# RADIOACTIVE WASTE MANAGEMENT PROGRAMMES IN OECD/NEA MEMBER COUNTRIES

## FRANCE

### Nuclear Energy & Radioactive Waste Management

## NATIONAL NUCLEAR ENERGY CONTEXT

Commercial utilisation of nuclear power in France started in 1959 and by 2010 there were 58 electronuclear reactors (run by EdF, the French utility). In 2009, they generated 410 TWh of electricity.

The last nuclear power plant (NPP) to be commissioned was the Civaux NPP (with its two 1540 MWe N4-type reactors connected to the electricity grid in 1999). The average availability factor of French nuclear power plants is slightly above 80%.

As far as new NPP development is concerned, EdF was granted in 2006 a building licence for an EPR type reactor to be sited at Flammanville (near the two currently existing PWRs). Construction is under way and commissioning is expected by 2012.

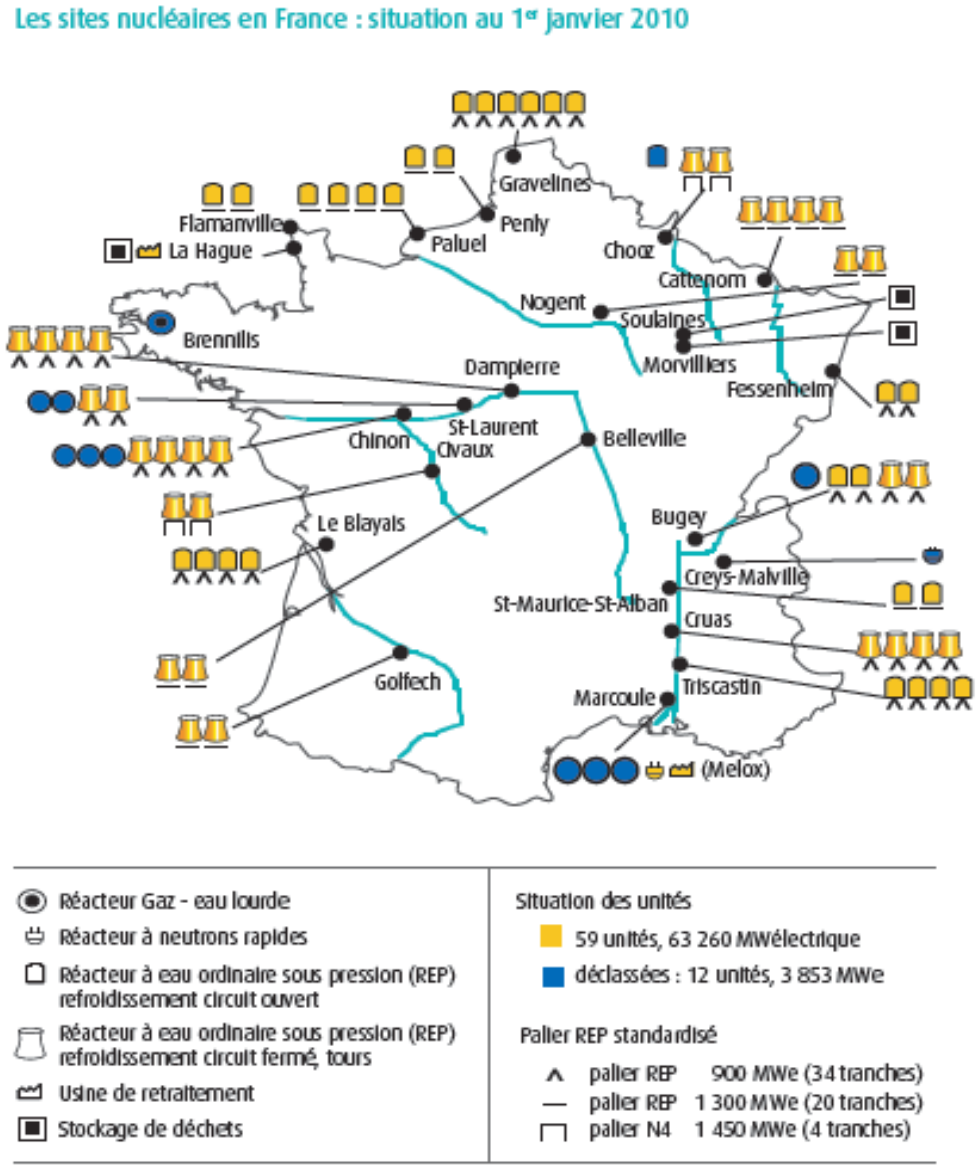
Another EPR project has been announced in February 2009 by the French government, to be sited within EDF Penly NPP. The administrative procedure has been launched such as the mandatory public national debate (from March 2010 until July 2010) and the public enquiry following the file application which lasted until January 2011. This project, as the previous EPR one at Flammanville, will as well concern several shareholders, but EDF is due to be the operator and main shareholder.

A possible 3rd EPR (probably operated by Suez-GDF and sited in the Rhone valley) seems to be postponed for the time being.

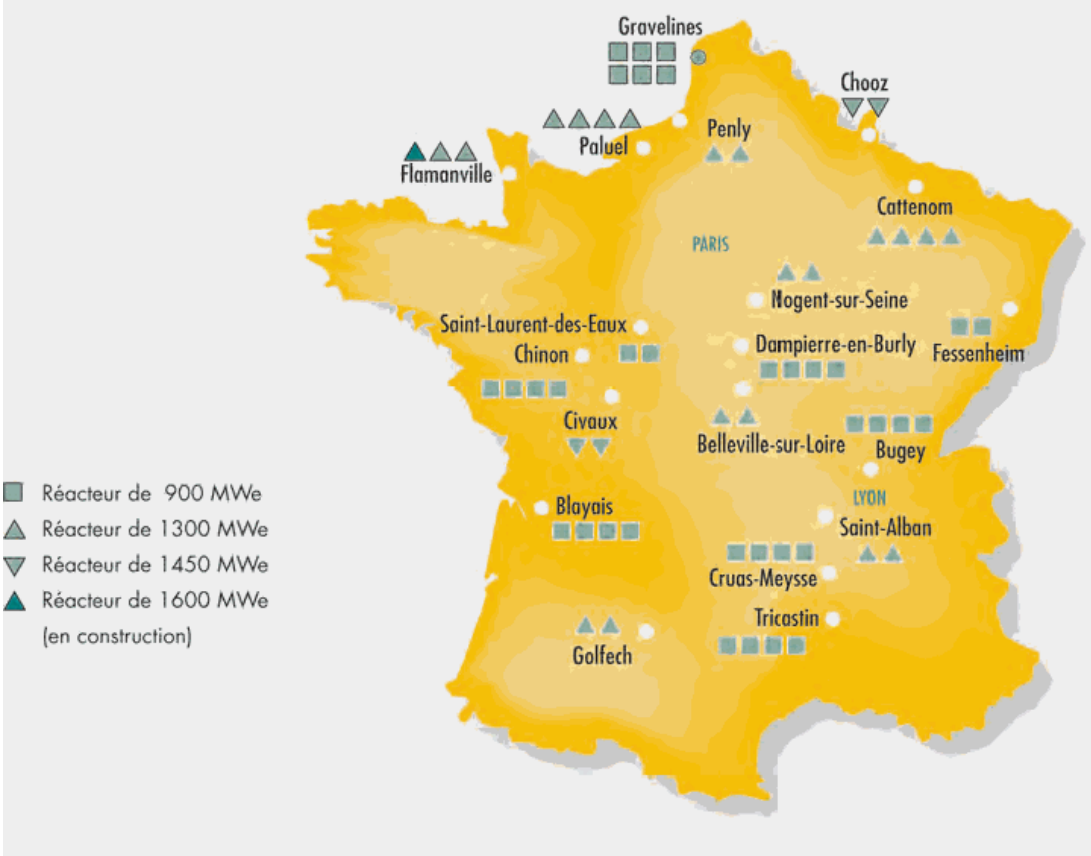
The current capacities for nuclear fuel fabrication are 750 tonnes heavy metal per year (HM/year) of uranium fuel for light water reactors and 140 tonnes HM/year of mixed oxide (MOX) fuel also for use in light water reactors. Spent fuel storage capacity is 24,450 tonnes HM, and the yearly amount of spent fuel is approximately 1,135 tonnes HM.

In France, spent nuclear fuel is not considered as ultimate waste and is reprocessed for recovery of reusable materials. Commercial reprocessing is carried out at the La Hague plant

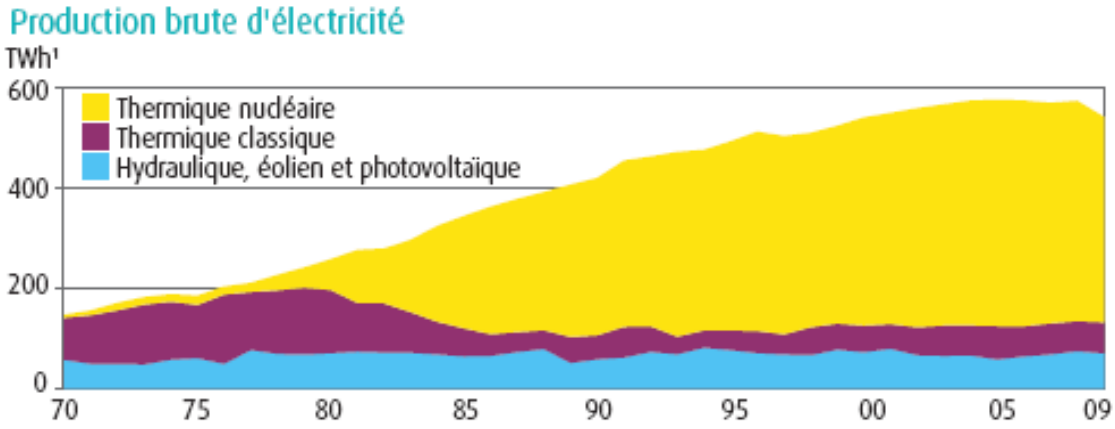
operated by AREVA. The two facilities at this plant have the combined capacity to reprocess up to 1,700 tonnes HM/year of spent fuel and they supply commercial services to national and foreign customers.



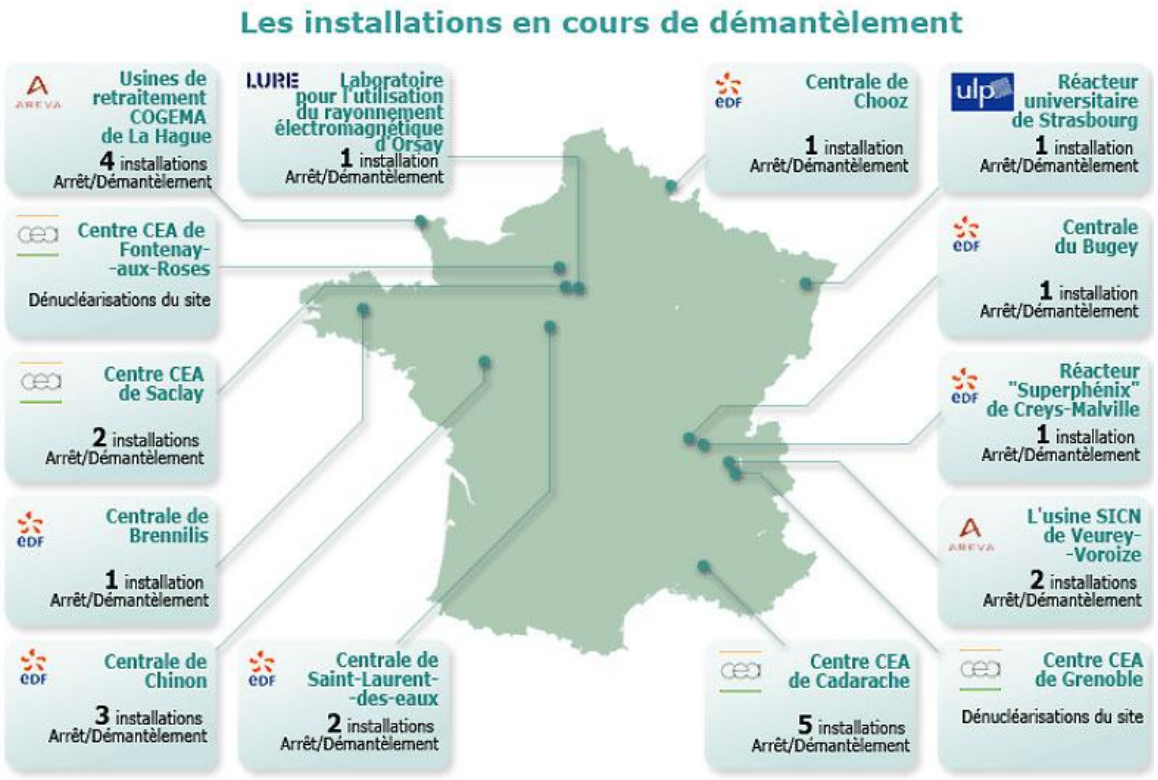

Map of decommissioned, commissioned and under-construction nuclear facilities in France (Status in October 2010 – source DGEC)




Map of electronuclear power plants and their reactors (operating and in construction) in France (Status in October 2010 – source DGEC)




Evolution of gross electricity production in France, showing the progress of nuclear electricity among years (Source DGEC)




**Les réacteurs de première génération d'EDF (UNGG) :** les réacteurs A1, A2 et A3 sur le site de Chinon, le réacteur de la filière graphite-gaz du Bugey et les réacteurs A1 et A2 de Saint-Laurent-des-Eaux.

**Les autres réacteurs d'EDF :** le réacteur Superphénix sur le site de Creys-Malville, le réacteur à eau sous pression sur le site de Chooz, la centrale de Brennilis (EL4).

**Les installations en démantèlement sur les centres du CEA :** le centre CEA de Saclay et de Cadarache.

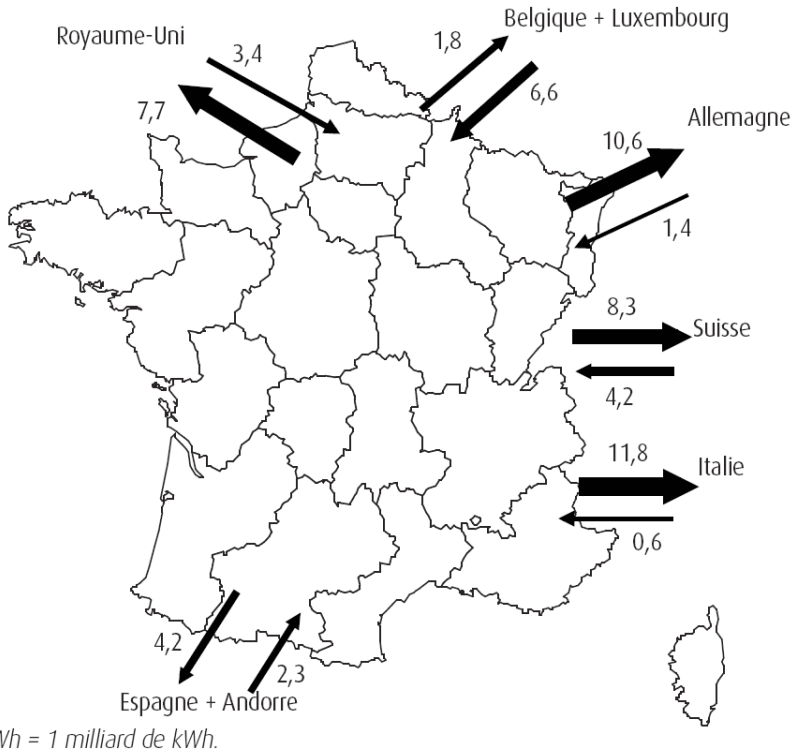
**Les centres du CEA en démantèlement :** le centre CEA de Fontenay-aux-Roses et le centre CEA de Grenoble.

**Les autres installations en démantèlement :** le Laboratoire pour l'utilisation du rayonnement électromagnétique (LURE) d'Orsay, le réacteur universitaire de Strasbourg, les usines de retraitement COGEMA de La Hague, l'usine SICN de Veurey-Voroize.

Map of decommissioned nuclear facilities in France
(Status in October 2010 – source DGEC)

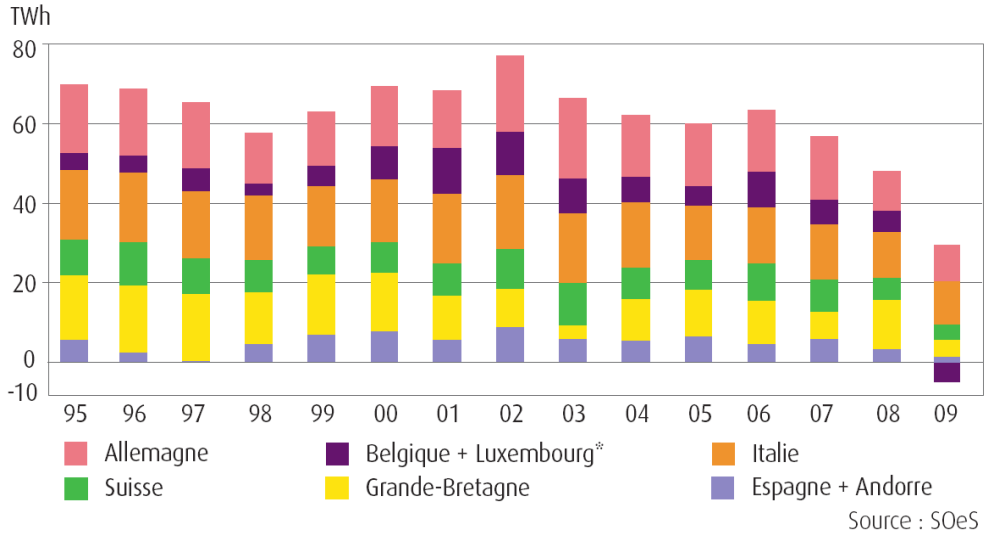
Out of the total electricity production, the balance between importation and exportation is still positive but decreasing. The two following figures illustrate the status of exchanges in 2009 between France and its neighbouring countries and their evolution from 1995 until 2009 (source DGEC).

## Échanges physiques d'électricité avec l'étranger en 2009 (TWh)*




** 1 TWh = 1 milliard de kWh.*

## Solde exportateur des échanges physiques d'électricité avec l'étranger

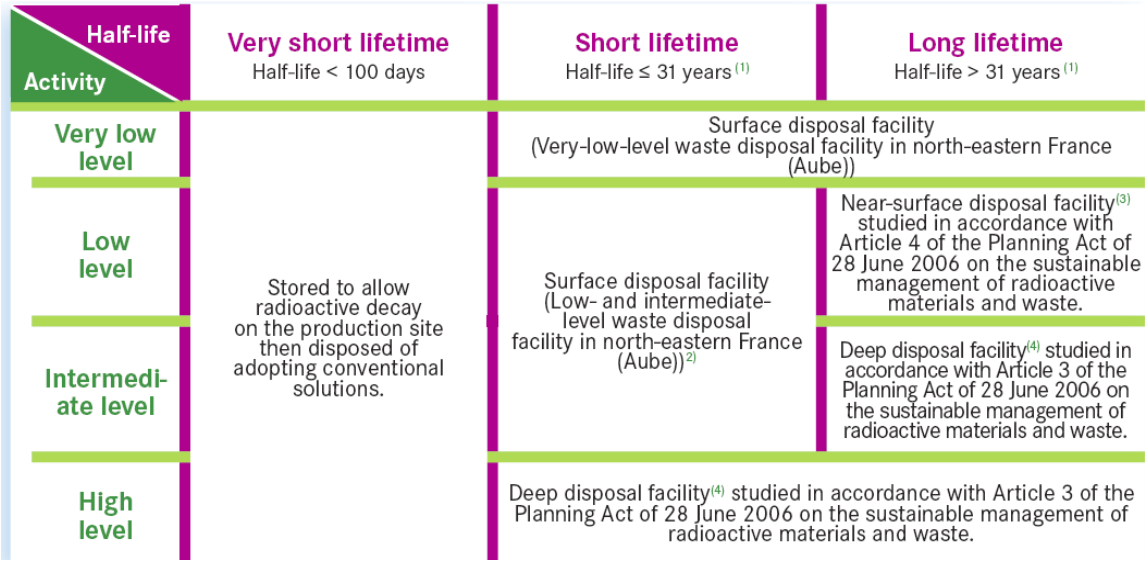



** En 2009, le solde exportateur des échanges avec la Belgique et le Luxembourg est négatif.*

In 2009, the balance was negative with Belgium and Luxembourg.

## SOURCES, TYPES AND QUANTITIES OF WASTE

Most of the radioactive waste in France is generated as a result of electricity production. The remainder arises from the use of radioactive materials in medical, research, defence and industrial applications. To meet the requirements for its safe management, waste classification considers four categories according to activity level. Then each waste category is subdivided according to half-lives of the radio-nuclides it contains as shown on the figure below.



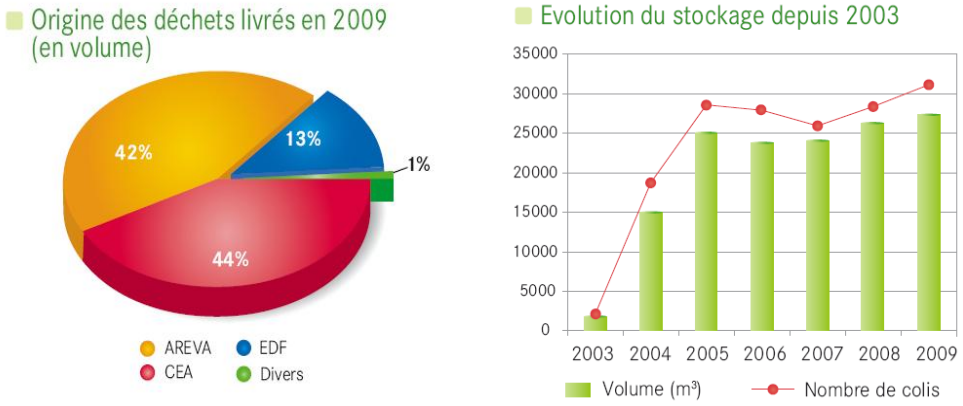

(1) The half-life of caesium-137, which is 30.07 years, marks the boundary between the notion of short-lived and long-lived. This figure is rounded up to the nearest whole number in the table for the sake of simplicity.
(2) The LILW disposal facility has taken over from the CSM disposal facility (Manche), which was closed in 1994.
(3) Near-surface means between the surface and a depth of 200 metres. A search is currently underway to find sites suitable for a new LLW-LL disposal facility.
(4) Deep disposal means at a depth of more than 200 metres. Andra is working on a repository project in the 250-square-kilometre transposition zone defined around the Meuse/Haute-Marne underground laboratory in 2005. The aim is to dispose of high-level and intermediate-level, long-lived waste in a single repository in a clay layer (Callovo-Oxfordian) 500 metres below the surface.

Starting by the lowest levels of activity, these four categories are: very low-level waste (VLLW), low-level waste (LLW), intermediate-level waste (ILW) and high-level waste (HLW). For each of these four categories, a further distinction is made between the waste containing radio-nuclides with a short half-life (less than 31 years) and those with a long half-life (more than 31 years). The very specific case of very-short-lived waste, mainly medical use, (Half-life below 100 days) is not considered in this document as it is managed through radioactive decay and then disposed of as current waste.

The rate of generation of VLLW is estimated to range from 15,000 to 40,000 $m^3$/year for the next 10 years (which means an average of 25,000 t/year). This waste contains various radio-nuclides and has an average activity of around 10 Bq/g. It is disposed of in a new surface repository (commissioned in 2003), the CSTFA, located at Morvilliers, a few kilometres from the

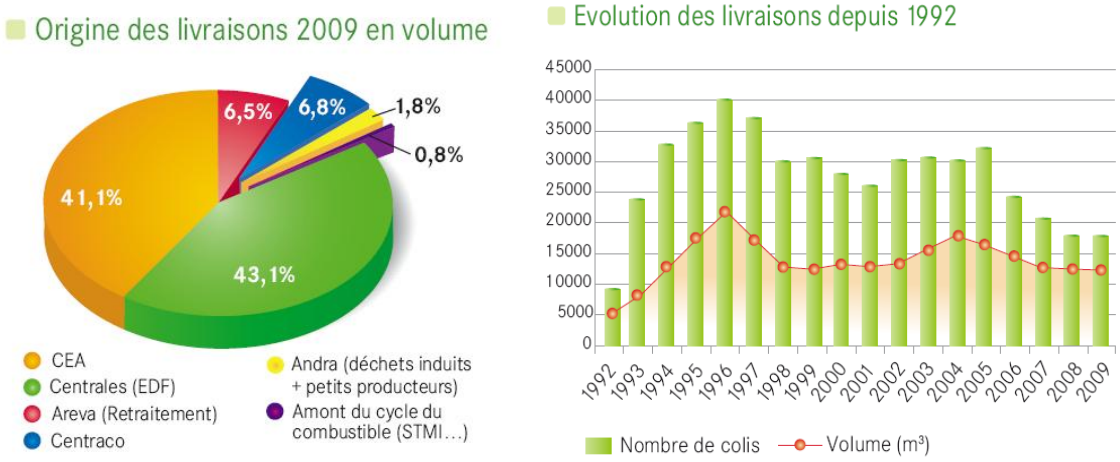
existing CSFMA disposal facility (for low- and intermediate-level short-lived radioactive waste) in the Aube district. This repository has an initial total capacity of 650,000 $m^3$ and is planned to operate during 30 years.

The amount of waste disposed of at the CSTFA in 2009 was 27,335 $m^3$ (versus 31,027 $m^3$ delivered). At the end of 2009 and since its commissioning, the CSTFA has received 142,990 $m^3$ out of a total capacity of 650,000 $m^3$.




Origin and evolution of the waste volumes delivered to the CSTFA

The short-lived LLW and ILW waste are disposed of in engineered, surface disposal structures at the CSFMA disposal facility, located at Soulaines-Dhuys in the Aube district. Most of this waste is originated either by the electronuclear industry (EDF, AREVA, cycle front-end) and the CEA, while the remainder, with less than 2% comes from "small-scale nuclear" activities such as hospitals, universities, industry and sometimes private individuals (the so-called "house-hold" radioactive waste with legacy items such as former needles or radium fountains, etc). The amount of waste disposed of at the CSFMA facility in 2009 was 11,107 $m^3$ (versus 12,363 $m^3$ delivered). At the end of 2009 and since its commissioning, the CSFMA has received 231,046 $m^3$ out of a total capacity of 1,000,000 $m^3$.




Origin and evolution of the waste volumes delivered to the CSFMA

The management of long-lived LLW (especially radium-bearing waste and graphite waste) was the subject of disposal studies performed by Andra, which have been postponed following sociopolitical siting problems in 2009. Long-lived ILW is presently kept in at the sites where it is generated, awaiting the availability of a dedicated disposal facility.

HLW arising from spent fuel reprocessing is vitrified. The resulting canisters are stored in dedicated facilities at the production sites, at La Hague and Marcoule. They will remain there for a few decades, until their disposal. The related vitrified HLW production to be derived from French reactors spent fuel is about 600 glass canisters per year out of the La Hague plant as the Marcoule plant has stopped its reprocessing activity.

Spent fuel (with the exception of spent fuel from research and National Defence reactors), as it contains recoverable materials is not considered as final waste according to the French regulation and, as such, cannot be disposed of.

**Quantities of waste presently in interim storage facilities**

The volume of radioactive waste in the interim storage facilities at the end of 2007 (Source: National Inventory issued in 2009 with figures at end 2007), by main individual category, was as follows:

- Short-lived ILW (tritiated waste): 2,905 $m^3$;
- Long-lived ILW: 41,757$m^3$;
- HLW: 2,293 $m^3$ (out which 74$m^3$ of spent fuel from research and National Defence reactors)

These figures exclude any waste either originating from a foreign country or arising from the reprocessing of foreign spent fuel, which, in compliance with the Environment Code, is to be returned to the foreign owners after the necessary storage period.

They also exclude long-lived LLW containing radium and graphite, which amounts by end 2007 at 82,536 $m^3$. This last figure does not consider the future graphite from former UNGG (natural-uranium gas-graphite) reactors which have not been yet dismantled; radium-bearing waste (originating mainly from chemical industry dealing with rare earths) needs as well to be taken into account. The total volume of radium-bearing and graphite waste, including its conditioning, can be expected to reach approximately 152,000 $m^3$ by 2030.

**Radioactive waste inventory**

An observatory of radioactive waste in France has been published on a yearly basis by Andra from 1993 until 2003. This observatory listed all the sites on which radioactive waste was present, including contaminated sites.

In 1999, the government decided to widen the objectives of this inventory by including the so-called committed (or pending) waste and all recoverable radioactive materials. The first edition of this inventory, to be updated every 3 years, was issued in 2004 with the status of radioactive waste and recoverable materials at end 2002 and a prospective forecast until 2020. The last version of this inventory was issued in 2009 with the status at end 2007 and prospective forecast until 2020 and 2030.

Volumes of radioactive waste produced by end 2007 (and their distribution) and expected quantities by 2020 and 2030 are shown in the tables below. This is based on the assumptions of the current NPP fleet and the reprocessing of 850 tonnes HM/year of spent fuel. As stated above,

these figures exclude those wastes arising from the reprocessing of foreign spent fuel.

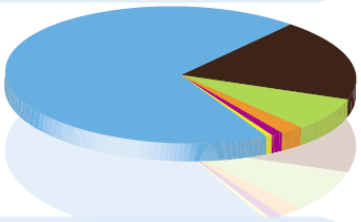
Volumes of radioactive waste, in storage or disposal facilities, at the end of 2007, in equivalent conditioned m³

| | Volumes (m³) |
|---|---|
| VLLW | 231,688 (of which 89,331 is in repositories) |
| LILW-SL | 792,695 (of which 735,278 is in repositories) |
| LLW-LL | 82,536 |
| ILW-LL | 41,757 |
| HLW | 2,293 (of which 74 is spent fuel) |
| Management solution to be defined* | 1,564 |
| **Total** | 1,152,533 (of which 824,609 m³ is in repositories) |

*The waste listed under the heading "management solution to be defined" is waste that the producers have declared without attributing it to an existing management solutions or to one being currently developed. It concerns waste either in a chemical or physical form which does not currently allow it to be considered with one of these solutions, or because no reprocessing method is currently envisaged.

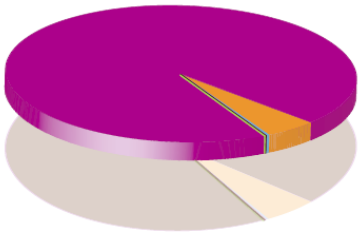
Distribution, at the end of 2007, of the volume of radioactive waste, by radioactive waste type, produced in France

| | | | |
|---|---|---|---|
| LILW-SL | 68.8% | HLW | 0.2% |
| VLLW | 20.1% | ILW-LL | 3.6% |
| LLW-LL | 7.2% | Not defined | 0.1% |



Distribution, at the end of 2007, of the level of radioactivity, by radioactive waste type, produced in France

| | | | |
|---|---|---|---|
| HLW | 94.98% | VLLW | 0.000 003% |
| ILW-LL | 4.98% | LLW-LL | < 0.009% |
| LILW-SL | < 0.03% | | |



Forecast quantities of stocks of radioactive waste by the end of 2020 and 2030 including all sectors of activity

| | 2020 Volumes: in disposal or storage facilities | 2030 Volumes: in disposal or storage facilities |
|---|---|---|
| VLLW | 629,217 | 869,311 |
| LILW-SL | 1,009,675 | 1,174,193 |
| LLW-LL | 114,592 | 151,876 |
| ILW-LL | 46,979 | 51,009 |
| HLW | 3,679 of which 74 is spent fuel | 5,060 of which 74 is spent fuel |
| Total | 1,804,142 | 2,251,449 |

## RADIOACTIVE WASTE MANAGEMENT POLICIES AND PROGRAMMES

### Waste management policies

Management of radioactive waste and other industrial waste, is subject to the general legal framework prescribed by article L.541 of the Environment Code (following Act n° 75-633 of 15 July 1975), and the associated decrees about recycling of materials and disposal of waste. The basic principles enshrined in this Environment Code are prevention of waste production, the responsibility of waste producers for their waste until it is safely disposed of, the traceability of waste, and the need for public information. In addition it is only when waste cannot be reused or recycled under current technical and economic conditions that it may be disposed of (concept of final waste).

The underlying concept is that facilities should be designed with all aspects of waste management in mind, from generation to reuse, recycle or safe disposal, and with regard to the interactions between inter-dependent waste management operations. In this way a system may be created that is optimised as part of an overall approach to waste management and which takes account of safety, traceability and volume reduction issues.

As regards the policy for waste management, broad guidelines were set out in article L.542 of the Environment Code, following the Waste Act of 30 December 1991 and the Planning Act concerning the sustainable management of radioactive materials and waste of 28 June 2006, as follows:

- The sustainable management of radioactive materials and waste, resulting notably from the operation and dismantling of nuclear facilities using radioactive sources and materials, shall be carried out with a concern to protect human health, safety and the environment.

Relevant means to ensure the final safety of radioactive shall be developed and implemented with a view to preventing and limiting the responsibilities to be borne by future generation. Any producer of spent fuel and of radioactive waste shall be liable for these substances, without any prejudice to the liability of their holders as people responsible for nuclear activities;

- Radioactive waste from foreign origin, as for instance arising from the reprocessing of foreign spent fuel, is to be shipped back to the originating country after the technically necessary storage period. It cannot, in any way, be disposed of in France;
- More specifically:
  - A National Radioactive Waste Management Agency, Andra, with the status of commercial and industrial public establishment was created in order to take care of the management of all radioactive waste produced in France[1]; this status gives it more independence from waste producers and places it under the supervision of the ministries for Ecology, Industry and Research;
  - A National Plan for the management of radioactive materials and waste (PNGMDR) is implemented and defines management objectives for waste without an existing disposal system (for instance radium-bearing and graphite waste); it is updated every three years (last issue in 2010);
  - In the specific case of HL and LL-IL waste, 3 three complementary venues with their milestones have been prescribed:
    - Partitioning and transmutation of long-lived radioactive elements, with notably an assessment of industrial prospect by 2012 and a transmutation pilot facility by 2020. This venue is entrusted to CEA;
    - Reversible geological disposal with a licence application to be filed by Andra in 2015 and, subject to that licence, a commissioning of the repository expected by 2025;
    - In term of storage, creation or modification of the current facilities by 2015 to meet future requirements. This venue is entrusted to Andra.
  - In terms of financing, it specifies:
    - the provision scheme to be implemented by waste producers with Nuclear Basic Installations (INB status[2]) in order to cover the long-term dismantling and waste management costs and its review by an independent commission;
    - the various additional taxes to be paid by these same waste producers for funding both the R&D carried out by Andra concerning HL and IL-LL waste geological disposal and the outreach scheme for the hosting communities of the current URL and later the possible geological repository.

**Programmes and projects**

**Radioactive waste treatment, packaging and tracking**

In the interests of optimising the management of short-lived LLW and ILW, both technically and economically, Andra and the waste generators have jointly developed an integrated waste

[1] Reminder: the so-called foreign waste, as for instance waste arising from foreign spent fuel reprocessing, is to be returned abroad according to the French legal framework.

[2] The term « INB » covers basically all major nuclear installations such as commercial or research reactors, nuclear fuel cycle plants and nuclear-related National Defence plants (for the latter the term is INBS).

management system that covers all phases of waste processing and conditioning, transportation and disposal. In this context, and for compliance with safety regulations, Andra has a further responsibility to develop technical specifications for waste packages. Under this arrangement, waste generators are required to submit, for Andra's approval, a waste acceptance file on each type of package they plan to produce.

A major component of this integrated waste management system involves tracking the waste from its production through to its final disposal. This is based on a computer network linking waste generators to the Andra headquarters, which records the characteristics of each package, checks compliance, authorises shipment, and then tracks the packages to their final location.

**Radioactive waste disposal facilities**

The CSM waste disposal facility located in the Manche district and adjacent to the AREVA La Hague reprocessing plant, was commissioned in 1969 for surface disposal of short-lived low- and intermediate-level radioactive waste and received 527 000 $m^3$ of waste up until June 1994 when disposal operations were terminated. It was covered with a multi-layer, engineered cap and has been actively monitored since 1997. In January 2003, it was licensed to enter its post-closure phase of institutional control. The transition from operation to institutional control was the subject of a licensing process similar to that for construction and commissioning of a nuclear installation, including a set of public inquiries. Nevertheless, the inventory of waste disposed of in the CSM is not so well known as QA procedures in the operating period of this facility (in the years 70's and 80's) were not implemented as it would be today and therefore it includes some long-lived radio-elements. It means that the institutional monitoring period may last at least 500 years instead of the planned theoretical 300-year period.

In the mid-1980s, in preparation for closure of the CSM, Andra designed a new surface disposal facility, the CSFMA, located 250 km east of Paris in the Aube district. Its design took stock of the lessons learnt at the CSM and it was commissioned in January 1992. It comprises waste conditioning facilities and a disposal area covering about thirty hectares. It is licensed to dispose of one million cubic metres of packaged, short-lived LLW and ILW and is expected to meet France's needs until at least 2040.

Andra subsequently proposed creation of a separate surface repository specifically for disposal of VLLW. After all necessary site investigations and public enquiries, the CSTFA, located at Morvilliers in the Aube district, was commissioned in August 2003. The repository has a capacity for 650 000 $m^3$ of VLLW and an expected operational lifetime of 30 years. It represents another essential component of France's overall system for radioactive waste management and will accommodate most of the waste resulting from the dismantling of facilities in which radioactive substances have been used.

**Development of new disposal systems**

Andra is required to carry out investigations with a view to proposing the means for disposal of those waste categories for which no permanent solution currently exists. These include long-lived LLW, such as radium-bearing residues, graphite and tritiated waste. They also include HLW and long-lived ILW.

These projects are carried out according to the objectives and milestones prescribed in the article L.542 of the Environment Code, following the Waste Act of 30 December 1991 and the

Planning Act concerning the sustainable management of radioactive materials and waste of 28 June 2006 (see § waste management policies). The National Plan for the management of radioactive materials and waste (PNGMDR) has been created to precise and follow up these objectives, with a regular 3-year updating according to research programme results and implementation plans.

The management of long-lived LLW (especially radium-bearing and graphite waste) was the subject of studies performed by Andra. Other waste such as disused sealed sources or bituminous waste could be added to this inventory, meaning a total up to some 151,000 $m^3$ by 2030. The disposal concepts are based on shallow disposal within a low-permeability clay host-formation at a depth varying from some 15 meters excavated from surface if the formation is outcropping (radium-bearing waste) or down to 200 meters through an underground installation if the formation is deeper (graphite waste).

A call for expression of interest has been launched by mid-2008 to identify volunteering municipalities among some 3000 ones with a potentially suitable geology for shallow disposal. By the deadline of end October 2008, some 40 municipalities did show an interest. On the basis of the Andra report submitted by end 2008 to the Ministry for Ecology and Energy and its review and opinion provided by respectively the regulator (ASN) and the National Assessment Board (CNE), a final selection of two municipalities was proposed by Andra to the Ministry, who endorsed it by mid-2009. But following pressure from opponents, these two municipalities withdraw in the same year and the socio-political process is to be reviewed.

Geological disposal of HLW and long-lived ILW is today Andra's major project. In 2006, at the end 15 year period prescribed by the December 1991 Waste Act and the following the results[3] achieved notably through the experimental programme carried out at and around the LSMHM underground research laboratory at Bure (Meuse district), basic feasibility of the reversible geological disposal in the Callovo-Oxfordian argillite near Bure (Meuse district) was confirmed.

As per the Planning Act concerning the sustainable management of radioactive materials and waste of 28 June 2006, reversible geological disposal of such waste is now the reference solution and Andra is entrusted to file a licence application for a geological repository by 2015 and, subject to the granting of this licence, to have the repository commissioned by 2025.

The reversibility issue will be submitted to the Parliament through a bill setting up reversibility conditions to be voted before licence granting.

Finally, a national public debate will be held as well before the licence application is filed by Andra. This debate is expected to take place by 2012.

Other venues concerning this type of waste are described briefly in § waste management policy.

According to the June 2006 Planning Act, Andra has proposed by end 2008 to the government an overall general management scheme for disused sealed radioactive sources (DSRS), which is integrated in the 2010 issue of the PNGMDR but still needs complementary studies. While nearly 83% of DSRS would be disposed together with LLW, 15% could be managed at the CSFMA and the remaining 2% through geological disposal.

[3] The results of R&D programme concerning reversible geological disposal in a clay formation were compiled in a report "Dossier 2005 Argile", which was reviewed by the Nuclear Safety Authority (ASN) and its technical support (IRSN), the National Review Board (CNE) and a Group of International Experts under NEA aegis (the latter through a Peer Review process upon the French government's request).

**Summary of programmes and projects**

The results of the work described above are depicted in the table below, which shows the disposal routes, or "channels", for the main categories of radioactive waste.

<table>
<tr><th>Activity/period</th><th>Very-short-lived<br>(Half-life < 100 days)</th><th>Short-lived<br>(Half-life ≤ 31 years)</th><th>Long-lived<br>(Half-life > 31 years)</th></tr>
<tr><td>Very-low-level</td><td rowspan="4">Management by in situ radioactive decay</td><td colspan="2">CSTFA waste disposal facility (Morvilliers in the Aube district) (*). Recycling channels (under investigation)</td></tr>
<tr><td>Low-level</td><td rowspan="2">Surface disposal at the CSFMA waste disposal facility (Aube district)<br><br>Tritiated waste: under study (see Planning Act 2006-739 of 28 June 2006)</td><td>Dedicated subsurface disposal facility designed for radium-bearing and graphite waste under study (see Planning Act 2006-739 of 28 June 2006)</td></tr>
<tr><td>Intermediate-level</td><td>Waste management solutions under study in the framework of Planning Act 2006-739 of 28 June 2006</td></tr>
<tr><td>High-level</td><td colspan="2">Waste management solutions under study in the framework of Planning Act 2006-739 of 28 June 2006</td></tr>
</table>

(*) Waste residue from uranium ore processing has its own specific disposal facilities provided for in the vicinity of the production sites.

Existing or future disposal systems for the main solid waste and residues resulting from radioactive effluent treatment

## RESEARCH AND DEVELOPMENT

As described under "Programmes and projects", Andra is carrying out one major R&D programme as per the National Plan for the management of radioactive materials and waste:

- Following a specific report issued by Andra (December 2009) and its later endorsement by the Ministry, the process of the implementation of a geological repository for HLW and long-lived ILW has progressed in 2010 with the focus over a 30 $km^2$ zone (the so-called ZIRA due to host the future underground installations of the geological repository) for detailed investigation and located within the 250 $km^2$ transposition zone of the LSMHM URL sited in Bure (Meuse district);

- The LSMHM URL licence was granted in August 2009 until end 2006 and extended in 2006 until end 2011. Therefore Andra has filed an application to renew it until 2030. The public inquiry was held from October 26th to November 30th. The licensing decree is expected to be granted before end 2011;
- Andra has as well sited a Technological Exhibition Facility (ETe) in Saudron (Haute-Marne district) in the near vicinity of the URL.

Studies and siting for a radium-bearing and graphite waste subsurface repository have been postponed, waiting for a siting political process to be defined (see previous chapter).

Although it does not refer *stricto sensu* to R&D, Andra is as well entrusted in terms of HLW and long-lived ILW storage, to the creation or modification of the current facilities by 2015 to meet future requirements.

Another major R&D programme is entrusted to CEA and concerns the partitioning and transmutation of long-lived radioactive elements, with notably an assessment of industrial prospect by 2012 and a transmutation pilot facility by 2020.The strategy is to design and study workshops to be added to existing reprocessing plants in order to fabricate specially designed fuel, loaded with minor actinides. The first step will focus on Americium recycling in fast neutron reactors. Preliminary design is targeted in 2014. This facility would be used for fabrication of experimental actinide loaded pins and assemblies by 2020. Meanwhile a smaller scale facility is also under consideration in the CEA Atalante facility.

## DECOMMISSIONING AND DISMANTLING POLICIES AND PROJECTS

### Current status

Decommissioning/dismantling operations must comply with the November 2nd 2007 decree. It requires that the final shutdown and the decommissioning shall be licensed by a specific decree. In its file application, the licensee must provide a preliminary decommissioning plan presenting the main principles with the technical steps and the planned schedule. The detailed decommissioning/dismantling plan must be presented at least three years before the final shutdown. After completion of the decommissioning/dismantling operations and the clean-up of the site, the former nuclear site may be still covered by some restrictions of use, after a public inquiry. The ASN guide n°6 published the 18 June 2010 on decommissioning and the associated appendix gives the lists the documents to be provided by the operator in view of the authorization for final shutdown and decommissioning/dismantling of its installation.

In addition, a ASN's draft guide n°14 has been published the 26 June 2010 sets. This guide provides recommendations for methodologies of complete clean-up of contaminated or activated structures (notably concrete structures) in BNIs. This guide is applicable whatever the situation of the nuclear facility is, under decommissioning or under operation. The purpose is to provide recommendations on the modification of the waste zoning of the nuclear facilities, where

decommissioning addresses the modification of all the nuclear zones to non nuclear zones to allow the implementation of the termination of the license process.

It is clearly up to the nuclear operator to present to the regulator its dismantling plan for the concerned decommissioned facility as the regulator does not prescribe any timetable. Nevertheless, and in agreement with the regulator recommendation, the current plans so far implemented aim at a quick dismantling without waiting for long decay period, in order to take advantage of the facility knowledge by the current operating staff. A deferred dismantling schedule, of 50 years or so, would obviously mean a safer reduced-radioactivity environment, but as drawback, the loss of the facility memory since the operating staff would not be anymore involved.

Most of the French decommissioning projects are concerned with either civilian nuclear facilities or those associated with defence activities.

There are three major civilian nuclear operators in France, running Basic Nuclear Installations (INB[4]).

- Électricité de France (EdF) operates the nuclear power plants. All of its 8 UNGG (natural-uranium gas-graphite) nuclear reactors and one HWGCR (Heavy-water gas-cooled) have been definitively shut down, as have the Superphenix fast breeder reactor and one Chooz (Ardennes) PWR reactor.
- AREVA operates nuclear fuel-cycle plants including chemical reprocessing facilities, uranium production facilities, gaseous diffusion plants, and other facilities.
- CEA operates most of the nuclear R&D facilities. Many installations such as research reactors, laboratories, pilot plants, etc. have already been dismantled, are presently being dismantled, or are on a waiting list for dismantling. CEA is as well entrusted with the technical support of nuclear activities for National Defence.

**Accounting for dismantling costs**

See § on financing.

## TRANSPORT

French legislation for the safe transport of radioactive materials is based on the Regulations for the Safe Transport of Radioactive Substances recommended by the International Atomic Energy Agency in 1985. Transport safety is secured by classifying materials according the hazards associated with radio-toxicity, nuclear criticality and dispersibility, and by providing appropriate packaging and shipping arrangements. Radioactive waste shipment programmes are drawn up in discussion with all relevant bodies and authorities, and with due regard to the different recycling or disposal routes available. After notification of the shippers, subsequent

[4] The term « INB » covers basically all major nuclear installations such as commercial or research reactors, nuclear fuel cycle plants and nuclear-related National Defence plants (for the latter the term is INBS).

shipment of waste is monitored by the authorities.

Radioactive waste is generally transported by road or rail from its site of production to an appropriately authorised facility, such as the melting and incineration SOCODEI plant operated by CENTRACO, or the disposal facilities operated by Andra. The aim is to dispose of waste through an appropriate route, or channel, as soon as possible, in order to minimise the amounts of waste stored at their production sites.

A particular feature of radioactive material transport in France is the trans-boundary movement of spent fuel and radioactive waste associated with spent fuel reprocessing operations carried out at La Hague on behalf of foreign utilities (for instance German, Japanese, Belgian, Swiss and Dutch customers). The reprocessing contracts with foreign utilities contain a clause stipulating return of the waste to its country of origin. This waste is packaged in a form suitable for safe transport and storage, while protecting public health and the environment. These trans-boundary movements are carried out in compliance with the comprehensive international, European and national regulations, and related international conventions, regarding safety, security, physical protection and public order. Trans-boundary movements within Europe are mainly by rail. Transport to Japan is by sea and port infrastructures complying with the requirements of nuclear safety have been built in France and Japan. There has been no significant incident compromising safety, security or radiation protection during these transport shipments in recent years.

## COMPETENT AUTHORITIES

### Regulatory body

The "Transparency and Security in the Nuclear Field" Act of 13 June 2006 created an independent administrative authority (ASN) in replacement of the former DGSNR which was under governmental supervision. ASN is responsible for regulating nuclear safety and radiation protection.

Apart from its missions of regulation and control, ASN participates in informing the public in its areas of competence. Regarding more specifically the issue of waste management, ASN together with the ministry for energy in charge of the National Plan for the Management of Radioactive Materials and Waste (PNGMDR) and its regular 3-year update.

### Technical and advisory bodies

ASN relies on the expertise provided notably by the Institute for Radiation Protection and Nuclear Safety (IRSN - *Institut de radioprotection et de sûreté nucléaire*) and Advisory Committees of experts (the so-called GPs standing expert groups).

The IRSN was created in February 2002 and is constituted by the former Institute for Nuclear Safety and Protection (IPSN) and by part of the former Office for Radiation Protection (OPRI).

According to the 2006 Planning Act on the sustainable management of radioactive materials and waste, a National Assessment Board (CNE) is entrusted to assess, on a yearly basis, the

progress of research and studies on the management of radioactive materials and waste[5] with reference to the National Plan for the management of radioactive materials and waste (PNGMDR). The CNE cannot be considered *stricto sensu* as a regulator as it cannot grant licence and is only an advisory body, but its conclusions are very often followed by decision-makers.

**Radioactive waste management organisation**

The implementing organisation is Andra, the National Radioactive Waste Management Agency.

It was established by the December 1991 Waste Act as a public body in charge of the long-term management of all radioactive waste, under the supervision of the Ministries for ecology, energy and research.

Its 3 basic missions defined initially by the December 1991 Waste Act, were extended and their funding secured through the 2006 Planning Act:

- a R&D mission to propose safe long-term solution for radioactive waste without current disposal system; this mission includes as well long-term storage for HLW and long-lived ILW;
- an industrial mission concerning design, construction, operation, closure and monitoring of waste repositories. This mission includes as well a public service mission in terms of i) collection of waste of the "small-scale nuclear activities" producers or owners (including the so-called "household" radioactive waste, ie waste owned by private individuals) and ii) clean-up and rehabilitation of orphan polluted sites;
- a public information mission about radioactive waste issues and programmes. It includes notably the regular publication of the National Inventory of radioactive waste and recoverable materials. This National Inventory is as well an important basis of the National Plan for the management of radioactive materials and waste (PNGMDR).

**Waste generators**

Électricité de France (EdF) is the electricity utility that owns and operates all nuclear power plants in France. Created with a public status in 1946, it was privatised in 2004 in line with the EU directives concerning the liberalisation of electricity markets.

The Commissariat à l'Energie Atomique (CEA) is a public body created in 1945 to carry out the implementation of civilian nuclear activities (energy, industry, research and health) and to provide the necessary support to the development of National Defence activities (as Nuclear Deterrent Forces).

AREVA (formerly COGEMA) is a private company, whose main shareholder is CEA, and is involved in all stages of the fuel cycle (from mining to fuel manufacturing and reprocessing), which makes it a major waste generator.

It is as well an international leader in nuclear reactors engineering and construction.

[5] Before the 2006 Planning Act, the CNE was entrusted only with the evaluation of the 3 R&D venues prescribed by the December 1991 Waste Act and concerning HLW and long-lived ILW management (i.e. partitioning and transmutation, geological disposal, waste conditioning and long-term storage)

# FINANCING

In France, operators are responsible for financing the management of their waste and the dismantling of their nuclear installations. It is important that financial resources (funds) will be sufficient and available when needed, notably to ensure a satisfactory safety level of the future operations as prescribed by the 2006 Planning Act on the sustainable management of radioactive materials and waste.

Each nuclear operator (EdF, AREVA, CEA) of Nuclear Basic Installations (INB) manages its fund which stays inside the company as provisions backed by assets of sufficient security and liquidity.

They shall transmit every three years to the administrative authority a report describing the assessment of the costs, the methods applied for the calculation of these costs and the choices adopted with regard to the composition and management of the assets earmarked to cover the reserves.

The first reports were issued mid 2007. They included a plan for constituting the assets. Every year operators shall transmit to the administrative authority a note updating this report and inform it without delay of any event likely to modify its content.

A national financial evaluation commission is created to assess the funding of the costs in dismantling nuclear installations and managing spent fuel and radioactive waste. This commission will issue a report which will be made available to the public.

Apart from this scheme which concerns only long-term liability of INB waste producers both in terms of dismantling and waste management cost, the necessary R&D HLW and long-lived ILW programme is financed through an additional INB tax, which is transferred to a fund, as prescribed by the 2006 Planning Act.

A similar scheme than the previous one with another additional INB tax, has been implemented, as prescribed by the 2006 Planning Act, to fund the economic development scheme of the local municipalities and two districts concerned by the project of geological repository for HLW and long-lived ILW, through their respective Public Interest Group (GIP).

As far as waste arising from installations without INB status, the owner must still comply with the “polluter pays” principle, but the above specific regulations do not apply.

Specific public funding has also been implemented in the framework of the 2006 Planning Act for the collection and management of waste from the “small-scale nuclear” activities, including “household” waste (owned by private individuals). This scheme is mobilised when financing cannot be fully supported by the waste owner or holder and as well to address the issue of clean-up and rehabilitation of orphan polluted sites (usually from former industries).

## PUBLIC INFORMATION

For more information, the websites of the relevant authorities and organisations are listed below.

### Government and Parliament

Ministère de l'Ecologie, de l'Energie, du Développement durable, du Transport et du Logement
Website: http://www.developpement-durable.gouv.fr/
Ministère des Finances, de l'Economie et de l'Industrie
Website: http://www.industrie.gouv.fr/
Ministère de l'Enseignement Supérieur et de la Recherche
Website: http://www.recherche.gouv.fr/
Ministère du Travail, de l'Emploi et de la Santé
Website: http://www.travail-emploi-sante.gouv.fr
Ministère de la Défense
Website: http://www.defense.gouv.fr
Direction générale de l'énergie et du climat (DGEC)
Website:http://www.developpement-durable.gouv.fr/-Energie-et-Climat,123-.html
Office Parlementaire d'Evaluation des Choix Scientifiques et Technologiques, OPECST (Parliamentary Office for the Evaluation of Scientific and Technological Choices)

- Sénat (Website: http://www.senat.fr)
- Assemblée Nationale (Website: http://www.assembleenationale.fr)

### Regulator and related

Autorité de Sûreté Nucléaire, ASN (Nuclear Safety Authority)
Website: http://www.asn.gouv.fr
IRSN
Website: http://www.irsn.org
Commission Nationale d'Evaluation, CNE (National Review Board).
Reports are available in French at the website: http://www.ladocumentationfrancaise.fr/rapports-publics/074000493/index.shtml

### Research

Commissariat à l'Energie Atomique, CEA (Atomic Energy Commission)
Website: http://www.cea.fr
Andra
Website: http://www.andra.fr

### Industry

AREVA
Website: http://www.areva.com
EdF
Website: http://www.edf.com

### Information

Website : http://dechets-radioactifs.com