then become a date for **making the decision** to realize such a demonstrator.

The Committee recalls the importance that it gave in its previous reports to a shared effort of the various research organizations in the field of hybrid systems, carried out in a European environment. Therefore it can but only encourage the two French partners, CEA and CNRS, to pursue and strengthen their co-operation, by contributing namely to the European programme which is being set up for such a demonstrator, while collaborating together to the American and Japanese initiatives linked to hybrid systems.

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Contrarily to the four preceding fields, **underground laboratories** form an intermediate case for which we cannot hope to have reached a sum of results in 2006, obtained on the Bure site, as important as what was obtained by our German partners (salt), Swedish partners (granite), Swiss partners (granite, clay) or Belgian partners (clay), who have all had underground laboratories for many years. Nevertheless, we may expect from this partnership applicable results in specific fields as varied as clay rock mechanics, their hydrogeology, geochemistry, and the migration of the various elements into the clay rock. In this way, the collaboration with the NAGRA on the Mont Terri laboratory is certainly the most precious one, considering that the two rocks studied in Mont Terri and Bure have very close properties, and that the Committee can only recommend to continue on this path, which does not seem sure to this day. For example, it would not be safe to keep certain scientific problems just for the Bure site when it is available. The total number of experiments in the world on these fields is so small that duplicating it must not create any regret. Therefore, the important international collaboration that the ANDRA is in the process of establishing in Bure, appears highly desirable to the Committee.

The experiments that will be carried out for three years on the Bure site, after completing the laboratory, should allow us to qualify the layer of clay for possible final disposal, if the results are positive and added to the results obtained by collaboration on the foreign sites. It would then be possible to present in 2006 to the Government and the Parliament a concept design study on results sufficiently well established to allow the Legislator to make a decision in principle, even if additional research work seem then desirable, particularly to define the precise location, the surface and the engineering for it.

This concept design study should include B waste, vitrified C waste, and the possible final disposal of used UOX and MOX fuels. However, the considerations presented in this report would justify **a priority for B waste**, for which clay soils seem particularly adapted in the absence of thermic problems, other categories having the possibility to offer the choice between final disposal or long term storage.

A similar reasoning based on international collaborations, could not possibly be used to a future laboratory in granite. These generic studies cannot apply to other cases, because we do not have in France geological situations comparable to the very old shields like in Canada, Sweden and Finland. At best, this international research can provide indications on the designing of the laboratory, if the second site planned by the 1991 law is set up in granite. The Committee has noted the outcome of the consultation mission on granite. It points out that the 1991 law has planned at least two laboratories, but does not establish the simultaneousness of the plants nor the nature of the rocks.

For the realization of the Bure plant, the concepts of the ANDRA are beginning to evolve. However some of the options considered, particularly the large disposal caves for B waste the control and above all the reversibility of which do not appear credible, as well as the concepts of C waste disposal at a temperature superior to 100°C, give rise to strong reservations on the part of the Committee . Indeed, the increase of all the kinetics permanent features and the velocities of transport, added to the disruptions in the environment connected to the evaporation-condensation cycle of water, make the system hardly controllable. The scientific and technological knowledge that must absolutely be acquired include geo-mechanics (we note here the weight given to rock mechanics on the American WIPP site situated in salt), material science, chemistry, geo-chemistry (element migration) and mining engineering, a subject on which we struggle to find, in the project, counterparts with a solid experience of underground plants (except with the contractors, but this situation is not satisfactory). Finally digital simulations are a priority for the correct realization and the safety of the plant.

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The digital modelling of a final disposal and of the radionucleide behaviour, from the container until a possible return, via underground waters, to the biosphere forms a major element of the research programme.

A tri-dimensional simulation platform is starting to be implemented at the ANDRA. It would seem fit to separate fairly clearly the research effort applied for its implementation from the subsequent research effort concerning digital methods and their modelling. Indeed, we must think now about the problems posed by the exploitation of a string of intensive calculation software : means of calculation, cost, competence of the exploiting team. With this in mind, the coupling of distant field – near field would outline the problems to solve.

Besides the difficulties of a physico-chemical nature, one of the final disposal scenarii suggested by the ANDRA for C waste, at temperatures superior to 100°C, will be very difficult to validate by simulation. Generally speaking, any delay or simulation difficulty would force the ANDRA to make choices based on very approximate predictive calculations. Everything should be done to offset these shortcomings and keep for the time being only those final disposal options for which validated simulation tools will be available in 2006.

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On the other hand, other subjects will not reach a conclusion before 2006. However it feels fit to list them and, if possible, rank them, in order to give them some thinking. Among the most important ones, we can mention plutonium and the waste coming from MOX fuel, rejects from nuclear stations into the sea or in the air, and the radiobiological knowledge on low doses.

Plutonium is not a waste in the sense given by French Law. It could even allow the valorization of uranium-238, one of the main sources of energy in the future. However, spent MOX fuels, which will exist in 2006, could end up all or in part, in waste as described in the 1991 law. In this respect, the Committee has not heard any presentation on a **complete strategy** for plutonium management.

The releases from nuclear stations into the sea or in the air which are authorized at present are based on the concept of dilution (iodine, tritium) and/or medium-lived elements (krypton, tritium), which is probably a solution with no biological disadvantage known to date, in the case of iodine and tritium. But these releases represent a non-negligible part of the activity mentioned, and we must expect a strong international pressure, within the context of the OSPAR treaty for instance, a pressure that will increase in time. Shall we be able in 2006 to offer the Legislator alternative solutions, if he so decided, for the grounding of these products, which would then belong to the solid waste category?

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In a future prospect, we may question the real possibility to offer the Legislator, when the time comes, a first global concept for the management of the radioactive waste concerned by the December 30th 1991 law, then alternatives that gives him the choice between several answers, even the possibility to later throw the choice itself back into question.

It is fit to be aware that the research on transmutation which is of a very high level and very long, will necessarily spread over several decades, even if important decisions can be made in 2006. In the same way, a decision on the mode of management may require long periods of time (up to 20 or 30 years) for the physical realization of an industrial site, like a hybrid reactor or an underground repository.

Having made these reservations, we may think that if each organization concerned respects, in the fields mentioned above, the notions of restrictive calendar and binding agreement, it will be possible to bring out a range of management solutions on December 30th 2006. Of course, additional research will appear to be then desirable, but it will be possible to offer the Legislator various options for the management of the initial part of the electro-nuclear cycle. The following text does not claim at all to anticipate his decision, but **to show that there is, now, at least one answer** on the basis of present equipment and research. Our duty before December 2006 is of course to provide the Legislator with the widest choice possible, even if some areas will require additional research.

Let's examine the various types of waste according to their increasing complexity and harmfulness:

- Low activity A waste, are now stored on the surface, and do not depend on the 1991 law. A rough estimate of their volume in 2020 will be of at least 800 000 m^3.

- Medium activity B waste but containing long-lived radio-elements, also represents a considerable volume, close to 100 000 m^3 in 2020. This volume, combined to the absence of high activity, removes practically all hope of transmutation and valorization of activation or contamination products, that they may contain. Therefore these are by nature ultimate waste, destined to final disposal, and reversible if the Legislator confirms that option. The two main problems they are concerned with are then a reliable conditioning and the amount of time available to have a final disposal structure. The need for an appropriate container for storage and final disposal depends, as we said, on a strict engineering with a restrictive calendar over 3 or 4 years. The time limit for a possible final disposal will be covered by a storage phase, that is inevitable in any case since the availability of a final disposal structure will require at least two decades. The necessary research to reach these results for B waste then becomes **a priority**. The extension over a longer period of time of the storage of this waste could only result from a political choice : it would be devoid of any scientific motivation.

- Present vitrified C waste is the seat of a high activity and heat, and contains most of the long-lived radionucleides. Reprocessing improvements, using the separation processes that are being developed, allow us to envisage the separation of actinides from most of the fission products. All the remaining fission products could then be vitrified (a few thousands of m^3 in 2020) and placed in storage, derived from the E-EVSE industrial facilities, and with the benefit of its experience feed-back, in La Hague. Following a long term storage (secular, which poses the problem of periodically re-examining the authorization granted by the safety authority), their level of heat would allow their final disposal in "cold" conditions.

- To reach the activity level of uranium mineral, the radioactive decrease of the actinides thus separated would demand several scores of millenniums; supposing however that we had succeeded in reducing the plutonium radio-toxicity thanks to its energy valorization. Considering the low quantities implied, they represent a priority objective for transmutation, more precisely fission in appropriate reactors. Considering the time required for the availability of these reactors, we should plan before then their packaging and storage.

- Spent fuels, if they are not reprocessed (a few thousands of m^3 in 2020), can also be placed in a secular storage following a concept comparable to the one for C waste, allowing for their cooling and, if the decision was made not to recuperate the valorizable materials, sent then to a possible appropriate final disposal.

The existence of long term intermediate storages (secular), for glasses (C waste) and used fuels, poses the problem of durability for the facilities and implies the need to periodically re-examine its functioning and secure an authorization from a safety authority. All this is, of course, possible only in the hypothesis of the durability of the institutions, even society, an issue that was examined in the 6th report of the Committee

Generally speaking, we shall note that a reprocessing approach is a prerequisite not only to the above description but also to any implementation of the area 1 of the law : outside the chemical separation processes, we do not see today any possibility of transmuting the actinides, even with the help of innovating systems.

This description does not claim in any way to be representative of the conclusions that can be drawn in 2006, but simply demonstrates that, in the present state of affairs, at least one global and coherent option seems possible. That is the whole responsibility of research to be able to offer, at that moment, to the Legislator, other possibilities which will enable him to make his own choice.