**Optimization of Waste and Materials Disposition in France – Policy, Strategies, and Techniques**

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*The present paper summarizes the findings of a working group within the PNGMDR that included representatives from Areva, CEA, EDF and Andra.*

## 1- Introduction

Since 1969 France has implement disposal solutions for low and intermediate level short lived wastes (low level wastes according to IAEA classification). These wastes have been first managed at Centre de la Manche disposal facility till 1994: a total amount of 527,000 m3 of waste packages have been disposed of. In 1992 this facility has been replaced by Centre de l'Aube, the capacity of which is 1,000,000 m3 of waste packages. At the end of the 1990$^{th}$, it appeared clearly that there would be an emerging issue for the management of decommissioning wastes and that a doctrine and a regulation had to be established. This regulation had to comply with European directives, in particular with directive 96/29 (now updated by directive 2013/39). To avoid any mistake in the orientation of wastes, and probably to anticipate public acceptance issues, the French regulatory body decided for nuclear facilities ("basic nuclear installations" according to French regulation) not to develop clearance levels and clearance processes but to require the implementation of a waste zoning within the facilities. In parallel it was decided to develop a new disposal routes for very low level wastes that should be safe but also cost effective.

The very low level waste disposal facility of Morvilliers (presently called Cires: industrial facility for logistics, storage and disposal) was designed in this context. It has a licensed capacity of 650,000 m$^3$, consistent with the estimated needs for 30 years, and started up in 2003. Very quickly the experience of the management of very low level waste on decommissioned sites showed that the needs were underestimated. It is presently considered that they presently correspond to the double of what was previously taken into account. Therefore new solutions have to be identified to avoid an anticipated saturation of disposal resources.

## 2- Waste zoning

The general legal and regulatory framework for waste management in France is described in the « Code for the Environment ». A specificity of the French regulation is that it prescribes the implementation within nuclear facilities of a waste zoning to segregate areas where waste cannot be contaminated or activated and areas where waste are or may have an added radioactive content. The first category may be managed in conventional routes; the second category (nuclear waste) requires a dedicated management in licensed facilities with a reinforced traceability.

Every French nuclear facility must establish a waste zoning with a view to segregate any sector where waste is actually or likely to be contaminated or activated (nuclear waste zone) from all other sectors where there is no waste-contamination or activation risk (conventional waste zone).

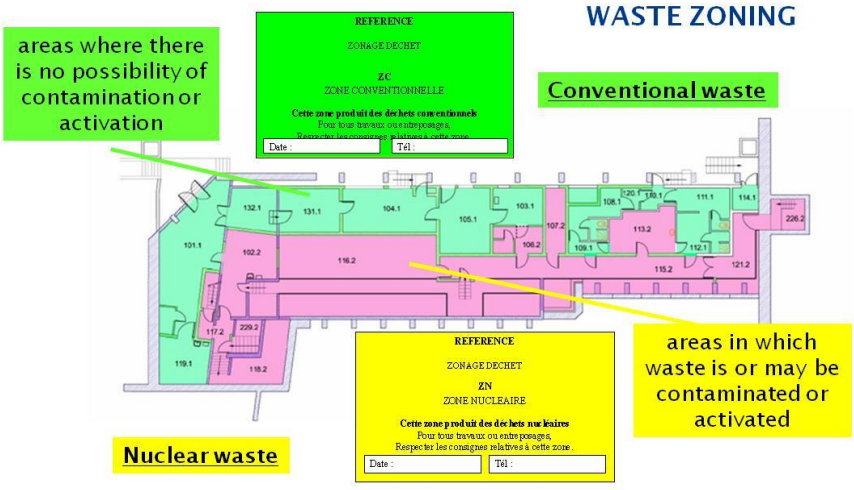


**Fig. 1: principles of waste zoning**

As a second line of protection systematic radiological controls secure the accuracy of the waste zoning. In case of a deviation waste zoning has to be reconsidered. The detection systems that implemented in conventional waste disposal facilities or other facilities that process waste make a third line of protection.

A consequence of waste zoning is that a large part of nuclear wastes may be just potentially radioactive. It is difficult to assess the actual distribution of activities as, for safety reasons, activities declared by waste generators are generally overestimated (mean activity is about 15 Bq/g). However dose rate monitoring of the workers of the disposal facility shows a very low impact in the range from 1 to 15 µSv per year.

## 3- Experience gained at Morvilliers disposal facility

The basic principle of the repository design was to comply with regulations governing disposal facilities for non-radioactive hazardous waste. Containment therefore relies on the properties of a low-permeability surface clay layer in which the repository is implemented.

**Fig. 2: Morvilliers disposal facility**

After the start-up of the facility, waste generators asked Andra to increase the technical ability to accommodate waste as their needs appeared quickly higher than expected. There was indeed no experience of waste zoning. Furthermore for facilities that were designed before this specific regulation, it was difficult to establish an optimized waste zoning.

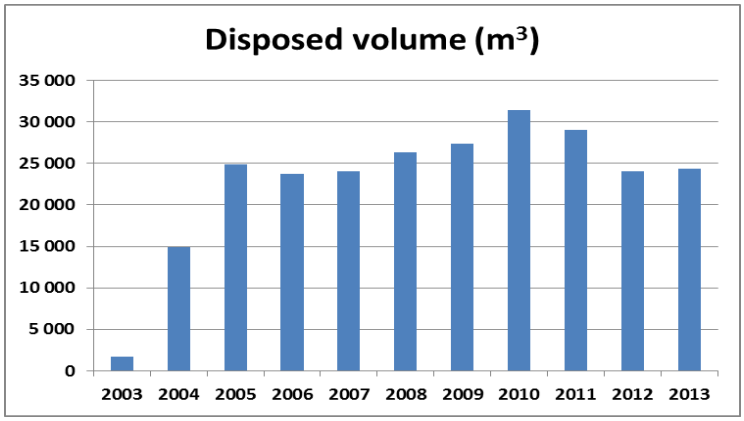


**Fig. 3: Disposal operations at Morvilliers**

At the end of 2013 252,000 m³ have been disposed of, that is above what was forecast for the design of the facility. It shows a risk that the saturation of the facility would occur earlier than planned.

This risk seems to be confirmed by data related to the generation of waste within the French National inventory for radioactive materials and waste. Indeed, according to these data, produced waste volumes could be higher by about 100,000 m³ than the capacity of Morvilliers facility by 2020 and could be twice than this capacity by 2030.

This situation needs to be managed, with the involvement of the actors who are in charge of the different phases of waste management in France, in particular waste generators and the waste

management agency. It is a topic of work within the French National plan for the management of radioactive materials and waste (PNGMDR).

## 4- The National plan for the management of radioactive materials and waste (PNGMDR)

The Planning Act of June 2006, the 28th, related to the sustainable management of radioactive Materials and waste, confirms the implementation of a National plan for the management of radioactive materials and waste (PNGMDR). This plan is chaired by the ministry in charge of ecology, sustainable development and energy and by the nuclear regulatory body (ASN). It involves waste generators, the national waste management agency and members of the civil society. It is updated every three years. The first version of PNGMDR was published in 2007, the present version, the third one, is applicable for the period between 2013 and 2015. As an important input for the PNGMDR a National Inventory of Radioactive Material and Waste is also updated every three years by Andra.

The plan deals with all types of radioactive waste and materials, with already available management routes and routes under development. It identifies areas to be improved and makes recommendations. It describes the research works to be performed. The follow up is done through periodical meetings, the conclusions of which are used to prepare the next plan.

Considering the forecast inventory of VLL waste, the PNGMDR addressed the question of recycling in its program for 2010-2012 and asked the main French nuclear operators, AREVA, CEA and EDF, and Andra to perform a shared study in order to assess the opportunity and economical/technical feasibility of the implementation of recycling routes.

In accordance with the French doctrine related to waste management within nuclear facilities, recycling should be performed within the nuclear industry. Therefore stringent constraints on the traceability of materials are to be considered. There are also potential constraints in the facilities that could process these materials in terms of radiation protection and also in terms of management of secondary wastes generated by the processes.

## 5- Recycling challenges

### 5.1 Present experiences of recycling in France

*The experience of SOCODEI/Centraco*

SOCODEI is a company that was created in 1990 and that is now a 100% subsidiary of EDF. Since 1999 SOCODEI is operating a facility, Centraco, which includes an incinerator and a melting workshop. The objectives of the facility are to reduce the volume of waste, to condition them in a way that it can be accepted in disposal facilities and to recycle metallic waste. The facility processes both very low level and low level waste: metal structures, valves, pumps, stainless steel tools, steel and nonferrous metals from maintenance and dismantling of nuclear facilities.

Metallic waste is sorted and melted in an electric induction furnace with a capacity of 4 tons. The furnace has treated an average of nearly 1,700 t / year.

According to the physico-chemical characteristics of these metal waste outlets or two uses are possible:

- volume reduction : non-recyclable waste are shipped as ingots to disposal facilities.
- Recycling: waste which correspond to specific metallurgical criteria are used to manufacture internal cylindrical shieldings for packages used for intermediate level waste (spent resins).

The mean activity of metal that was process to make shielding was 6 Bq/g with a maximum value of more than 160 bq/g.

Between 1999 and 2011, 21,700 tons have been processed and 600 tons have been recycled in shieldings.

*The experience of lead recycling*

This recycling route was implemented by Areva in 2003 and operated by the CEA since 2005. The process includes:

- Collection of lead inside Marcoule nuclear facilities,

- First melting inside Marcoule facility to make ingots. The activity of metal after melting is less than 1 bq/g;
- Second melting in a conventional facility to manufacture shieldings,
- Recycling in nuclear facilities.

100 tons of lead per year are currently recycled. However this is a fourth of the capacity of the melting furnace and this route appears to be costly in comparison with a direct disposal in a very low level disposal facility. Therefore it is planned to stop this route.

5.1 Metal resources

The forecast inventory of very low level metallic waste was reviewed for the next thirty years by main generators and the part with the lowest activity was assessed. It was estimated that among the 400,000 tons of metallic waste, between 250 and 375,000 tons could be reused. About 90% of them are ferrous waste. This corresponds to a mean flow of very low level iron in the range of 10,000 tons per year.

This amount is small in comparison of the overall mass of metals that are presently recycled in France. The mean yearly mass is about 0.1% of conventional recycled steels in France.

**Fig. 4: Metallic waste disposed of in Morvilliers (Cires) disposal facility**

This inventory includes very homogeneous components, as about 140,000 tons that could be provided by the dismantling of a gaseous diffusion enrichment plant and more heterogeneous components provided by other fuel cycle facilities, power plants…

5.2 The potential use of recycled metals

Main waste generators and Andra investigated the potential use of recycled ferrous metals and considered different types of products:

- Construction products in nuclear facilities with a focus on steel frames to reinforce concrete,
- Packages to condition wastes.

For the second reuse the present metallic packages that accommodate wastes to be delivered to existing or planned disposal facilities were taken into account. But the possibility to replace a part of concrete packages by cast iron packages was also assessed for Centre de l'Aube disposal facility; for some types of waste this option could both save disposal space at Morvilliers facility and at Centre de l'Aube facility.

The study showed that for the next 30 years a potential reuse of 300,000 tons could be identified. The main contribution is provided by waste packages (about 70%). Furthermore a significant part of them could be made with cast iron. The needs could meet the available metals to be recycled.

However for the replacement of concrete packages by cast iron packages conditioning tools and handling tools have in most cases to be adapted to the new geometry of containers. In addition safety assessment may have to be reconsidered with the new types of packages. This is true in particular for the safety assessment in the long term for Centre de l'Aube disposal facility where the durability of packages is taken into account for the containment of wastes. The corresponding costs can have an impact to appreciate the overall relevance of the required modifications and, then, of the recycling route.

**Fig. 3: Disposal of low level concrete packages at Centre de l'Aube**

5.3 The relevance of the recycling route

The interpretation of regulatory constraints for the implementation of a recycling route leads to consider dedicated facilities to process the materials into new products. Provisions for radiation protection should be taken with respect to hazards and secondary wastes should be managed as nuclear wastes.

The amount of metal scraps appears too small to dedicate facilities for the fabrication of steel products with mills, extruders or wire drawing machines in a relevant industrial and economical way. The industrial organization should rather include a foundry; the capacity of such facilities can be indeed consistent with the quantities to be treated (in the range 10,000 tons per year). This is also relevant for the manufacture of cast iron containers.

But, if a recycling route may be relevant in terms of the industrial tools to be implemented, it must also have an economical relevance. Costs in a new configuration with recycling options have to be compared with the present available route of direct disposal, i.e. the recycling route has to compete with the direct disposal route. It was considered that investments costs to modify waste generating and conditioning facilities were too high to achieve profitability, even if a weak but actual economic interest could be shown downstream of these facilities to process and dispose of the wastes, especially when savings of disposal space was possible for very low level wastes as well for low level wastes.

It was concluded that recycling would be more a relevant option to consider for the reuse of metals in new facilities or in new disposal facilities. The opinion of some members of the working group within the PNGMDR was that such a route would only be feasible with a clearance process. Or there could be routes developed in a marginal way connected with the management of some specific decommissioned facilities or units.

## 6- Conclusion

To face an early saturation of disposal capacities for very low level waste, the development of alternative routes to disposal could be a solution. Recycling of metallic waste could save a part of these capacities. They indeed represent about one half of the forecast inventory that was taken into account for the design of the disposal facility of Morvilliers. Therefore the French National plan for the management of radioactive materials or wastes tried to impulse the development of recycling of very low level metallic wastes. In accordance with the principles of waste management within nuclear facilities recycling should be performed within the nuclear industry.

The amount of available metals could meet the needs for metal in the identified recycling routes, provided some changes in the conditioning of some low level wastes were decided. However for some uses as the replacement of concrete low level waste packages by cast iron packages that could absorb a significant part of recycled metals, waste generators considered that investments to adapt conditioning and handling tools in the presently operated nuclear facilities would be so high that it

would not provide any profitability in comparison with direct disposal. Recycling would be more a relevant option to consider for a reuse of metals in new facilities or in new disposal facilities.

Therefore there is still a need to find reuse modes for the 5 to 10,000 tons per year of very low level metallic wastes that would have to be accommodated in a disposal facility and to explore new options. There may be also marginal developments for some dedicated wastes. But they will have to compete with direct disposal option in the framework of the present French regulation. Recycling of very low level wastes remains a sustainable development challenge.