Andra

Everything you ever wanted to know about radioactive waste management

ANDRA
Mastering radioactive waste

Meuse/Haute-Marne Underground Research Laboratory

CONTENTS

RADIOACTIVITY
and radioactive waste

Radioactivity

Radioactivity is a natural phenomenon and is a property of certain unstable atoms that can spontaneously transform into another atom, while emitting radiation. Radioactive atoms can be found naturally in the human body, in food (milk, potatoes, fish, *etc.*) and in the environment (soil, rainwater, seawater, stars, *etc.*).

Since the discovery of radioactivity, its properties have been used for numerous applications: generation of electricity, chemistry, biology (study of cells), geology, archaeology (dating), agriculture, medicine (diagnosis and treatment of cancers), and so on.

It also has many uses in industry, for the conservation of foods (ionisation), weld inspection in metallurgy, sterilising medical equipment or smoke detection systems.

All of these activities produce waste, some of which is radioactive.

Examples of naturally-occurring radioactivity

(Expressed in Becquerel, see glossary page 14)

1 kg of artichokes: 300 Bq

1 litre of mineral water: 5 Bq

1 kg of potatoes: 150 Bq

Radioactive waste

By radioactive waste, we mean radioactive substances that cannot be reused or reprocessed, and which require special management.

Radioactive waste comes in a variety of forms: rubble, scrap metal, gloves, filters, resins, coats, pipettes, beakers, needles or everyday objects such as alarm clocks, fountains or lightning rod tips.

Radioactive waste can come from the maintenance and operation of nuclear facilities, their dismantling, the reprocessing of spent fuel from nuclear power plants, the remediation of polluted sites, or from private individuals. They can also be the result of industrial processes, medical examinations and treatments, or research activities.

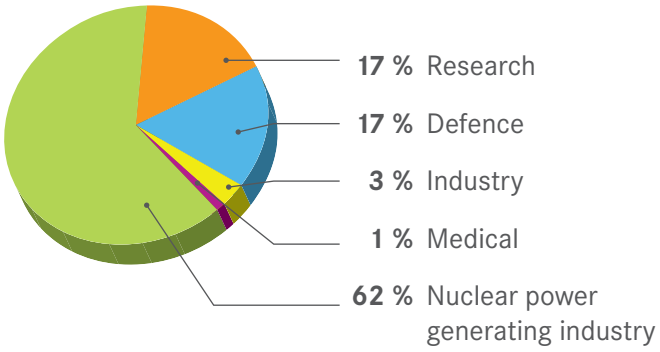
Radioactive waste means a risk because it emits radiation that is a health hazard. The harmfulness of radioactive waste diminishes with time, owing to the natural decay of its radioactivity.

To protect humans and the environment against these dangers for as long as they are present, France – like most countries – has opted to dispose of radioactive waste in industrial facilities appropriate to each type of waste. The aim is to isolate them until their radioactivity has decreased sufficiently.

There are currently two centres in operation, dealing with 90% of the radioactive waste produced in France.

Origin of radioactive waste per sector in France, by volume

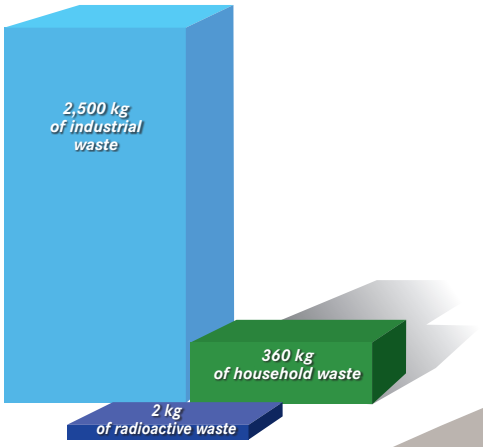
(Source: French National Inventory of Radioactive Materials and Waste – 2009 edition)



Key figures

The 2009 edition of the French National Inventory of Radioactive Materials and Waste identifies about 1,153,000 m^3 of radioactive waste produced.

Quantity of waste produced in France per inhabitant and per year



Control of packages at the very-low-level waste disposal facility, CSTFA, located in the Aube district.

ANDRA

The National Radioactive Waste Management Agency

Andra is an industrial and commercial public body created by the 30th December 1991 Waste Act.
Its duties were completed to by the 28th June 2006 Planning Act on the sustainable management of radioactive materials and waste.
Andra is independent of the radioactive waste producers and is under the supervision of the ministries responsible for energy, the environment and research.

Its role

Andra is responsible for identifying, implementing and guaranteeing safe management solutions for all French radioactive waste, in order to protect present and future generations from the risks inherent in them.

Disposal – in brief

In France, as in many countries, disposal is the long-term solution chosen for the industrial management of radioactive waste.
Disposal facilities are designed to confine the radioactivity present in the waste for the time needed to allow it to decay.
The safety of a disposal facility depends on several components, depending on the nature of the waste:

- the package containing the waste;
- the disposal cell (or repository structure) in which waste packages are placed;
- the geology of the site, constituting a natural barrier.

Its activities

Andra's role involves a number of activities:

- **operating the two existing surface disposal facilities** in the Aube district, the first one for low- and intermediate- level, short-lived (LL/IL-SL) waste and the other one for very-low-level (VLL) waste.
- **monitoring** the Manche disposal facility, France's first surface disposal facility for low- and intermediate-level waste, which is today in post-closure phase.
- **studying and designing disposal facilities** for waste as yet without a special facility, that is:
  - **> low-level, long-lived waste**
  - **> intermediate-level, long-lived and high-level waste.**
- **collecting and taking-over** radioactive waste from hospitals, research laboratories, universities, *etc.*, **and radioactive objects owned by private individuals** (luminescent clocks and watches, radium objects for medical uses, natural laboratory salts, certain minerals, *etc.*).
- at the request of the owner or the public authorities, **cleaning up sites polluted** by radioactivity, such as the former Marie Curie laboratories.
- **surveying and listing** French radioactive waste and publishing the National Inventory of Radioactive Materials and Waste every three years.
- **informing all members of the public** by means of documents, exhibitions, visits to its facilities, *etc.*
- **promoting and disseminating its know-how** in France and abroad.

Its financing

Andra is financing through

• **contracts with radioactive waste producers** (EDF, Areva, CEA, hospitals, research centres, *etc.*), for the disposal of their radioactive waste;

• **a** so-called research **tax** collected by the French Nuclear Safety Authority (ASN) from the radioactive waste producers, for the research works and studies concerning storage and disposal of intermediate-level, long-lived and high-level waste;

• **a subsidy** from the State, for its public service duties (French National Inventory, collection of radioactive objects from private individuals, clean-up and remediation of sites polluted by radioactivity for which the party responsible has defaulted).

Keeping the memory

Andra is required to preserve the memory of its disposal facilities for several centuries, so that future generations will be aware of their existence and their contents, will understand the changes occurring in them and can intervene if necessary.

A detailed memory record of the Manche disposal facility, kept on permanent paper, is available to present and future generations on the site itself and in the National Archives.

Key figures

on October 31, 2011

532 staff
6 sites including:
- **1** head office in Châtenay-Malabry
- **3** disposal facilities: **2** in the Aube, **1** in the Manche
- **1** underground laboratory and **1** technological exhibition facility in the Meuse/Haute-Marne region

The Andra head offices in Châtenay-Malabry

THE CLASSIFICATION OF RADIOACTIVE WASTE

and the disposal concepts

In France, there are 5 waste categories, classified according to their disposal solution, which depends in particular on 2 criteria: the level of radioactivity and the half-life.

VLL / Very-low-level waste

Its level of radioactivity is very close to that of natural radioactivity.

It is produced primarily by the dismantling of facilities (whether or not nuclear power plants) or the clean-up of polluted sites. It generally takes the form of industrial waste (scrap, plastics), inert materials (concrete, rubble, earth) or special materials (ashes, sludges, *etc.*). It is disposed of at surface in the Aube CSTFA disposal facility, commissioned in 2003.

On its arrival in the facility, plastic and metal waste is compacted. Liquid waste (polluted water, sludges) is solidified and made chemically inert. The waste is then placed in drums or big bags.

Once prepared, these waste packages are identified and stacked in vaults, a few meters deep and excavated in a clay layer.

Once the vault is full, it is capped with a clay backfill, previously pre-compacted in order to restore its original impermeability.

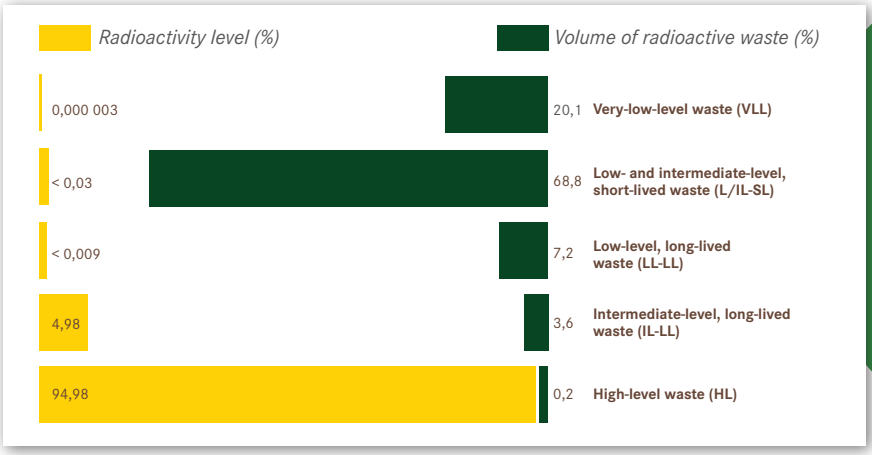
LIL-SL / Low- and intermediate-level, short-lived waste

This waste is produced either by the maintenance and operation of nuclear facilities (clothing, tools, filters, *etc.*), or by research or treatment activities in laboratories and hospitals.

It contains essentially short-lived radioactive atoms and since 1992 has been disposed of in the Aube CSFMA disposal facility, which took over from the Manche disposal facility, operated from 1969 to 1994.

Prior to disposal, some of the waste packages are compacted or solidified and then mixed with concrete before being placed in a concrete or metal container. A package of LIL waste comprises 15 to 20% waste and 80 to 85% embedding material. It is placed in reinforced concrete surface structures 25 metres long and 8 metres high, built over two superposed geological layers: one of sand, the other of clay.

These structures are then closed by a concrete slab, made watertight by a layer of impermeable resin. Finally, a clay cap several metres thick will be placed on the structures to guarantee long-term protection.



Key figures

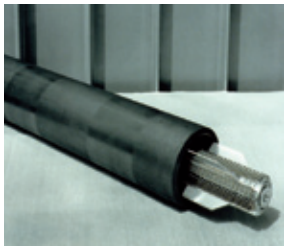
(Source: National Inventory of Radioactive Materials and Waste – 2009 edition)

Breakdown of volume and radioactivity level per type of radioactive waste.

LL-LL / Low-level, long lived waste

There are essentially two kinds of this radioactive waste: “radium-bearing” and “graphite”.

> Radium-bearing waste owes its name to the radium it contains. It comes from the processing of various minerals used, for example, in the automotive industry or fine metallurgy. It is currently stored on the CEA and industrial producer sites.



> Graphite waste, as its name implies, contains graphite, a mineral corresponding to a very pure variety of carbon. It is produced during the dismantling of the first generation of nuclear reactors, today shut down, and currently stored on the EDF, CEA and Areva sites.

> Other types of waste also fall into this category: radioactive lighting rod tips, smoke detectors, luminescent paint (formerly used in the clock-making industry for example).

Andra is examining the various possible management scenarios for this waste, in order to propose safe and appropriate disposal solutions.

IL-LL / Intermediate-level, long-lived waste

This waste mainly comes from the nuclear power generating industry.
It primarily consists of the cladding structures surrounding the spent fuel (hulls and end-pieces) or residues from the operation of nuclear facilities.

HL / High-level waste

This is the result of reprocessing of the spent fuel from the nuclear power generating industry.

For these two types of waste, Andra is tasked with designing a reversible disposal facility at a depth of 500 m, called Cigéo – a French acronym for Industrial Geological Disposal Facility – defined as the reference solution by the Planning Act of 28th June 2006.

For that purpose, Andra is carrying out research and studies, notably in its underground laboratory located in the Meuse/Haute-Marne area.

Pending the commissioning of this disposal facility, scheduled for 2025, the intermediate-level, long-lived and high-level waste is stored on its production and conditioning sites at La Hague (50), Marcoule (30) or Cadarache (13).

Disposal of packages in the low- and intermediate-level, short-lived waste disposal facility located in the Aube district

THE ROUTE
of a radioactive waste

Producers

Andra

Use of the properties of radioactivity
(nuclear power generation, medicine, research, hospitals, chemistry, etc.*)*

Conditioning,
*on the producers premises**

Transport to the Andra disposal facilities

Reception of the waste
by Andra in its dedicated disposal facilities in the Aube district

***In-situ* sorting**

Production of radioactive waste

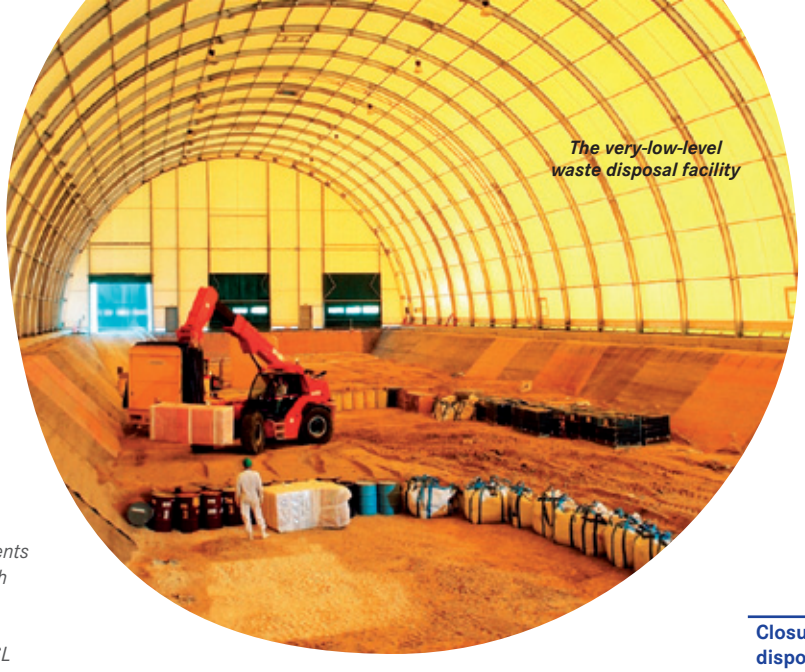
- **LIL-SL and VLL waste**
- **Very-short-lived waste** radioactive half-life of less than 100 days
- **HL, IL-LL and LL-SL waste**

Concerning radioactive waste from hospitals, research and medical analysis laboratories, private individuals and so on, Andra is responsible for collection, sorting, conditioning, treatment and transport to its disposal facilities

***In-situ* radioactive decay**
It is then disposed of in the same way as conventional waste

Temporary storage on the production site
pending commissioning of a dedicated disposal facility

* The producers are required to comply with the prescriptions issued by Andra: weight, radioactive atoms contained, radiological activity and risks presented. These data are recorded by means of a unique barcode identification number for each package of LIL-SL waste, enabling the waste to be traced and its exact position in the disposal facility to be located. In order to ensure the quality of packaging and compliance with these rules, inspections are regularly performed on the producer's premises by Andra.



The very-low-level waste disposal facility

Preserving the memory of the sites
and transmission to future generations after 300 years

Radiological checks
on packages, their contents and their conformity with Andra requirements, in particular by means of the barcodes on LIL-SL waste packages

Closure of disposal facilities

In-depth inspections
on randomly sampled LIL-SL waste packages at delivery

Treatment as applicable
(compacting, incineration, solidification for example)

Package emplacement

Monitoring of disposal facilities
Environmental monitoring is carried out during operation and after closure

Radioactive waste management modes in France

Management mode	Decay on the production site	Disposal facility			Under study	
		Closed, under monitoring (Manche district)	In operation (Aube district)			
		CSM	CSTFA	CSFMA	LL-LL project	Cigéo Project
Type of radioactive waste	Very-short-lived, whatever the radioactivity level	Low- and intermediate-level	Very-low-level	Low- and intermediate level, short-lived	Low-level, long-lived	Intermediate-level, long-lived and high-level

ANDRA

SITES

The Manche disposal facility (CSM)

France's first disposal facility, with a 15-hectare footprint, from 1969 to 1994 received 527,225 m³ of low- and intermediate-level radioactive waste.
It is currently in the monitoring phase, which will last several centuries.

CENTRE DE STOCKAGE DE LA MANCHE :
ZI de Digulleville - BP 807 • 50448 Beaumont-Hague cedex • France
Phone: +33 233 016 900

The Aube disposal facilities (CSA)

- **The very-low-level waste disposal facility (CSTFA)**

This disposal facility with a 45-hectare footprint has a capacity of 650,000 m³. It has been receiving very-low-level waste since 2003.

- **The low- and intermediate-level waste disposal facility (CSFMA)**

This facility, with a 95-hectare footprint and a capacity of 1,000,000 m³ of waste packages, is dedicated to low- and intermediate-level, short-lived waste. Commissioned in 1992, it took over from the Manche disposal facility, thus taking stock of the 25 years of experience already acquired.

CENTRES DE STOCKAGE DE L'AUBE :
BP 7 • 10200 Soulaines-Dhuys • France
Phone: +33 325 923 300

CSA key figures *as at 30/06/2011*

> 220,111 waste packages disposed of in the CSTFA since 2003, or 189,823 m³, corresponding to 29% of the facility's disposal capacity.
> 312,940 waste packages disposed of in the CSFMA since 1992, or 249,634 m³, corresponding to 25% of the facility's disposal capacity.

The Meuse/Haute-Marne facility (CMHM)

The Meuse/Haute-Marne Underground Research Laboratory

The Underground Research Laboratory was built at a depth of 490 m for Andra's research into the feasibility of deep reversible disposal of intermediate-level, long-lived and high-level waste. Its underground drifts allow *in-situ* study of a 160-million-year old clay layer.

LABORATOIRE SOUTERRAIN DE MEUSE/HAUTE-MARNE :
Route départementale 960 • BP 9 • 55290 Bure • France
Phone: +33 329 755 373

Technological Exhibition Facility

The Technological Exhibition Facility is an opportunity for the public to find out about Cigéo, the reversible deep disposal facility project for intermediate-level, long-lived and high-level waste. It displays models and a variety of robots and industrial prototypes built by Andra to test and validate the technological concepts involved in this facility: concrete package container, handling system, *etc.* New prototypes are added to the permanent exhibition as and when they are built.

ESPACE TECHNOLOGIQUE :
Chemin des trois finages
52230 Saudron • France
Phone: +33 329 755 373

Laboratory - key figures *(2011)*

About ***1,000 m of experimental drifts.***
80 laboratories involved in research
12 partnerships (BGS, BRGM, CEA, CNRS, INERIS, INRA, INRIA, Nancy-Université, Sandia National Laboratories, Technology University of Troyes, Carnot, LNE).

Andra's sites are open to the public free of charge, all year round

Environmental monitoring

Before the commissioning of each site, during its operation and then afterwards, during the monitoring phase, Andra permanently checks the very slight impact of its activities on the environment, by means of numerous samples and analyses of the quality of the water, air, soil, fauna and flora.
For example, in 2010, more than 1500 radiological analyses were performed in the environment of the CSTFA and about 11,000 radiological analyses and 2,000 physico-chemical analyses in that of the CSFMA.
For the Cigéo project (the future reversible deep disposal facility for IL-LL and HL waste), the readings taken and observations made have since 2007 been input into the Perennial Observatory of the Environment (OPE) comprising a biodiversity observatory and an eco-bank for the conservation of samples (plants, insects, soils, *etc.*). The purpose of this observatory is:
> establishing the initial status of the environment, taking account of the natural variability,
> monitoring and surveillance, as of the construction of the disposal facilities.
Environmental monitoring will continue well after closure of the facility, for a period in excess of a century.

GLOSSARY

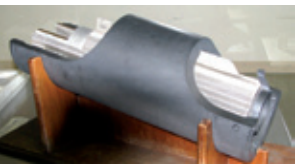
Activity: level of radioactivity. Measured in Becquerel.

Atom: essential element of matter (constitutes air, water, earth, living beings, *etc.*).
Each atom comprises a nucleus (protons and neutrons) and electrons which orbit around it.

Becquerel (Bq): unit of measurement of the level of radioactivity, named after Henri Becquerel who discovered radioactivity at the end of the 19th century.

Disposal: long-term solution for industrial management of radioactive waste.
Disposal safety is based on three components: the packages which contain the waste, the disposal **structures** in which **the packages** are placed and the site **geology**, which constitutes a natural barrier.

Disposal structure: structure in which the waste packages are placed.



Graphite waste: primarily the sleeves surrounding the fuel in the first nuclear reactors today shut down.

Package: container in which radioactive waste is placed, generally immobilised in a “matrix” (concrete or glass).

Radioactive half-life (or period): average time after which a radioactive atom naturally loses half of its activity. Thus the activity of a radioactive product is divided by four after two half-lives and by eight after three half-lives. After ten half-lives, the activity has been divided by a bit more than 1,000. A distinction is made between waste in which the main radioactive atoms have a short half-life (≤ 31 years) and waste in which these main radioactive atoms have a long half-life (>31 years). The 31-year limit was determined by the radioactive half-life of caesium 137 (30.05 years). It is generally considered that the first category no longer presents any risk after 300 years.

Radioactivity: most atoms (such as hydrogen for example) are stable and are not radioactive. Others, such as plutonium, are unstable and spontaneously transform into other atoms (which may or may not be stable). In transforming, they release surplus energy in the form of radiation, until such time as they become stable again: this is the phenomenon of radioactivity.

Henri Becquerel

Radiation: radioactive atoms emit radiation with widely differing types of energy.
There are three main types of radiation which are penetrating to varying degrees.

Alpha radiation, which travels a few centimetres through air, is stopped simply by a sheet of paper.
Beta radiation travels several metres in air. It is stopped by a sheet of aluminium or a pane of glass. Gamma radiation, which is of the same type as X-rays but far more energetic, is stopped by several centimetres of lead or several decimetres of concrete.

Radium-bearing waste: primarily earth contaminated with radium as a result of cleaning up polluted industrial sites, and materials from the treatment of ore containing uranium or thorium.

Reversibility: pursuant to the Planning Act of 28th June 2006, deep disposal of intermediate-level, long-lived and high-level waste must be reversible for at least 100 years. Reversibility consists in leaving future generations the option of modifying or altering the disposal process, for example by retrieving the disposed-of packages if another management mode became available. A new Act will specify the reversibility conditions.

Sievert (Sv): unit of measurement of the biological effects on humans as a result of exposure to radioactivity.
According to the regulations, the annual dose linked to activities in the nuclear industry must be as low as possible and not exceed 1 mSv for the population. By way of comparison, in France, the average annual exposure to naturally occurring radioactivity is 2.4 mSv and 1.1 mSv for artificial radioactivity (exposure of medical origin).

A dose of 1 mSv is: 17 months in the Paris area, 7 Paris-San Francisco round-trips by air, the annual average of the medical radiology procedures in France per inhabitant.

Storage: temporary solution for the management of radioactive waste, before their disposal.

KEY DATES

in radioactive waste management in France

1969
Opening of the Manche disposal facility (surface facility). It stopped receiving waste in 1994 and is today in active monitoring phase.

1979
Creation of Andra within the CEA.

1991
Act of 30th December, the first in France, concerning the responsibility for and management of radioactive waste.
It gave Andra its status as an industrial and commercial public body, independent of the radioactive waste producers.

1992
Commissioning of the Aube low- and intermediate-level disposal facility (surface facility).

1999
Licencing of the Meuse/Haute-Marne underground research laboratory to study the feasibility of deep disposal of intermediate-level, long-lived and high-level waste.

2001
> First four-year contract between the State and Andra, defining the Agency's duties.
> Dual ISO 9001 and ISO 14 001 certification obtained.

2003
> Commissioning of the very-low-level waste disposal facility (surface facility).
> The Manche disposal facility officially enters the monitoring phase.

2005
Submission to the public authorities of a synthesis report *(Dossier 2005)* on the feasibility of reversible deep disposal of intermediate-level, long-lived and high-level radioactive waste.

2006
Parliamentary debate on the long-term solutions for the management of radioactive waste, with the 28th June Planning Act being passed to expand the role and duties of Andra.

2008
Call for applications by local communities for the siting of a disposal facility for low-level, long-lived waste (about forty applications were received over the year).

2009
> Withdrawal by two municipalities selected for the LL-LL waste project, under pressure from opponents.
> Publication of the new edition of the National inventory of radioactive materials and waste.

2010
> Publication of the 2010-2012 National radioactive materials and waste management plan (PNGMDR).
> Validation by the Government of the area of about 30 km² proposed by Andra for siting Cigéo, the industrial geological disposal facility for intermediate-level, long-lived and high-level waste.
> Launch of the website: dechets-radioactifs.com.
> OHSAS 18001 Certification.

2011
Issue of a call for bids for the selection of the prime contractor of the project management of Cigéo.

The dechets-radioactifs.com website gives an informative, clear and exhaustive presentation of the radioactive waste issue as a whole, from the use of the properties of radioactivity, up to disposal.
Anyone concerned by this topic will find simple answers to legitimate questions on an interface that is both entertaining and easy to access.

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