

**EDF Industrial Strategy for the Management of Radioactive Waste– 15204**

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**ABSTRACT**

In France, EDF is in charge of electronuclear power operation since the sixties and consequently has to manage radioactive waste. Radioactive waste management is based on the control of each industrial step, taking into account the classification by activity level and radioactive half life. The main steps are to limit waste quantities at the generation stage, sort out non-rad and recoverable items from the waste, recycle, treat and package the radioactive waste as soon as it is generated, limit the use of interim storage, prepare and achieve as soon as reasonably practicable conditioning and disposal. EDF aims to empower operators in charge of NPP operating and of decommissioning and to centralize interfaces with the stakeholders in order to pool management routes and to guarantee the consistency of our industrial policy.

The French regulatory framework for the management of radioactive waste and material is set by the French 2006 planning Act, in line with the European Directive. The legal framework structures interactions between EDF and the regulatory bodies (Nuclear Safety Authority, General Directorate for Energy and Climate), the French National Radioactive Waste Management Agency (ANDRA) and other waste producer (mainly AREVA Company and CEA).

Regarding short lived waste, management routes are in current operation for the large majority of this waste generated both by power plants in service and during decommissioning. EDF is working on new management route for metallic materials knowing the future evolution of deposits is the field of large refit and decommissioning activities.

Regarding long lived waste, disposal development represents a major stake for EDF. EDF contributes to design studies of the geological disposal center and collaborates with ANDRA for the acceptance of future national waste disposal.

**INTRODUCTION**

Radioactive waste management is a major concern for EDF as operator of 20 nuclear power plants (67 units, 9 of which are shut down) and producer of radio nuclides in France. In this area, industrial and nuclear safety, radiation protection of the workers and the public are the main issues for the operating and shut down units.

The destination of the waste is taken into account during the design stage of facilities and in more detail during operation. The management of the spent fuel and the operating waste has been driven in the framework of national regulations from the beginning. Moreover radioactive waste management has become more and more significant in public opinion. The French Environmental Code Public precisely regulates this area.

As radioactive waste is intended for disposal on other sites than nuclear plants, these issues concern several other industrial activities beyond strict power production. In France, the final management of radioactive waste is entrusted to ANDRA (French National Radioactive Waste Management Agency) which is thus a main partner of EDF in this area. As front-end and some parts of back-end of the fuel

cycle process are operated by AREVA, EDF strategy is carried out in collaboration with this second main partner. Partnership is also achieved with CEA (atomic and alternative energies commission) in research and industrial areas.

In this paper, we present EDF industrial strategy and main steps for the management of radioactive waste.

### EDF FLEET

In France, EDF is operating 58 pressurised water reactors (PWR) units and is responsible for 9 shutdown nuclear power reactors (figure 1). The first reactor of the fleet started in 1963, as beginning of a Unat-Gas-Graphite Reactors UNGG series (6 units on the 3 sites Chinon, St-Laurent and Bugey). A single Heavy Water Reactor (HWR) type was built and operated in Brennilis from 1967 to 1979. The 300 MWe PWR in Chooz started in 1967 and shut down in 1991. Under government decision, EDF started construction of the PWR series having the total of 58 units. They started from 1978 to 1998. The fast breeder reactor (FBR) in Creys-Malville started in 1986 and was closed in 1998 by political decision.

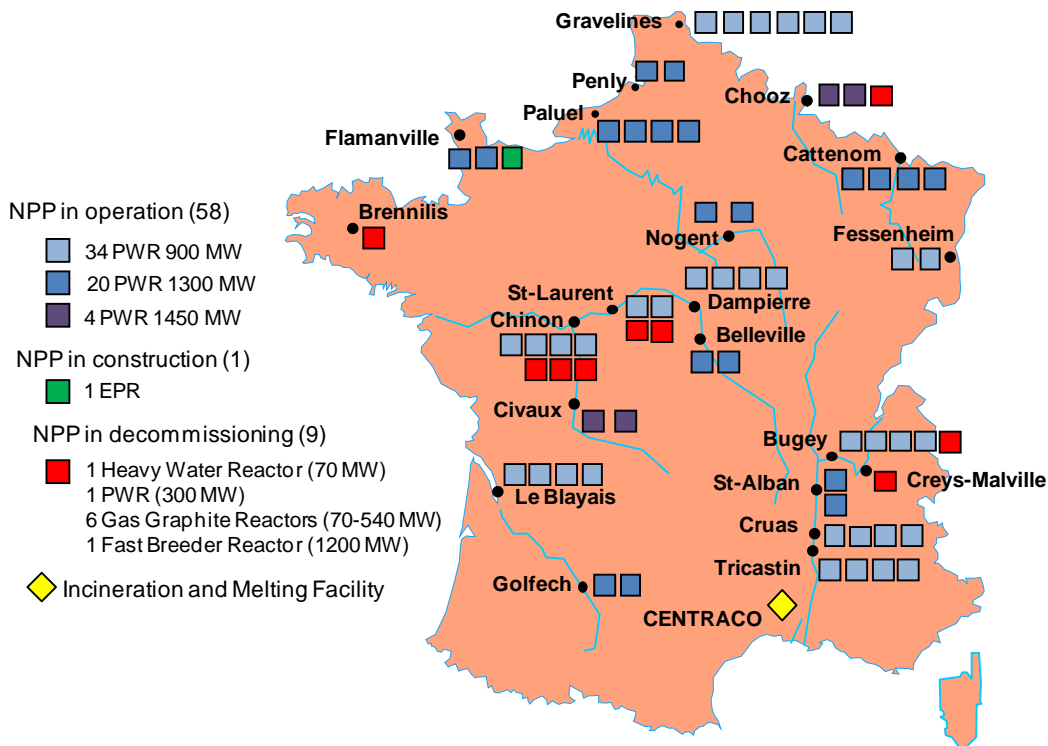


Fig.1. EDF NPP and facility

Operating the 58 PWR produces used fuel and radioactive waste:

- 1,200 t/year of used fuel
- About 10,000 m<sup>3</sup>/year to 15,000 m<sup>3</sup>/year of technological, maintenance and process radioactive waste
- Decommissioning waste, coming later after the units shut down.

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Regarding the 9 shutdown units (that belong to 4 different nuclear designs UNGG, HWR, PWR an FBR), the volume of the radioactive waste from the decommissioning in progress is evaluated to 180,000 t. CENTRACO facility is operated by SOCODEI Company, EDF subsidiary for melting and incineration of waste.

### **REGULATORY RULES**

Consistent with previous regulations on nuclear activities and installations, strong government involvement on management of high level radioactive waste is based on French Environmental Code, Act of December 30, 1991. This law launched a study and research program and its monitoring process over a 15 years period.

The "program Act" of June 28, 2006 was born on time to provide the follow-up framework for the high and intermediate level radioactive waste management. Three categories of studies are scheduled: on separation and transmutation of long lived radio nuclides, reversible storage in deep geological and interim storage. Implementation phases of these studies are defined. Evaluation of the results is given to a national committee established for this purpose (on all technical and financial aspects) and in charge of reporting every year to the parliament. Public involvement is organized in the region of geological laboratory.

Moreover, Act 2006 prescribed studies whose goal is to develop a disposal site for lower level radioactive waste such as graphite and radium waste, tritium containing waste, sealed radioactive sources and processing residues from uranium extraction. Funds allocated for these studies are provided to a large extent by taxes paid by the waste producers.

The French Act 2006 (now part of the French Environmental Code) is in line with the European Directive 2011/70 on "responsible and safe management of spent fuel and waste".

This law re-affirms the responsibility of the producers of nuclear waste and spent fuel for unlimited period. So EDF, as the first nuclear producer in France, must not only continue to take care of operating waste and spent fuel but also participate in the mastering of the activities in the front end and in the back end of fuel cycle.

This law requires achieving the National Plan for the Management of Radioactive Waste and Material (PNGMDR) presenting the synthesis of waste management routes and action plans for works leading to the recognized unmet goals. As a program document, the PNGMDR structures interactions between the body in charge of supplying the document, French National Radioactive Waste Management Agency (ANDRA), the waste producers as EDF under overall management of the legislative bodies (Nuclear Safety Authority, General Directorate for Energy and Climate) and surveillance of other public representatives.

The Transparency Act of June 13, 2006 and the other laws require transparency on nuclear activities by several rules such as public debate and legal means. A high committee for transparency is created, as local commissions of information and surveillance.

Requirements on updating and publishing every 3 years of the inventory of the radioactive materials and waste present in France correspond to these objectives. EDF provides this inventory data to ANDRA who is in charge of the publication in France.

Radioactive substances producers have to finance the cost of decommissioning and of radioactive waste management from short to long term. As a result, dedicated assets are included in EDF operating accounts and in (reserve) funds. About €3 billion were accounted at the end of 2013, covering provisions for spent fuel and radioactive waste management and decommissioning.

### BASIC DESIGN AND GENERAL ACHIEVEMENT MAKING EDF STRATEGY FOR WASTE MANAGEMENT

A French classification system for waste, which has been used for years, has also been consistently strengthened in PNGMDR document. The classification, origin and destination of EDF radioactive waste are presented in Table I. The activity values are indicative only because noxiousness of waste depends on the radio nuclides they contain.

TABLE I. French waste classification with main origin and destination of waste

Activity	Half life	
	Short lived Half-life < 31 years	Long lived Half-life > 31 years
Very low level < 100 Bq/g	Waste mainly from dismantling operations Recycling or dedicated to surface disposal as CIRES (disposal facility in the Aube department) since 2003	
low level < 10 <sup>6</sup> Bq/g	Waste mainly from day-to-day operation of NPPs To surface disposal, CSM from 1969 to 1994, CSA since 1992	Graphite, radium-bearing waste Treatment and/or disposal being studied
Intermediate level <10 <sup>9</sup> Bq/g		
High level >10 <sup>9</sup> Bq/g	Waste stemming from used fuel recycling dedicated to geological disposal facility in France (CIGEO) to be commissioned in 2025 or later	

Waste management is closely connected with the management of fuel cycle regarding high and intermediate level waste. For the EDF fleet, 1200 t/year of used fuel is withdrawn from the 58 cores. Reprocessing a part of the UOx used fuel allows reduced consumption of natural uranium and reduction of the high and intermediate level waste volume [3].

Figure 2 shows the general results on waste production.

Regarding the used fuel from the UNGG reactors, EDF has transferred his responsibility to AREVA with payment of appropriate equity. UNGG irradiated graphite subject is broached in decommissioning paragraph. The used fuels from the two HWR and FBR reactors (EL4 and Superphenix) are stored for potential processing.

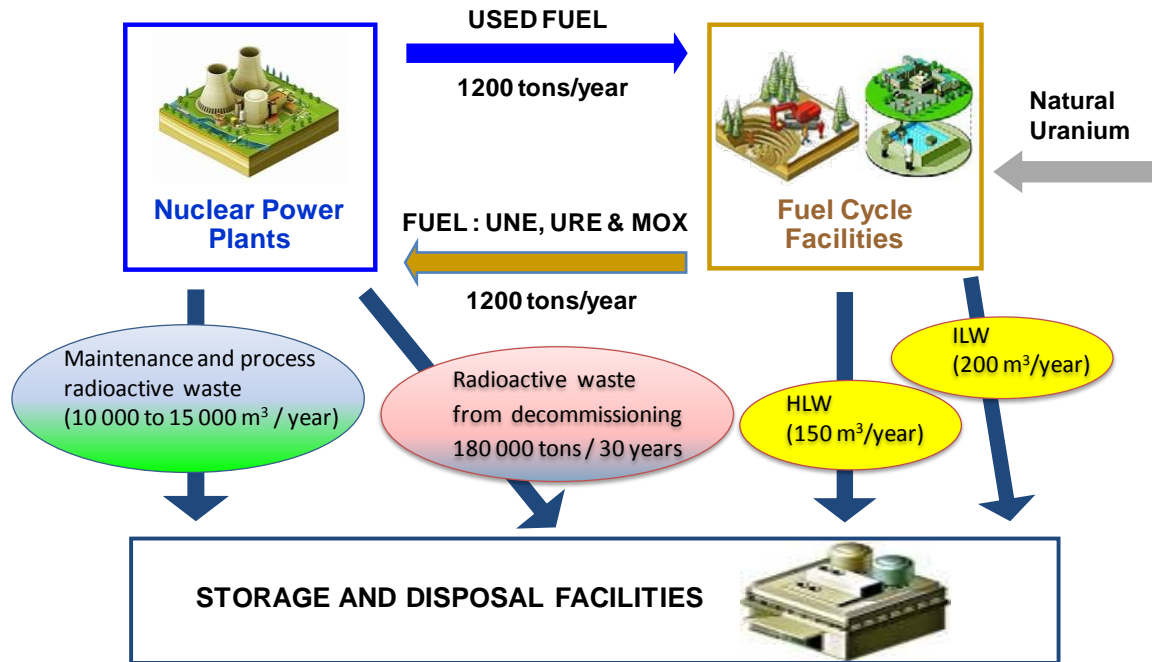


Fig.2. Logic of radioactive waste production

A lot of EDF and contract technicians and engineers are involved in the process presented in the very simplified scheme (figure 2). EDF organization aims to empower operators in charge of NPP waste and to centralize interfaces with the stakeholders in order to develop and use common management routes and to guarantee the consistency of the industrial policy.

The main missions for radioactive waste management are assigned to EDF units as follows:

- Policy for radioactive waste is defined by a dedicated 'Radioactive Waste Management Directory' who includes senior managers of the three nuclear and engineering divisions. The executive secretary of this radioactive waste Directory is provided by the Nuclear Fuel Division (DCN). This EDF Division is in charge of the management of nuclear fuel activities including used fuel, and of the general strategy of radioactive waste activities. In this area of back-end fuel cycle, DCN is responsible for the general relationship with ANDRA and regulatory bodies. DCN is also responsible for transport of nuclear fuel and operating waste.
- Each NPP is a unit and responsible for managing the operations in the NPP field with its own procedures; these activities represent the main work on radioactive waste in EDF facilities: limiting volume at source, sorting, using adapted packaging.
- Operational and Technical Unit (UTO) controls the overall environment performance of all NPP in the area of operating waste ; its missions are to plan the sizing activities, coordinate the actions on NPP, help them for technical aspects, training and improvement analysis, to develop and implement common means for waste treatment : UTO manage standardization and technical

improvements of waste packaging approval for repository.

- Engineering Center for Decommissioning and Environment (CIDEN) manage and achieve all decommissioning activities, including transportation mainly conducted as projects, in accordance with the policy defined by the Directory introduced above.

## **OPERATING SHORT LIVED WASTE MANAGEMENT**

Regarding operating short live waste, EDF has developed complete and safe management paths. 28 groups of waste are precisely constituted, and 8 other groups are constituted for decommissioning waste. Each group is defined for a particular type of waste (technological incineratable waste, compactable metals, non compactable metals, charcoal, rubble, chemically dangerous waste, asbestos containing, water filters, resins, evaporator concentrates, oils, irradiating metals, etc...) and sometimes by activity level. For each type of waste, a technical path is established, including treatment in some cases, packaging, interim storage, transportation and disposal.

For instance, evaporator concentrates and oils are transported in specific tanks to CENTRACO facility and incinerated. Some groups of waste have a second alternative path: incineration and melting routes have direct disposal as an alternative.

Transport means are numerous enough in order to secure evacuation requirements. Efficient routes are defined and operational for all waste on all aspects from generation control to disposal, except waste containing free asbestos fibers for which there is no agreement on disposal. Studies are being conducted for this case.

Metal melting process at the CENTRACO facility (an EDF subsidiary company) has been conducted since 1990 and ceased in 2011; restarting this treatment unit is planned for 2015. The goal is to achieve treatment of 3,500 t/year. The process provides volume reduction of waste, declassification of the majority of waste to ‘very low activity’ and allows recycling material for nuclear needs.

For some years, significant increase in the volume of waste comes from chemical cleaning of the steam generators. Treatment of this waste by incineration in the CENTRACO facility will be an improvement. EDF looks for increasing the capacity above 1,500 t/year.

Moreover, the volume of short lived operating waste is foreseen to increase for next decennial, because of maintenance activities. EDF is consolidating the different management paths.

Management of worn out steam generators stored on sites in warehouses is an important topic with recycling as a possible option. EDF is studying and comparing the options before industrial engagement [4].

Transportation of nuclear fuel and waste is a strong challenge regarding nuclear safety, radiation protection and performance of the schedules. EDF is in charge of all such transport between its own facilities and partner’s facilities. Contracts with suppliers ensure the exclusive availability of about 400 containers, 20 tanks and 10 specific trailers. The use of standard and modular equipment provides reliability and availability of the system which allows making nearly 3,000 transports each year. EDF is preparing for an increase in these activities to face the period of ‘major overhaul’ and complement the means for instance to transport waste to the new facility ICEDA (cf. next paragraph).

## DECOMMISSIONING WASTE

Immediate decommissioning of the shutdown nuclear plants is the general strategy for EDF. The main purpose of this option is to not leave NPP decommissioning works to future generations. Nowadays this option is considered by French safety Authority and is consistent with IAEA standard preference.

The immediate decommissioning strategy presents opportunities:

- Use present generation power plants operators technical knowledge,
- Build a useful experience now for NPP operation, new NPP design and future decommissioning operations,
- Implement international practices from other licensees having decommissioning projects.

For the 9 EDF nuclear reactors being decommissioned in France, the inventory of waste yields the following quantities:

- 500 t of low and intermediate-level activity / long lived waste,
- 17,100 t of graphite (low-level activity and long lived waste),
- 53,000 t of low-level activity and intermediate-level activity / short lived waste,
- 115,000 t of very low-level activity.

Decommissioning also generates 880,000 t of conventional waste (non radioactive) to manage. Destination of the radioactive waste is summarized in the Table II.

TABLE II. Decommissioning waste routes

Activity	Half life	
	Short lived Half-life < 31 years	Long lived Half-life > 31 years
Very low level	115,000 t CIREs : ANDRA disposal in Morvilliers, Aube department	
Low level	53,000 t CSA : ANDRA disposal in Soulaines, Aube department	Graphite : 17,100 t Disposal being studied
Intermediate level		500 t ICEDA : EDF conditioning and interim storage 50 years and then disposal CIGEO

Regarding irradiated graphite from UNGG reactors the development of optimized treatment, conditioning and disposal is not carried out at present time. EDF, who is responsible for this waste, is working on this topic with ANDRA to find the more relevant solution [4].

Intermediate level waste coming from decommissioning of first generation NPPs is mainly activated steels and estimated at 500 t. Activated materials from operating NPP as used control rods have to be

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stored also. 1500 t of such waste exists. The chosen concept is to store these two types of waste in safe containers for about 50 years and to transfer to disposal at the end of this period. For this purpose, ICEDA (facility for conditioning and interim storage of activated waste) was designed by 2006 and EDF obtained a license in 2010 to build the facility near Le Bugey NPP. Construction work was halted in 2012 because of judicial reviews. The selected packaging to keep waste safe is concrete containers. This treatment in ICEDA could begin in 2016.

### **LONG LIVED WASTE MANAGEMENT**

Nuclear power industry needs safe and operational solution for long lived waste.

The 1991 Waste Act opened new study works on underground disposal for long lived waste. The law assigns responsibility to ANDRA. Studies required by the law included the creation of an underground laboratory and naturally the inside researches. Official creation authorization was obtained in 1999 on the site of Bure, in the eastern France, chosen for Callovo-Oxfordien clay geological feature. Feasibility study results were presented by ANDRA in 2005 to the French Parliament and to the Government.

Since that time and enacting the consecutive Waste Act of the June 28, 2006, a major ANDRA's mission is to develop a safe disposal.

Named CIGEO (acronym meaning 'Industrial Center for Geological disposal'), the project gives the opportunity of EDF collaborative actions and challenging studies using experience in nuclear area and in underground infrastructures construction. For this last area, EDF brings its expertise to hydroelectric plants. EDF studied the following topics:

- The transposition to CIGEO of proven operational safety and security principles as the sectorization against spread of fire,
- The dimensioning of some installations,
- The advantages and consequences of the use of a different drilling technique (for example the tunneling boring machine for the connecting galleries),
- The extension of the excavated zone and its role in the performance analysis.

Such cooperation will certainly be useful to meet next milestones: after the public debate held in 2013 on the site region as required by law, ANDRA plans to deposit a license demand before 2017 in order to open the storage facility for a pilot phase in 2025 and the industrial commissioning in 2028.

Knowing this schedule and jointly with the other producers, EDF prepares this long lived waste management route. Transportation is one of the subjects: in order to be ready for optimized transportation of the high-level activity waste to CIGEO, EDF achieve the preliminary studies for new optimized packing.

### **CONCLUSION**

Radioactive waste management takes a major part to the confidence in safety of nuclear energy. French regulatory framework in this area has increased these ten last years and involves several stakeholders and EDF as the main company responsible.

In the legal framework and in association with the stakeholders (ANDRA, AREVA, CEA and public representatives) EDF implements a global industrial strategy for all radioactive waste. Technical knowledge, appropriate developments and resources may allow solving the issues in this area.



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On the basis of its experience in nuclear operation and many related disciplines, EDF claims to face the challenges of radioactive waste management.

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