

# International peer reviews and radioactive waste management in France

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The organisation of independent, international peer reviews of national studies and projects is an important NEA activity in the field of radioactive waste management. Several of these have been carried out over recent years, for example for the governments of Belgium, Switzerland and the United States. Member governments have found these reviews of significant value and are now asking for them to cover topics of a broader scope. These independent OECD/NEA peer reviews help national programmes assess accomplished work. The general comments expressed in these reviews are also of potential interest to other member countries. Nevertheless, in order to ensure that such country-specific requests are not conducted to the disadvantage of other members, they are separately funded by the requesting country and the NEA Steering Committee for Nuclear Energy is informed in advance.

The French Government recently requested the NEA to organise two peer reviews in the radioactive waste management area. The first concerned the review of the “*Dossier 2005 Argile*” (the “2005 Clay Report”) prepared by the French National Agency for Radioactive Waste Management (Andra). The second concerned the “CEA 2005” report by the French *Commissariat à l’énergie atomique* (CEA). These studies present the results of research in the areas of disposal and of partitioning and transmutation of high-level and long-lived radioactive waste, as required by the 30 December 1991 law. This law stipulated that research had to be carried out in the following areas:

- Area 1 – “Research into solutions enabling long-lived radioactive elements present in waste to be partitioned and transmuted”.
- Area 2 – “Study of the possibilities of reversible or irreversible disposal in deep geological formations, particularly through the construction of underground laboratories”.

- Area 3 – “Study of conditioning and long-term surface storage processes for long-lived wastes”.

The law also required that, after a period not exceeding fifteen years, i.e. by the end of 2006, the Government must submit an overall evaluation report to Parliament. That time has now arrived and the French authorities have been engaged in considerable activity to prepare proposals for what comes next.

## Deep geological disposal and the “Dossier 2005 Argile”

Radioactive waste management has been an issue in France since 1960, when the first reactors were built and began operation. From the beginning, deep geological disposal has been considered as a potential solution to the long-term management of the waste. Construction of underground facilities for *in situ* characterisation of the potential host geology was envisaged as the best method of evaluating the feasibility of geological disposal.

As outlined above, the 1991 law defines the general frame of research and development and identifies three avenues of research concerning the management of high-level and long-lived radioactive waste. Within this legal frame, the French National Radioactive Waste Management Agency (*Agence nationale pour la gestion des déchets radioactifs*, Andra) was created as an independent

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public body for radioactive waste management and made specifically responsible for the second avenue of research related to assessing the feasibility of the deep geological disposal of this radioactive waste, notably with underground laboratories. Options for reversible or non-reversible disposal were to be studied under the 1991 law; however, in 1998, the French Government indicated that emphasis should be given to a “logic of reversibility”.

As an input to the 2006 global assessment report to be produced by the National Review Board for the decision-making bodies (Government and Parliament), and as required by the 1991 law, Andra produced a feasibility report concerning geological disposal of high-level and long-lived radioactive waste with a reversibility rationale in the Callovo-Oxfordian clay formation, the *Dossier 2005 Argile*. A similar report concerning the *Projet HAVL Granite*, based on data representative of French granitic formations, but without any particular site identified, was also produced.

### Review objective and conclusions

The overall objective of this peer review was to inform the French Government whether the *Dossier 2005 Argile* was: i) consistent with international practices and with other national disposal programmes, in particular the ones considering argillaceous formations, and ii) whether the future research needs were consistent with the available knowledge basis and if priorities were well-identified.

In terms of this overall objective, the International Review Team (IRT) found Andra’s scientific and technical programme to be fully consistent with international best practice and, in several areas, to be on the forefront for waste management programmes. It also found that:

- Andra has made effective use of research programmes in other argillaceous formations, notably the Opalinus Clay, to train its own experimental personnel and to develop experimental techniques and equipment for use in the Meuse/Haute Marne underground research laboratory.
- Andra has done a comprehensive job of identifying future research needs consistently with the available knowledge base, although prioritisation of those needs is not discussed in the relevant programmatic document. Relevant observations and recommendations are provided by the IRT in the review.
- Andra has made a visible and successful effort of responding to the findings of the international review of the earlier *Dossier 2001 Argile*.

In more specific terms, the review was to check that the *Dossier 2005 Argile* is soundly based and competently implemented in terms of approach, methodology and strategy. The IRT found that the *Dossier 2005 Argile* successfully establishes confidence in the feasibility of constructing a repository in the Callovo-Oxfordian argillites in the region of the Meuse/Haute-Marne underground research laboratory. This is based on the findings according to which:

- The *Dossier* establishes a viable approach to achieving reversibility without compromising operational and post-closure safety.
- The scientific and technical basis is developed from first principles in a highly traceable manner.
- The safety evaluation method is sound and appropriately implemented.
- There is great confidence in the key safety function of the Callovo-Oxfordian, i.e. diffusion-controlled transport and radionuclide retention.
- Andra appears to fully understand the mining and engineering challenges to be met, and to be capable of meeting those challenges.

The IRT also found that the design developed by Andra had met the requirement to demonstrate the principle of reversibility, and concluded that reversibility during the pre-closure phase had not been acquired at the cost of prejudicing long-term safety. Nevertheless, building the repository according to design does present engineering challenges.

Overall, the *Dossier 2005 Argile* should provide a relevant and important basis of information for the forthcoming discussions and decisions in France regarding the formulation of an updated national policy for the final management of high-level and long-lived radioactive waste.

In February 2006 the international peer review was presented to Minister Loos, Minister-Delegate for Industry of the Ministry of the Economy, Finance and Industry. The review is available on the NEA website ([www.nea.fr](http://www.nea.fr)) under the title: *Safety of Geological Disposal of High-level and Long-lived Radioactive Waste in France*.

### Partitioning and transmutation (P&T) and the “CEA 2005” report

In many countries of the world spent nuclear fuel is currently considered to be a waste (the once-through fuel cycle). In others, particularly in France, the spent fuel is reprocessed, with the objective of separating the uranium and plutonium

for recycling. The residual high-level waste is then encapsulated in a special glass for storage and subsequent disposal at some future point. A typical assembly of around 500 kg of spent UOX fuel contains about 470 kg of uranium (94%), 5 kg of plutonium (1%) and 25 kg (5%) of other radionuclides (fission products and actinides).

Industry is already conducting partitioning (separating into pre-chosen groups of elements) of uranium and plutonium. Area 1 research was aimed at exploring the possibility and value of separating out further elements, specifically the actinides neptunium, americium and curium (collectively termed the minor actinides) and some fission products (iodine, technetium and caesium). The research looked at how this could be achieved and at how those materials might possibly be recycled, so that they could be re-irradiated and thus transmuted into other, more benign or shorter-lived elements. The primary aim of the research was to reduce the long-lived radiotoxicity of the final wastes being sent for disposal.

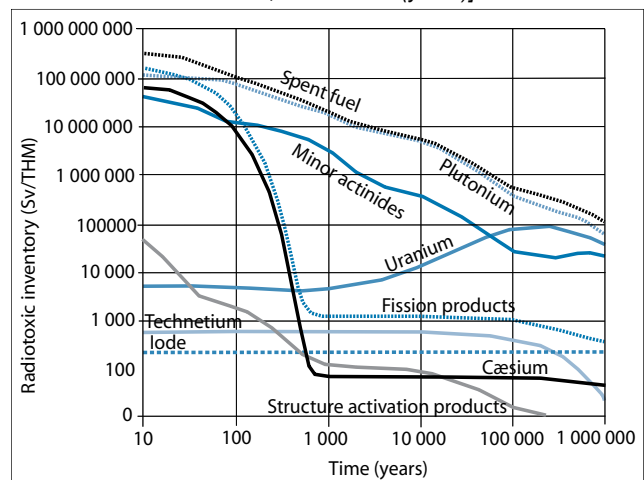
A major research programme was conducted by the CEA with, in some areas, contributions from the *Centre national de la recherche scientifique* (CNRS). This was all brought together in the CEA report “*Les déchets radioactifs à haute activité et à vie longue – Recherches et résultats, Axe 1 – Séparation et transmutation des radionucléides à vie longue*” (CEA/DEN/DDIN/2004-62). This report is available on the CEA website ([www.cea.fr/fr/sciences/dechets\\_radioactifs](http://www.cea.fr/fr/sciences/dechets_radioactifs)) and was the document on which the peer review focused.

Figures 1 and 2 are taken from this CEA report. Figure 1 shows the relative contributions of the various elements to the radiotoxicity, where clearly plutonium, already recycled in France, dominates. The fission products selected for study (iodine, caesium and technetium) were chosen because of their relative mobility in repository situations. Their contribution to the total activity can also be seen in Figure 1. Figure 2 shows the potential result available if the minor actinides can be eliminated; the radiotoxicity of the waste falls below that of the uranium from which it was produced in less than 300 years.

## Review conclusions

The International Review Team (IRT), made up of ten international specialists, was very complimentary about the quality of the French R&D. It confirmed its agreement with the major conclusions of the report and made a number of detailed recommendations for further study. The team recognised that some of the issues it raised might be covered in other work areas that it had

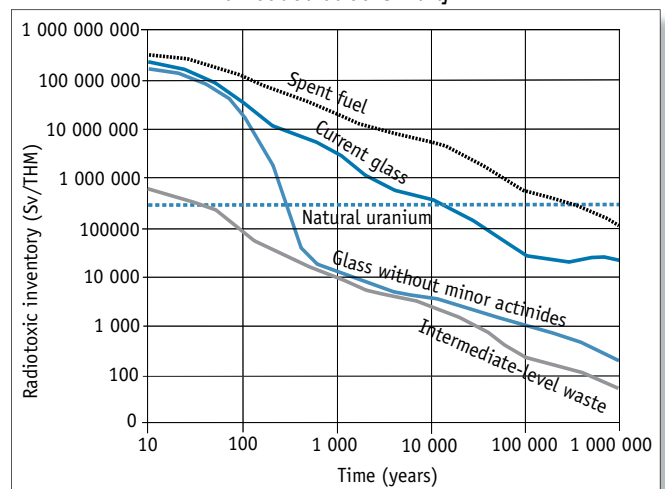
**Figure 1. Evolution of the radiotoxic inventory** [expressed in sieverts per tonne of initial heavy metal (uranium) (Sv/THM) of UOX spent fuel unloaded at 60 GWd/t, versus time (years)]



Source: CEA, 2004.

**Figure 2. Evolution versus time (years) of the radiotoxic inventory**

[expressed in sieverts per tonne of initial heavy metal (uranium) (Sv/THM) of waste produced by reprocessing UOX spent fuel unloaded at 60 GWd/t]



Source: CEA, 2004.

not been asked to review. It is not possible to present the detailed recommendations here, but the major conclusions are summarised below.

## Scope and limits of the report

- The report presents many areas of excellent technical work. In view of the forthcoming debate on the new nuclear waste law, it would also be helpful to produce a version accessible to non-specialist readers.

- It was not within the scope of the report to address an integrated approach to the effects of P&T on the whole fuel cycle. For example, it does not look at the implications of minor actinide recycling on fuel fabrication, or at the consequences of P&T implementation on final disposal repository performance. At some point in the near future, a complementary overview will be necessary.

### Strategy

- Much of the technical work reported is of a very high standard. Within the text, the underlying strategic logic of the approach could have been highlighted to a greater extent.
- The level of development of the various technical areas is different. Chemical partitioning of pressurised water reactor (PWR) spent fuel is very well developed, with some excellent work. The research on transmutation fuels and targets (fabrication, performance testing, and subsequent chemical processing) is still at an exploratory stage. However, shrinking R&D infrastructures and especially a lack of fast neutron irradiation facilities would endanger progress in this area.

### Objectives

- The IRT notes that the goals of the research are all stated in terms of radiotoxicity reduction. There are two perspectives with respect to the management of the long-term hazard of the waste – namely to reduce the total radiotoxicity inventory or to reduce the long-term radiation dose to populations from any future disposal – and some discussion on this point would be beneficial. P&T of actinides addresses the first, while P&T of fission products would be more directed at the second. P&T might also have a possible role in the efficiency of repository use, through a reduction in the heat loading and volume of waste to be disposed.
- The goals of future research for partitioning and transmutation should be set more in terms of what is necessary to achieve outcome objectives, for example reduction of heat level in the repository or reduced dose to the public from final disposal, rather than in terms of what might be achievable.

### Achievements and IRT agreements

- The CEA has done excellent work to demonstrate that technically feasible pathways exist for the management of minor actinides in light water

reactors, as it had done in the past for the management of plutonium.

- The scientific and technical aspects of aqueous partitioning are well-founded. They provide a high-level of confidence of the ability to deploy those processes in advanced fuel cycles.

In January 2006, the final report was presented to French Government officials from the Ministry of Industry and Research. This report is available on the NEA website under the title: *French R&D on the Partitioning and Transmutation of Long-lived Radionuclides*. ■

### Further reading

1. NEA (2004), *Post-closure Safety Case for Geological Repositories – Nature and Purpose*, OECD/NEA, Paris.
2. NEA (2005), *Actinide and Fission Product Partitioning and Transmutation – Eighth Information Exchange Meeting, Las Vegas, Nevada, USA, 9-11 November 2004*, OECD/NEA, Paris.
3. NEA (2005), *Fuels and Materials for Transmutation – A Status Report*, OECD/NEA, Paris.
4. NEA(2005), *International Peer Reviews for Radioactive Waste Management – General Information and Guidelines*, OECD/NEA, Paris.
5. NEA (2005), *Radioactive Waste Management Programmes in OECD/NEA Member Countries*, OECD, Paris.
6. NEA (2006), *Physics and Safety of Transmutation Systems – A Status Report*, OECD/NEA, Paris.